2007

Exploring faculty changes in science courses at Maryland community colleges in response to the Associate of Arts in Teaching degree option for elementary education majors

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EXPLORING FACULTY CHANGES IN SCIENCE COURSES AT MARYLAND COMMUNITY COLLEGES IN RESPONSE TO THE ASSOCIATE OF ARTS IN TEACHING DEGREE OPTION FOR ELEMENTARY EDUCATION MAJORS

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Dissertation submitted to the College of Human Resources and Education at
West Virginia University in partial fulfillment of the
Requirements for the degree of

Doctor of Education
in
Higher Education Leadership Studies

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Key Words: Resistance to Curriculum Change,
Inquiry-Based Learning, Associate of Arts in Teaching Degree in Maryland

Abstract

Exploring Faculty Changes in Science Courses at Maryland Community Colleges in Response to the Associate of Arts in Teaching Degree Option for Elementary Education Majors

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Education majors at Maryland community colleges have often faced difficulties in transferring to four-year colleges, frequently having to repeat courses, resulting in greater financial burdens and delayed graduation. In the fall of 1999, the Chief Academic Officers Intersegmental Group appointed the Teacher Education Articulation Committee whose task was to establish a seamless transfer between two- and four-year public and private colleges in Maryland. This committee determined outcomes for elementary teacher candidates that defined the requirements of a new degree, the Associates of Arts in Teaching. Although the original intention of this degree was to establish a seamless transfer between two- and four-year colleges in the area of teacher education, its work has evolved into a major paradigm shift from instructivist teaching to inquiry-based learning. This study was designed to answer the following research questions:

1. What are the science faculty's attitudes toward the science content and pedagogy requirements of the new AAT degree?
2. What changes (including the type and degree of the change) have faculty made in the course content and pedagogy in order to satisfy AAT degree requirements?
3. What changes have faculty made in student assessment techniques in order to satisfy AAT degree requirements?
4. What factors affect the science faculty's implementation of the changes necessary to comply with the AAT degree requirements?
5. From the perspective of the students, what course activities promote critical thinking?

Data was collected from four Maryland community colleges during the spring of 2004. The sources of data include interviews with faculty, document analysis, classroom and campus observations, and student questionnaires. A case study was developed for each college, followed by a cross-case analysis. This study concluded with well-grounded recommendations for practice and future research.

Table of Contents

Chapter One: Introduction and Problem Statement..1

Purpose..6
Research Questions..7
Structure of Dissertation...7
Summary..8

Chapter Two: Literature Review..10

Factors Affecting Change..11
External Influences...12
Internal Influences..13
Organizational Influences...18
Effect of Faculty Attitudes Toward Change..22
Coping with Change..23
The Role of the Student...25
How Faculty View Students and Student Learning.................................25
How Students View Teaching and Learning...26
Summary and Concept Map..30
Key Terms..32

Chapter Three: Research Design..37

Knowledge Claims...37
Strategy of Inquiry..39
Qualitative Research..40
Case Study...41
Audience..42
Limitations to the Study..42
Bias and Subjectivity..44

Chapter Four: Research Method..47

Site Selection..47
Site Contact and Approval..50
Sampling Procedures...51
Sources and Collection of Data..52
Personal Interviews..54
Document Review..55
Campus and Classroom Observations..56
Student Questionnaires...57

Assurances of Trustworthy Data....58
Pilot Study....58
Letters....59
Interviews/Interview Protocols....59
Document Analysis Protocols....61
Classroom Observation Protocol....61
Student Questionnaire....62
Documentation....62
Member Checking and Peer Review....63
Triangulation....64
Data Analysis....65
Data Display....65
Data Reduction....66
Summary....70
Research Timeframe....71

Chapter Five: Case Study of Oakmont Community College....72

Background Information....72
Institutional Context....72
History of the AAT Degree....73
Faculty Interviewed....76
Awareness of and Attitudes Toward the AAT Degree Requirements....78
Awareness and Knowledge of AAT Degree Requirements....78
Attitudes Toward AAT Degree Requirements....83
Changes Made in Course Content/Pedagogy by Individual Faculty....87
Changes in Assessment Techniques....90
Students' Perceptions of Constructivist Teaching Activities....93
Perceived Improvements in Critical Thinking....94
Perceived Helpfulness of Teaching Techniques....96
Potential Factors Affecting Implementation of Change....98
External Factors....99
Organizational Factors....100
Internal Factors....103
Attitudes Toward Request, Awareness, Participation, and Belief in Change....103
Prior Use of Constructivism, Faculty Background, and Teaching Philosophy....106
Students' Attitudes Toward Learning and the Faculty's Attitudes Toward Students....108
Summary....114

Chapter Six: Case Study of Lakeside Community College..........................116

Background Information..........................116
Institutional Context..........................116
History of the AAT Degree..........................118
Faculty Interviewed..........................120
Awareness of and Attitudes Toward the AAT Degree Requirements..........................122
Awareness and Knowledge of the AAT Degree Requirements..........................122
Attitudes Toward AAT Degree Requirements..........................126
Changes Made in Course Content/Pedagogy by Individual Faculty..........................131
Changes in Assessment Techniques..........................139
Students' Perceptions of Constructivist Teaching Activities..........................143
Perceived Improvements in Critical Thinking..........................144
Perceived Helpfulness of Teaching Techniques..........................147
Potential Factors Affecting Implementation of Change..........................149
External Factors..........................149
Organizational Factors..........................151
Internal Factors..........................153
Attitudes Toward Request, Participation and Belief in Change..........................153
Prior Use of Constructivism, Faculty Background, and Teaching Philosophy..........................156
Students' Attitudes Toward Learning and the Faculty's Attitudes Toward Students..........................161
Summary..........................163

Chapter Seven: Case Study of Beltway Community College..........................165

Background Information..........................165
Institutional Context..........................165
History of the AAT Degree..........................166
Faculty Interviewed..........................169
Awareness of and Attitudes Toward the AAT Degree Requirements..........................171
Awareness and Knowledge of AAT Degree Requirements..........................171
Attitudes Toward AAT Degree Requirements..........................175
Changes Made in Course Content/Pedagogy by Individual Faculty..........................178
Changes in Assessment Techniques..........................182
Students' Perceptions of Constructivist Teaching Activities..........................184
Perceived Improvements in Critical Thinking..........................185
Perceived Helpfulness of Teaching Techniques..........................189
Potential Factors Affecting Implementation of Change..........................190
External Factors..........................191
Organizational Factors..........................192
Internal Factors..........................198
Attitudes Toward Request, Awareness, Participation and Belief in Change..........................199

Prior Use of Constructivism, Faculty Background, and Teaching Philosophy....200
Students' Attitudes Toward Learning and the Faculty's Attitudes Toward Students....203
Summary....208

Chapter Eight: Case Study of Bayview Community College....210

Background Information....211
Institutional Context....211
History of the AAT Degree....214
Faculty Interviewed....216
Science Courses that Support the AAT Degree....219
Development of the Science Courses....219
Present State of the Science Courses....225
Physical Science....225
Environmental Science....234
Awareness of and Attitudes Toward the AAT Degree Requirements....240
Awareness and Knowledge of AAT Degree Requirements....240
Attitudes Toward AAT Degree Requirements....246
Students' Perceptions of Constructivist Teaching Activities....257
Perceived Improvements in Critical Thinking....258
Perceived Helpfulness of Teaching Techniques....262
Summary....264

Chapter Nine: Cross-Case Analysis....266

Research Question #1....267
Research Question #2....272
Research Question #3....274
Research Question #4....275
External Factors....276
Organizational Factors....277
Internal Factors....278
Research Question #5....287
Trends in the Percent of Yes Responses....288
Classroom Activities and Perceived Gains in Critical Thinking....292

Chapter Ten: Summary and Recommendations for Practice and Future Research....296

Summary of Findings....296
Research Question #1....296
Research Question #2....297
Research Question #3....297
Research Question #4....298

Research Question #5 300
Recommendations for Practice 300
Recommendations for State Policy Makers 300
Recommendations for Community College Personnel 302
Recommendations for Further Research 304

References 308

Appendix A: Synopsis of Relevant Excerpts 317
Appendix B: Letter of Request to the Head of the Science Dept. or Dean.........320
Appendix C: Template of Letter of Approval 321
Appendix D: Invitation Letter to Directors of Teacher Education and Department/Division Chairs 322
Appendix E: Invitation Letter to Teaching Faculty 323
Appendix F: Research Questions and Concept Map with Links to Sources of Data 325
Appendix G: Interview Protocol for Directors of Teacher Education and Chairs of Science Departments 327
Appendix H: Interview Protocol for Teaching Faculty 329
Appendix I: Syllabus Analysis Protocol 333
Appendix J: Non-syllabus Analysis Protocol 336
Appendix K: Permission Letter from Dr. Basili 338
Appendix L: Classroom Observation Protocol 339
Appendix M: Student Questionnaire 341
Appendix N: Permission Letter from Dr. Perry 344

List of Figures

Figure Page

1 Concept Map – Factors that may Affect Science Faculty 31

2A Revised Concept Map – Factors that Affected the Science Faculty 286

2B Revised Concept Map – Factors that Affected the Science Faculty 299

List of Tables

Table Page

1 Fundamental Differences Between Traditional and Constructivist Classrooms 4

2 Overview of Schlossberg's Transition Theory 24

3 Research Participants 52

4 Sources of Data for Each Research Question 53

5 General Outline of Case Study 66

6 Research Questions Linked to Data from Oakmont, Lakeside, and Beltway Case Studies 69

7 Research Questions Linked to Data from Bayview Case Study 70

8 Oakmont Students' Perceptions of Critical Thinking 95

9 Lakeview Earth and Space Science Students' Perceptions of Critical Thinking 145

10 Beltway Students' Perceptions of Critical Thinking 185

11 Case Study of Bayview Community College 211

12 Student Assessment in Bayview's Physical Science Course 231

Table		Page
13	Student Assessment in Bayview's Environmental Science Course	239
14	Bayview Students' Perceived Occurrences of Aspects of Critical Thinking	258
15	Bayview Students's Perceptions of Use of Core Critical Thinking Skills	260
16	Teaching Faculty Awareness Of and Attitudes Toward AAT Degree Requirements	268
17	Number and Percent of Student Participants According to College and Course	287
18	Number and Percent of Yes Responses to Critical Thinking Questions	289
19A	Most Commonly Mentioned Activities Associated with Perceived Gains in Critical Thinking	292
19B	Most Commonly Mentioned Activities Associated with Perceived Gains in Critical Thinking	300
20	Changes Made in Course Content and Pedagogy in Response to the AAT Degree	297

Chapter One: Introduction and Problem Statement

Education majors at Maryland community colleges have often faced difficulties in transferring to four-year colleges, frequently having to repeat courses, resulting in greater financial burdens and delayed graduation. For example, an elementary education major at Allegany College of Maryland (a typical, small community college) would have read page 71 of the 2001-2002 College Catalog and found the following daunting advice on preparation for transfer.

> This curriculum is specifically designed for students majoring in Elementary Education (grades 1-6 and middle school) and transferring to Frostburg State University. This curriculum has been designed in cooperation with officials at Frostburg State University to satisfy the freshman and sophomore year requirements of this major.
>
> Students interested in transferring to any other college or university (other than Frostburg) would be better served by the General Studies Curriculum or the University Studies Curriculum. Students majoring in secondary education would be better served by the Secondary Education Curriculum.
>
> Due to the nature and extent of the specific requirements for teacher certification at all four-year institutions, it is essential that every prospective teacher (elementary or secondary) work very closely with the academic advisor in planning the program in order to avoid errors in the course selection.
>
> Successful completion of this program qualifies a student to apply for an Associate in Science Degree in Education. (p. 71)

The student would also have been faced with a confusing array of required and elective courses, and six qualifying footnotes about what will or will not be accepted at Frostburg State University. When the number of colleges in Maryland is considered, each with its own special requirements, and the increasing mobility of modern college students is factored in, it is critical that the process of transfer from a two-year school to a four-year school in Maryland become a smoother transition.

In the fall of 1999, the Chief Academic Officers Intersegmental Group (CAO) appointed the Teacher Education Articulation Committee [TEAC], whose task was to establish a seamless transfer between two- and four-year public and private colleges in Maryland (TEAC, 2001). This committee decided to seek a totally new route to articulation. The committee rejected the idea of designating a set of courses to be taught by all community colleges and accepted by all four-year schools. Instead, the committee decided to follow the current conceptualization of teacher preparation (for all teaching candidates) by stating outcomes for elementary teacher candidates that define the requirements of a new degree, the Associates of Arts in Teaching. The chosen outcomes for the elementary teacher (and other teacher) candidates were based on the National Council for Accreditation of Teacher Education (NCATE) standards, since the Maryland four-year colleges follow NCATE guidelines (see Appendix A). NCATE is a coalition of many national organizations that have come together to improve the teaching and learning process in American schools (National Council for Accreditation of Teacher Education [NCATE], n.d.). TEAC (2001) then charged the individual schools to organize their own programs of study for elementary (as well as other) teacher candidates that would meet the designated outcomes. Both the Maryland State Department of

Education and the Maryland Higher Education Commission (in its *Redesign of Teacher Education,* 1995) now require complete program congruence with NCATE standards.

Although TEAC's original intention was to establish a seamless transfer between two- and four-year colleges in the area of teacher education, its work has evolved into a major paradigm shift in both curriculum content and pedagogy (including student assessment). Kuhn (1970) describes a paradigm shift as the changing of an accepted model of education practice in a fundamental way, with this change having an impact on the entire education program. The two-year college faculty who will be expected to teach courses taken by the elementary teacher candidates may now be facing the full brunt of this paradigm shift, and they may need to make many changes. To what extent the faculty embrace (and implement) these changes and how they organize the programs of study in relationship to this paradigm shift ultimately will determine the success or failure in terms of the Associates of Arts in Teaching degree meeting NCATE standards.

Science faculty at the two-year colleges are among those faculty who may be implementing courses for the AAT degree. They, too, may be faced with the double-edged paradigm shift of changes in curriculum content and changes in pedagogy, including student assessment. The State Board (n.d.) of Education stipulates that the elementary teacher candidate must have twelve credit hours of science in order to be certified to teach in Maryland (Code of Maryland Regulations 13A.12.02.04), so the science outcomes for NCATE somehow need to be met in these twelve science credits. Meeting the NCATE standards may involve either a change in content and/or pedagogy of existing courses, or the creation of new courses, as is being done at Allegany College of Maryland.

NCATE and other leading national scientific and educational organizations, such as the National Research Council (National Research Council, 2000) and the Fund for the Improvement of Postsecondary Education (FIPSE) (Laws & Hastings, 2002), stress the importance of using inquiry and constructivist based methods of teaching and learning (including multiple methods of student assessment) rather than the traditional, instructivist method of teaching and learning. There is a deep philosophical difference between instructivism, which uses traditional teaching methods, and constructivism, which includes inquiry-based learning (Brooks & Brooks, 1999). Each method has its own way of characterizing the students, the expected role of the instructor, and student assessment techniques. Table 1 clarifies the differences between traditional (instructivist) and constructivist classrooms.

Table 1
Fundamental Differences Between Traditional and Constructivist Classrooms

Traditional Classrooms	Constructivist Classrooms
Curriculum is presented part to whole, with emphasis on basic skills.	Curriculum is presented whole to part, with emphasis on big concepts.
Curricular activities rely heavily on textbooks and workbooks.	Curricular activities rely heavily on primary sources of data and manipulative materials.
Students are viewed as "blank slates" onto which information is etched by the teacher.	Students are viewed as thinkers with emerging theories about the world.
Teachers generally behave in a didactic manner, disseminating information to students.	Teachers generally behave in an interactive manner, mediating the environment for students.
Assessment of student learning is viewed as separate from teaching and occurs almost entirely through testing.	Assessment of student learning is interwoven with teaching and occurs through teacher observations of students at work and through student exhibitions and portfolios.

Excerpted from *The Case for Constructivist Classrooms* (p. 17), by J. G. Brooks and M. G. Brooks, 1999, Alexandria, VA: ASCD.

The inquiry-based approach to learning science parallels Carl Sagan's claim that "science is a way of thinking much more than it is a body of knowledge" (Sagan, 1979, p. 13) and is based on the idea that the learning of science should be done in the same manner that science is carried out (Siebert & McIntosh, 2001). Students should be challenged to answer scientific questions through a process of critical thinking and by using tenets of the scientific method. Many science classes at the college level are still being taught using instructivist (traditional) teaching methods (Laws & Hastings, 2002), and science faculty teaching courses that support the AAT degree may have to make a shift from using instructivist methods in their classrooms to using constructivist and inquiry-based methods.

Individually, either a change in content or in pedagogy may be difficult for science faculty to achieve, but making both changes concurrently could be a challenge for the science faculty at the two-year colleges. According to then president of Rice University, "Changing a curriculum has all the physical and psychological problems of moving a graveyard" (Schneider, 1999, p. 1). Researchers have shown that there are many factors that could affect how the science faculty at the two-year colleges make the necessary changes. Some of these factors include faculty attitudes toward change (Ancess, 2000), prior learning and teaching experiences (Haas & Keeley, 1998), learning and teaching philosophies (Schneider), and faculty development programs (Eldred & Fogarty, 1996).

Although the literature on curriculum change and causes of faculty resistance to change is extensive, there is a dearth of literature on the attitudes of the science faculty in Maryland community colleges who are, or who have been, involved in making the paradigm shift necessitated by the mandates of the AAT degree. Informal reports from the field have indicated that faculty (who are acting as change agents for their colleges) from different community colleges face different barriers to the implementation of the science courses associated with the AAT degree (Dr. Pat Basili, Director of Teacher Education at Prince Georges Community College, personal communication, October 23, 2002). In order for the faculty to successfully implement the changes needed to meet the mandates of the AAT degree, both the faculty and college administration need to be aware of the factors that affect the change process and the pitfalls that impede this process. Once the science faculty and college administration are cognizant of the factors and problems associated with implementing the science courses, they should be much better equipped to overcome any barriers to making this or future shifts in paradigms.

Purpose

This qualitative research project attempted to fill a void in the literature concerning the attitudes of science faculty at Maryland community colleges who are or have been involved in making the paradigm shift necessitated by the mandates of the AAT degree. The purpose of this study was two-fold. The first part of the study determined what changes science faculty had made, or were making, in (science) course content, pedagogy, and student assessment in order to satisfy the requirements of the new AAT degree offered by Maryland community colleges. The second part of the study demonstrated which factors had the most effect on the implementation of the changes necessary for the science courses associated with the AAT degree. Student perceptions of critical thinking were included in this section.

Research Questions

1. What are the science faculty's attitudes toward the science content and pedagogy requirements of the new AAT degree?

2. What changes (including the type and degree of the change) have faculty made in the course content and pedagogy in order to satisfy AAT degree requirements?

3. What changes have faculty made in student assessment techniques in order to satisfy AAT degree requirements?

4. What factors affect the science faculty's implementation of the changes necessary to comply with the AAT degree requirements?

5. From the perspective of the students, what course activities promote critical thinking?

Structure of Dissertation

This dissertation is divided into ten chapters. The first chapter is the introduction to the study, which includes the problem statement. This section justifies the importance of the study. The following literature review (Chapter 2) provides a synopsis of background information. A conceptual framework to guide the study is formulated from the literature review, and key terms and concepts are also defined. The research design is explained in the third chapter. The fourth chapter completely describes the research method, beginning with a review of how the research problem was identified and ending with how the recommendations were formulated. The next four chapters (Chapters 5 – 8) encompass the four case studies of this qualitative research project. The cross-case analysis, and conclusions drawn from this analysis, is described in Chapter 9. In the final chapter (Chapter 10), recommendations for practices and future research are presented.

Finally, the references are listed, along with appendixes that contain all appropriate research documents and relevant information.

Summary

What began as an attempt to make the transfer process for elementary education majors in Maryland two-year colleges a smoother transition ended in a major paradigm shift of curriculum in terms of both content and pedagogy (including student assessment). The new Associates of Arts in Teaching for elementary education majors, based on the National Council for Accreditation of Teacher Education (NCATE) standards, requires that elementary education majors learn science using constructivist-teaching methods. Many of Maryland's community college science faculty may be faced with making both a change in content and pedagogy in order to comply with the requirements set forth in the AAT degree. To what extent the science faculty embrace and implement necessary changes will ultimately determine the success or failure of the AAT degree in meeting the NCATE standards.

The research is designed to answer the following questions:

1. What are the science faculty's attitudes toward the science content and pedagogy requirements of the new AAT degree?
2. What changes (including the type and degree of the change) have faculty made in the course content and pedagogy in order to satisfy AAT degree requirements?
3. What changes have faculty made in student assessment techniques in order to satisfy AAT degree requirements?
4. What factors affect the science faculty's implementation of the changes necessary to comply with the AAT degree requirements?

5. From the perspective of the students, what course activities promote critical thinking?

The answers to these questions should be of interest to any professional educator who is involved in the planning of, or who is asked to make a major shift in any educational paradigm. Maryland's Higher Education Commission may be able to use this report in order to determine how they can help community colleges implement the requirements for both the elementary and secondary AAT degree options.

Chapter Two: Literature Review

Faculty at Maryland community colleges may need to make many changes in course content, pedagogy, and student assessment in order to meet the new Associate of Arts in Teaching (AAT) degree requirements. For many of the science faculty, these changes may require a shift from the instructivist to the constructivist teaching paradigm and a major rethinking of personal educational philosophies. This literature review begins by describing the three major influences (and factors within each influence) identified by Stark and Lattuca (1997) that may affect the science faculty involved in the planning and implementation of the science courses that support the AAT degree. The effect of faculty attitudes toward change is explored next. Following the effect of faculty attitudes toward change is a discussion on coping with change. This section includes an outline of Wagner's (2001) SURE Model and Schlossberg's Transition Theory (Schlossberg, Waters, & Goodman, 1995), along with a discussion of factors that may increase the science faculty's commitment to change. Finally, the role of the student in the change process is examined from two different perspectives. The first perspective is how the faculty view students and learning. The second perspective comes from the students' view of constructivist learning and critical thinking. This view is extensively reviewed in the context of Baxter Magolda's (2004) Epistemological Reflection Model and King and Kitchener's (1994) Reflective Judgment Model. A very brief summary of the literature follows. This summary includes a concept map showing key factors and how these factors may interrelate with each other. The definition of key terms as revealed in the literature concludes the literature review and its brief summary.

Factors Affecting Change

Stark and Lattuca (1997) describe three sets of influences on the college curriculum: external influences, internal influences, and organizational influences. These three sets of influences not only affect the curriculum but also the faculty involved in planning or changing the curriculum, as the science faculty at Maryland community colleges may be doing in response to the mandates of the AAT degree. External influences include (but are not limited to) society as a whole, the media, the economy, governmental organizations, disciplinary and professional associations, public and private funding agencies, and accrediting agencies (Stark & Lattuca, 1997). Internal influences include, but are not limited to, faculty backgrounds, educational beliefs, discipline of study, and student characteristics. Organizational influences are directly related to the infrastructure of the college, especially its mission and governance structure (Stark & Lattuca, 1997). The college administration and its support of faculty can be considered to be an organizational influence that may affect the science faculty's implementation of the AAT degree science courses. These three influences operate together and, in combination, affect the change process at both the institutional and individual faculty levels. The three sets of influences also overlap somewhat. For example, disciplinary organizations are listed as an external factor, yet the discipline itself is listed by Stark and Lattuca as an internal influence. The following sections of the literature review show specific examples of each of the influences listed by Stark and Lattuca that may be relevant to the science faculty at Maryland community colleges. Although student characteristics are part of the internal influences, they will be given a separate section of this literature review.

External Influences

There are three major external influences that have shaped the Associates of Arts in Teaching degree at Maryland community colleges: the National Council for Accreditation of Teacher Education (NCATE), the Maryland State Department of Education (MSDE), and the Maryland Higher Education Commission (MHEC). NCATE is a coalition of thirty-three professional associations of teachers, teacher educators, content specialists, and local and state policy makers; this coalition represents over three million people. This organization is dedicated to establishing and maintaining high quality teacher preparation programs across the nation and has been identified by the United States Department of Education and the Council for Higher Education Accreditation as being a professional accrediting body for teacher preparation (NCATE, n.d.). NCATE has defined a set of outcomes for elementary education majors that form the basis for the outcomes of the Associates of Arts in Teaching degree offered by Maryland community colleges (TEAC, 2001; see Appendix A). The Maryland State Department of Education sets the standards for the certification of public school teachers; these standards dictate that the elementary education major take 12 credit hours of science in order to be certified to teach in Maryland public elementary schools. Thus, the science faculty implementing the science courses for the AAT degree must somehow meet all of the science outcomes specified by NCATE within 12 credit hours, but how they do so is not specified by MSDE. MHEC, the Maryland Higher Education Commission, is the body that oversees all higher education in the state of Maryland and sets statewide policies. This Commission is responsible for approving the AAT degree proposals submitted by the individual community colleges in Maryland. Both MHEC and MSDE require complete program congruence with NCATE standards in teacher education programs in order for a school to offer the AAT degree.

There is one other external entity that may also influence some faculty who are involved with the AAT degree. This is the Maryland Articulation Partnership for Teachers (MAPT). This initiative, funded by the National Science Foundation, was designed to assist instructors in meeting pedagogy and content mandates of the AAT degree.

Internal Influences

Wagner (2001) believes that the training of most teachers in their undergraduate programs strengthens resistance to change; other studies have shown mixed results as to how the academic or professional background of faculty affects their ability to make changes in educational practices. Studies by Lattuca and Stark (1994) have shown that disciplinary beliefs and training affect the emphasis faculty give to pedagogy as well as content. Dressel and Marcus (1982) describe an academic discipline as a systematic way of organizing and studying phenomena. They conceptualize an academic discipline as being composed of five components: substantive, linguistic, syntactical, value, and conjunctive. The interaction of these components gives rise to a discipline's distinctive and unique character. Lattuca and Stark (1994) found strong correlations among faculty members' background and preparation, the ways they viewed their disciplines, and their educational beliefs about the purposes of college. These factors were found to be much more important to the faculty than factors such as the college mission or goals and student characteristics. Lenze (1995) found that much of the discipline-specific knowledge of teaching is implicit rather than explicit and that further research should be done in order to find what academics hold as the core concepts of teaching in their field. Knowing the core concepts, according to Lenze, is the first step to understanding the reasons for the teaching processes used by academics.

Disciplinary factors may be either a positive or a negative influence on science faculty faced with making shifts in paradigms. Stokstad (2001) indicates that physics faculty across the nation (led by a strong national organization and centers for research in education) are very active in making the transition from the traditional instrucitivist educational paradigm to the constructivist paradigm. According to Stokstad, the chemistry faculty are following the lead of the physicists, but the biology faculty seem in general to be having more difficulty in making this leap of pedagogy toward constructivism. The biology faculty face two major hurdles as they try to change content or pedagogy in their courses. The first problem is that the biology discipline lacks a strong national organization to champion and guide change (Stokstad, 2001). The physics faculty can look to the American Association of Physics Teachers (AAPT) for guidance and support (American Association of Physics Teachers [AAPT], n.d.). This is a very strong organization with a section devoted to research in physics education. The second issue faced by biologists (that physicists don't have to contend with as much) is the diverse nature of the discipline and the fact that it is not based on first principles (the fundamental laws of the universe) as is physics (Stokstad, 2001).

Although Stokstad's news article is relevant to this study since it deals with the benefits of constructivist learning and teaching methods, he may be criticized for making sweeping generalizations, especially with respect to biology faculty being reluctant to change to constructivist teaching and learning methods. There are several good models of constructivist-based learning in biology courses to be found in the literature. These models come from both the public school and university levels of education; examples are described in the following paragraphs.

Roger Bybee and his Biological Science Curriculum Study team (BSCS) have developed a general instructional model for constructivism called the Five E's (Miami Museum of Science, n.d.) that has been used in the public school setting but is also applicable to higher education. This is a five-step teaching and learning cycle that is initiated with a phase of engagement, where the students' attention is captured, their thinking is stimulated, and the instructor helps them to access prior knowledge (the First E). In this phase, the students have hands-on experiences with very little help from the instructor; students derive solutions themselves. The Second E, exploration, is where the students plan, investigate, collect, organize, and analyze information. In explanation, the Third E, the students formally and informally communicate results or answers to queries, and demonstrate understanding.

During the fourth phase, elaboration, students expand their understanding by applying knowledge to real world situations or to new situations. The Fifth E (which Bybee terms evaluation) is an assessment phase where both the students and the teacher take the opportunity to assess student learning. Ideally, the instructor may modify lesson plans if there is evidence of misconceptions or if the students show an interest in a particular aspect of the topic under study. This leads back into the engagement phase and the cycle starts over again (Miami Museum of Science, n.d.). The MAPT initiative is using the Five E's as its model of constructivist teaching and learning.

The biology department at Samford University elected to use problem-based learning (PBL) in its courses (Major, 2002). The problem-based courses in biotechnology, biochemistry, and introductory biology courses developed at the University of Delaware are very successful models of PBL. The faculty who created these courses benefited from a strong faculty training and development program supported by the National Science Foundation (NSF), the Fund for the Improvement of Postsecondary Education (FIPSE), and the University of Delaware's own Center for Teaching Effectiveness (Duch, Groh, & Allen, 2001).

A core of PBL faculty at the University of Delaware realized that many instructors were intimidated by active student-centered learning and were not sure of how to implement PBL in their courses. In order to give those faculty support and hands-on experiences with PBL and other active learning strategies, the core PBL faculty created an Institute for Transforming Undergraduate Education in 1997. This Institute was instrumental in getting faculty to incorporate problem-based learning in more than 150 courses campus wide, allowing over 4000 students to experience PBL within just three years of the Institute's existence (Duch, Groh, & Allen, 2001).

Just as with the faculty at the University of Delaware, knowledge or prior use of constructivist pedagogy should be an influential factor in how well the science faculty at Maryland community colleges adopt the inquiry-based pedagogy that is mandated for the AAT degree. Manouchehri and Goodman (1998) found that what public school math teachers knew about content and innovative pedagogical practices strongly affected how much they valued and implemented curricular change. Although most instructors are familiar with instructivist teaching methods, constructivism "baffles, scares, and even annoys a large portion of educators – it requires new behaviors for many teachers who learned science and how to teach it in conventional ways" (Loucks-Horsley, Harding, Arbuckle, Murray, Dubea, & Williams, 1987, p. 108).

College faculty may not receive much help from their textbooks when it comes to using constructivist methods or stimulating critical thinking. Haas and Keeley (1998) found that textbooks are organized to cover content rather than to stimulate critical thinking. Many science texts (especially the ones used in biology) encourage an encyclopedic, factual approach to course content. They typically include test banks of easily graded multiple choice and true-false questions. A constructivist or critical thinking emphasis demands a much greater creativity and variety in assessment procedures. Also, many teachers believe that students can internalize critical thinking by a process akin to osmosis. That is, by just being in the presence of critical thinking professors, a process of gradual assimilation will occur and the students will become critical thinkers without professors having to actively teach them critical thinking (Haas & Keeley, 1998).

There are also more personal reasons that make it difficult for some faculty to shift their classroom teaching emphasis from disseminating information to critical thinking and constructivist learning. For example, faculty who are good at dispensing information and who can entertain students typically receive good evaluations and direct praise from their students. Their peers also consider them to be effective and model teachers. For these faculty, retooling a course away from their strong points and toward unfamiliar territory introduces risks that may have negative impacts on evaluations and promotions (Haas & Keeley, 1998). These faculty may feel that they will be losing both personal and professional advantages. The literature shows overwhelming evidence that incentives such as financial benefits, increased resources (especially time), and career enhancement must be part of the change process as a way of increasing the sense of relative personal advantage to faculty (Jones, 2002; Major, 2002; Sunal et al., 2001).

Organizational Influences

In order to make the transition to the constructivist paradigm, the instructivist faculty must first embrace this unfamiliar and often distrusted vision of the teaching and learning process. Faculty who are asked to make major changes in their teaching paradigms and philosophies, such as the science faculty who undertake implementing the courses for the AAT degree, should find the change process smoother when they think that they are not solely responsible for all of the necessary changes. Change and growth can occur best if it occurs within a collegial atmosphere that is supportive (National Research Council, 1996). Change will not likely take place unless faculty members work with their colleagues, coming to a consensus about the change and how to negotiate the change process (Sunal et al., 2001). However, getting faculty to work with their colleagues from different disciplines in creating change may be a difficult task for administrators. Some faculty may be more concerned with turf and resource protection for their own specialization and use this as an excuse to limit cross- disciplinary dialogue and cooperation on curricular change (Stark & Lowther, 1998).

When the college administrators work with the faculty, and create individual incentives for change, it gives faculty a clear message that the administration embraces not only the change but also those faculty who are involved in the change process (Lanphear, 1999). Creating individual incentives for change may be somewhat difficult for administrators to do. What is an incentive to one faculty member may not be an incentive to another faculty member. For example, one faculty member may really appreciate a summer salary given while he is working on the desired curricular change while another faculty member might find that support from a new graduate or teaching assistant would be enough of an incentive to spark active participation in the change process (Jones, 2002). A faculty's incentive for change is not stagnant; the needs of the faculty generally will change as the individual progresses through the change process (Cavanaugh, 2001).

The timing of and degree of support that administrators provide to the science faculty may have a great effect on how they implement the changes needed for the AAT degree. In a study involving 30 institutions of higher education, Sunal et al (2001) found that 90% of the faculty studied indicated that collegial and administrative support was critical for successful change. These researchers also found that administrator presence in some aspect of the change process helped to generate greater change. But if too much support is given too early in the change process, the faculty may have the perception of the change initiating in the administration and that they have been given a top-down mandate. If the support comes too late, the faculty may have the perception that the support is too little and too late and that the administration really did not support the change (Cavanaugh, 2001). The administrative support also should be in tune with faculty sentiment on academic rigor and standards. According to Priscilla Laws, a noted innovator in physics education (Association of American Colleges and Universities, 1994),

> You're talking about the critical role of the administrator convincing faculty that excellence doesn't have to be compromised … We have to help faculty recognize that developing a project-centered course or a problem-oriented curriculum that pertains to social needs doesn't mean that learning is just reduced to playing with mud pies. Students can learn demanding concepts in exciting and relevant ways. There's a real fear in the nation's faculty about the potential erosion of standards. (What Is at Stage section, ¶ 6)

In order to help faculty see the benefits of and learn how to use problem-based learning or other constructivist learning techniques, the administration could employ one or more faculty development programs. Types of faculty development include, but are not limited to, workshops, written descriptions of effective practices, expert or peer consultation and mentoring, and involvement in funded course development initiatives (Sunal et al., 2001). The University of Delaware has had great success with a faculty development model that includes a summer training institute followed by numerous workshops throughout the year. Faculty mentoring is also important in this model. Interested faculty who created the institute received enough funding so that the institute became a long-term structure designed to promote faculty development in problem-based learning (Duch, Groh, & Allen, 2001). The success of this venture validates the findings of Sunal et al. (2001). This group of researchers found that effective change requires a long-term and systematic commitment to faculty development that is collaborative in nature (Sunal et al., 2001).

Even faculty who are fully committed to change and already embrace the constructivist-learning paradigm will need support from their administrations. Faculty have listed some specific obstacles associated with the use of active learning: limited class time, a possible increase in preparation time, the potential difficulty in using active learning in large classes, and a lack of needed materials, equipment, or resources (Bonwell & Eison, 1991). The college administration has control over several of these variables. The most precious commodity for many faculty is time. Faculty are increasingly asked to do more, resulting in even heavier workloads that are extremely time consuming. Very often, when the administration proposes a change in curriculum or pedagogy, the change effort put forth by the faculty is in addition to their workload. This often creates a situation where faculty feel that they are forced to decide whether they can afford, in terms of time, to adopt the change (Cavanaugh, 2001). For example, if the faculty feel that investing time in the change process may negatively impact promotion and tenure decisions, they will be less likely to participate in that process (Arnold & Civian, 1997).

Unfortunately, some administrators will be faced with faculty who may view learning as a student or elementary/secondary school problem. These faculty who believe that the problems of learning are someone else's, not theirs, have an enormous defense against rethinking their responsibilities toward students (Lazerson, Wagener, & Shumanis, 2000). Academic leaders need to provide learning opportunities that enable teachers to "construct" a new understanding of their students and of their craft of teaching. This will enable the faculty to "own" both the problem and the solution, and not be forced into mere compliance with change that they don't understand or agree with (Wagner, 2001).

Effect of Faculty Attitudes Toward Change

According to Wagner (2001), the temperament, working conditions, and training of most teachers predispose them to be hesitant to change. Change involves taking risks, and many educators have entered the teaching profession because of its high degree of order, security, and stability; they have a natural tendency to avoid risk. This same author notes that many educational "fads" have swept through the nation and reinforce the belief held by many faculty that all educational innovations are fleeting in nature and will not stand the test of time. Many tenets of the "learning" paradigm (which includes constructivism) have been advocated by reformers over the years. These tenets have been experimented with by some college faculty, but have not been widely adopted because they have only been applied piecemeal within the "instructivist" paradigm that distorts them or totally rejects them (Barr & Tagg, 1995; Ewell, 1997). Ewell also notes that curriculum changes have been attempted "without a deep understanding of what collegiate learning really means and the specific circumstances that are likely to promote it" (p. 3). This lack of understanding of how students learn may lead some faculty to distrust the constructivist paradigm. Academic professionals do not replace strongly held views and behavior patterns in response to the latest vogue. Instead, they respond slowly to opinions and sentiments held by respected colleagues or to real incentives that reward their serious efforts to explore new possibilities (Levitt, 2001).

Traditions are very hard to displace, and most faculty teach in the manner that they were taught (Hansen & Stephens, 2000). Many faculty members enjoy working alone and have a great sense of satisfaction and pride in teaching courses that they themselves have developed. When they are asked to make changes in content or pedagogy, their identity may be threatened and their enjoyment of teaching diminished, again contributing to a reluctance to change (Wagner, 2001). Changing traditional methods of teaching or usual science course content will not occur unless the science faculty experience dissatisfaction with their existing methods or content (Sunal et al., 2001). An important goal of successful faculty development programs is to create cognitive conflict with faculty members' conceptions of teaching, allowing them to experience dissatisfaction with the status quo, then providing the faculty a variety of experiences that make the wanted change in method or content seem necessary and plausible (Sunal et al, 2001). However, even when faculty embrace the need for change, they still must have the ability to cope with change in order for the wanted curricular change to be effective in the long run.

Coping with Change

Any major change involves the ability to learn and to cope with the change effectively. Wagner (2001) proposed four essential conditions for adult learning that he termed the SURE model:

- Shared vision of the goals of learning, good teaching, and assessment;
- Understanding of the urgent need for change;
- Relationships based on mutual respect and trust; and
- Engagement strategies that create commitment rather than mere compliance (Buy-in Versus Ownership section, ¶4).

The SURE model may be used to guide effective academic change. It can also be used as a standard to assess administrative support of the science faculty as they implement the courses for the AAT degree as well as a measure of the extent of faculty buy-in of the educational change. But in order for this model to be used effectively, the administration and faculty must understand factors that may affect the ability of individual science faculty to cope with change or a major transition. Just as incentives for curricular change vary from faculty to faculty, abilities to cope with change also vary. The transition theory proposed by Schlossberg and her associates (Schlossberg, Waters, & Goodman, 1995) may help administrators to understand factors that affect coping mechanisms of individual faculty members, and to link these factors with individualized incentives for curricular change.

According to Schlossberg and her associates (Schlossberg, Waters, & Goodman, 1995), there are four major sets of factors that influence a person's ability to cope with a change or transition: situation, self, support, and strategies, the "4 S's" (see Table 2). Each of these factors may be viewed as being an asset, a liability, or a combination of asset and liability.

Table 2
Overview of Schlossberg's Transition Theory

FACTOR	EXAMPLES OF ASSETS/LIABILITIES
Situation	Triggering event, timing of event, amount of control over the situation, previous experience with the situation, assessment of the situation
Self	Socioeconomic status, health, psychological resources, level of optimism, commitment, values
Support	Institutional, collegial, affirmation, honest feedback
Strategies	Modify situation, deny situation, control meaning of the situation, seek information, act directly, control stress

Source: Adapted from Schlossberg, Waters, & Goodman, 1995.

The individual science faculty's ability to make the changes necessary in order to comply with AAT requirements in part depends upon the components of the "4 S's" that can be considered as assets versus those that may be liabilities at the particular time of the transition or change. Schlossberg and her associates state that how the individual views the change and how the individual assesses his or her resources for coping with the change may fluctuate during the change process and will determine the extent or outcome of the change (Schlossberg, Waters, & Goodman, 1995). If the science faculty view the changes necessary for the AAT degree as being positive and if they have the necessary personal and institutional resources, their commitment to making a long-lasting change should increase.

The Role of the Student

The student should be the focal point of any academic change, and is certainly a factor that can affect the changes faculty make in two separate ways. How the faculty view the students and student learning affect how they plan courses for the AAT degree. Just as importantly, how the students view learning and teaching also affect the changes that faculty make in pedagogy and assessment. Both of these aspects of the students are considered to be an internal factor by Stark and Lattuca (1997).

How Faculty View Students and Student Learning

The teacher education degree has rarely been held in high regard (Murray, 2000) and this may color the attitude of science faculty toward the elementary teacher candidates in their courses. According to Haas and Keeley (1998), professors are not likely to change unless they are convinced that their efforts will pay off in major shifts in student learning. In a study involving medical school faculty, Lanphear (1999) found that some faculty react negatively to problem-based learning because they do not accept the premise that students can learn core concepts of their disciplines from case examples. Many basic science teachers also react negatively to proposals to institute other forms of small-group learning, since these approaches are foreign to their prior experience of medical education, even though these same faculty did most of their graduate work in seminar settings. The concerns of the medical school faculty about students not learning core information are shared by faculty in other academic settings.

Lanphear's suggestion (found in his study of medical school faculty) that the introduction and adoption of new teaching strategies, even though they may be radically different from past methods, must involve an effort by those making the change to focus on the similarities between the approaches being proposed and those already in use appears to be valid for the science faculty involved with the AAT degree. Many of the existing laboratory exercises in physics, chemistry, and biology could be converted into inquiry-based activities leading the student to a more active way of learning (personal knowledge). But, as mentioned before, a barrier for faculty using active learning techniques involves risks: risks that the students will not participate, use higher order thinking, or that the faculty will feel a loss of control and lack the necessary skills (Bonwell & Eison, 1991).

How Students View Teaching and Learning

Just as the faculty's attitudes toward teaching and student learning color their acceptance of the constructivist paradigm, so does the student's attitudes toward teaching and learning. The literature concerning student attitudes toward constructivist learning points in two directions, one positive and one negative. On the positive side, many studies have shown that students actually prefer strategies that promote active learning to the more traditional lectures (Bonwell & Eison, 1991).

On the negative side, Hansen and Stephens (2000) note that student expectations of the educational process, as they advance through elementary and secondary schools, may foster attitudes that are counterproductive and very hard to change. Too many students have been socialized in prior schooling to believe that they cannot learn course material unless it has been "pre-digested" by an instructor. The students rely on the instructor to tell them everything they need to know. They do not understand the need to be actively engaged in the learning process, or that this engagement requires their own critical thinking (Hansen & Stephens, 2000). Traditional student assessments based on judgmental feedback (for example, "This is correct but that is wrong.") cause students to continue or alter their thinking because of an external prompt. Student thinking is not affected by internal realization. This type of feedback tends to make students even more teacher-dependent (Brooks & Brooks, 1999). So in college, when the students are required to take the lead in constructivist learning situations, they may see the faculty as being unfair and expecting too much (Hansen & Stephens, 2000).

Since constructivist learning requires critical thinking on the part of the students, it is important to understand students' perceptions of critical thinking. This understanding may shed light on how students will react to constructivist learning situations. Also, one can gauge the effectiveness of constructivist teaching processes by measuring the outcomes of critical thinking. Critical thinking consists of two main components. According to Facione (1990), the first component includes the cognitive skills of interpretation, analysis, evaluation, inference, explanation, and self-regulation.

These skills are defined in the section on Key Terms. The second component is the disposition to use these cognitive skills. Dispositions are behavioral tendencies for students to use their cognitive skills (Jones, 1995). Perkins, Jay, and Tishman (1993) argue for a triadic dispositional theory to fully explain intellectual behavior. The three parts of this theory include ability, sensitivity, and inclination. All three of these aspects are inter-related and necessary for the critical thinking to occur. Jones (1995) has further broken down the triad into fourteen specific behavioral characteristics such as perseverance, flexibility, and honesty in facing prejudices.

The reluctance that some students show toward constructivist learning may also stem from their level of cognitive or psychosocial development. According to Baxter Magolda (1992) "Understanding college students' intellectual development is at the heart of effective educational practice" (p. 3). Baxter Magolda's Epistemological Reflection Model defines four stages of knowing: absolute knowing, transitional knowing, independent knowing, and contextual knowing. In absolute knowing, the first stage of knowing, knowledge is viewed as certain, and the students see their instructors as authorities who dispense knowledge. Students in the second stage of knowing (transitional knowing) begin to realize that not all knowledge is certain, and that authorities are not all knowing. Students in this stage expect teachers to help them understand and apply knowledge. In the third stage, termed independent knowing, knowledge is viewed as being uncertain. Students in this stage want instructors to provide appropriate contexts for their learning experiences. The final stage of this model, contextual knowing, holds that the legitimacy of knowledge claims are dependent upon their context. The learner requires supporting evidence in building an opinion or point of view. The instructor creates learning situations that support contextual applications of knowledge (Baxter Magolda, 2004; Evans, Forney, & Guido-DiBrito, 1998).

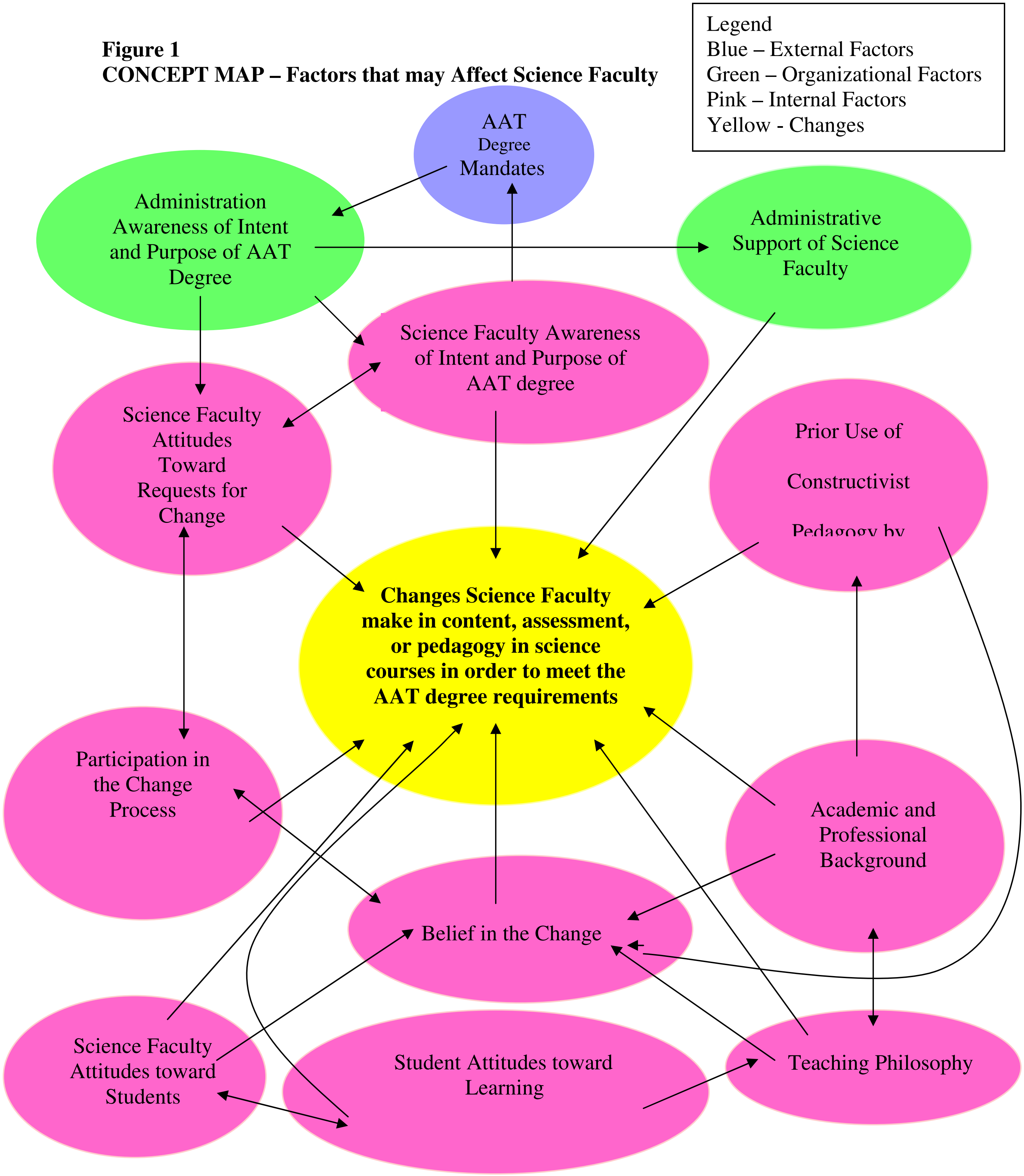
Baxter Magolda found that absolute knowing was most prevalent in the first year of college, and about half of all sophomores that were studied were transitional knowers (Evans, Forney, & Guido-DiBrito, 1998). These findings are important for community college science faculty who are designing problem-based learning or critical thinking activities for their predominantly freshman and sophomore students. Many PBL or constructivist learning activities are centered upon ill-structured problems that have a great deal of uncertainty in their structure and solutions. Students will need to use critical thinking as well as reflective thinking or judgment as they work toward solutions of these ill- structured problems (Evans, Forney, & Guido-DiBrito, 1998). King and Kitchener (1994) assert that reflective judgment is a neglected aspect of critical thinking and that it is important for teachers to help their students learn to make defensible judgments about ill-structured problems. How students understand knowing and how they justify their beliefs about ill-structured problems is a very important cognitive growth process described by King and Kitchener in their Reflective Judgment Model.

There are seven stages in the Reflective Judgment Model, with each stage representing a clear set of assumptions about knowledge and the process of acquiring knowledge. Each set of assumptions results in a characteristic strategy for solving ill-structured problems; students in the more advanced stages show increasing complexity and reflection in their solutions (King & Kitchener, 1994). The stages can be clustered into three categories: pre-reflective thinking (stages 1-3), quasi-reflective thinking (stages 4 and 5), and reflective thinking (stages 6 and 7). King and Kitchener found that reflective judgment increases over time, with freshmen predominantly demonstrating stages 3 and 4 reasoning, and college seniors showing a prevalence of stage 4 reasoning. In stage 3 reasoning, knowledge is certain, or only temporarily uncertain. Certain knowledge comes from authorities, and personal beliefs are legitimate when knowledge is temporarily uncertain. Stage 4 reasoners view knowledge to be uncertain; justification involves reasoning and evidence, but evidence may be arbitrarily selected (King & Kitchener, 1994). When Baxter Magolda's model is compared to that of King and Kitchener, it is clear to see that they reinforce each other and give credence to the effect of student characteristics on the science faculty as they plan the AAT courses.

Summary and Concept Map

This literature review describes the three main influences and factors within each main influence that may affect the science faculty involved in the planning and implementation of the science courses needed for the AAT degree. Some of the factors seem to overlap, and some factors seemed to have an influence on other factors. A concept map is used in order to summarize these factors and their interactions (see Figure 1). This map also provides a framework to the study. The map is color-coded: blue represents external influences, pink represents internal influences, green represents organizational influences, and yellow represents the changes that the science faculty make. Arrows are drawn to show how one factor may influence another factor. Each arrow points away from an influencing factor towards a factor that is being influenced.

Figure 1
CONCEPT MAP – Factors that may Affect Science Faculty



Key Terms

AAT DEGREE – Associate of Arts in Teaching degree – A new outcomes based degree that is designed to improve elementary teacher education and provide a seamless transfer between two and four-year schools in Maryland.

ASSESSMENT – The process of gathering and discussing information from multiple sources in order to develop a deep understanding of what students know, understand, and can do with their knowledge as a result of their educational experiences; the process culminates when assessment results are used to improve subsequent learning (Huba & Freed, 2000, p. 8).

ASSESSMENT FORMAT – The framework or type of assignment that is used to demonstrate student learning, such as multiple choice or other types of objective tests, laboratory reports, essays, word-problems, or other types of subjective tests.

ASSESSMENT MEASURES – The instruments or assignments formally or informally used to gauge student understanding.

AUTHENTIC STUDENT ASSESSMENT – Activities (such as projects, papers, portfolios) that are used to evaluate higher order thinking and require students to demonstrate abilities that are specifically desired by professors (Huba & Freed, 2000, p. 12)

CONSTRUCTIVISM (INTERPRETIVISM)– An interactive, social process of building personal meaning from the information available in a learning situation and then integrating that information with what is already known to create new knowledge. Knowledge resides in individuals; it is not an external quantity (Brooks & Brooks, 1999). Involves the Five E's: engagement (motivation of topic), exploration (activities that lead to discovery), explanation (concept invention, check of understanding), elaboration (further activities to show usefulness or applicability of learned concept), and evaluation (students and instructor both assess student learning) (Miami Museum of Science, n.d.).

COURSE ACTIVITIES – Events inside or outside of the classroom that are part of the learning-teaching process, such as: lectures, discussions, group problem solving, outside readings, oral presentations, etc.

CRITICAL THINKING – A set of skills and attitudes used to apply rational criteria in order to evaluate written or oral arguments (Browne & Freeman, 2000). The core skills ideally used in critical thinking include "analysis, evaluation, presentation of arguments, inference, interpretation, reflection, and the dispositions to use those skills (Jones, 1995). This list of core skills is similar to Facione's (1990) critical thinking skills of interpretation, analysis, evaluation, inference, explanation, and self-regulation.

Analysis Skills – Ability to identify the overt and implied features of a communication or argument (Facione, 1990).

Dispositions – Behavioral tendencies or traits of mind of students to use their cognitive skills (Jones, 1995).

Evaluation Skills – "The ability to assess the credibility of a communication and the strengths of claims and arguments" (Jones, 1995, p. 134).

Presentation of Arguments (explanation) – The ability to give a clear explanation and justification of one's reasoning (Jones, 1995).

Inference Skills – "The ability to reason from previous knowledge in order to form and use new knowledge (Facione, 1990).

Interpretation Skills – "Understanding and expressing the meaning and significance of a variety of communications" (Jones, 1995, p. 124).

Reflection (self-regulation) – "Monitor[ing] one's own comprehension and correct[ing] one's own process of thinking" (Jones, 1995, p. 148).

EDUCATIONAL BACKGROUND – The type of degrees earned from colleges or universities, including the content and pedagogy of science courses taken.

FACULTY ATTITUDES – The opinions or dispositions held by faculty that may influence the faculty's teaching or response to change in content or pedagogy, the faculty's participation in the change process, or the faculty's belief in the change.

FIVE E's – A general instructional model for constructivism that includes a five step learning cycle (Miami Museum of Science, n.d):

Engagement – Student's attention is captured, their thinking stimulated, and prior knowledge is accessed; students have hands-on experiences with little help from instructors and they derive their own solutions.

Exploration – Students plan, investigate, collect, organize, and analyze information.

Explanation – Students formally and informally communicate results or answers to queries and demonstrate understanding.

Elaboration – Students expand understanding by applying knowledge to real-world situations or new situations.

Evaluation – More properly termed assessment; the students and the instructor both take the opportunity to assess student learning.

INSTRUCTIVISM – A process of teaching or learning whereby the student is perceived as the receiver of information and knowledge is given to the student by the instructor.

INQUIRY – The abilities students should develop to be able to design and conduct scientific investigations and to the understandings they should gain about the nature of scientific inquiry (National Research Council, 2000).

INQUIRY BASED PEDAGOGY – The teaching and learning strategies that enable scientific concepts to be mastered through investigations (National Research Council, 2000), such as problem-based learning. In this paradigm, students are challenged to answer scientific questions through a process of critical thinking and by using tenets of the scientific method.

NCATE – National Council for the Accreditation of Teacher Education – A coalition of over 30 national organizations committed to high quality education. NCATE's constituency includes over 30 million individuals (NCATE, n.d.).

NCATE STANDARD FOR SCIENCE – Candidates know, understand, and use the fundamental concepts in the subject matter of science – including physical, life, and earth and space sciences as well as concepts in science and technology, science in personal and social perspectives, the history and nature of science, the unifying concepts of science, and the inquiry processes scientists use in discovery of new knowledge to build a base for scientific literacy (TEAC, 2001).

OBJECTIVES – The targeted learning goals for students that are defined by the instructor and often stated in the course syllabus or other documents.

OUTCOMES (LEARNING OUTCOMES) – High quality, culminating demonstrations of significant learning in context, or the end products of a clearly defined process that students carry out (Spady, 1994).

PARADIGM SHIFT – An accepted model of educational practice is changed in a fundamental way, having an impact on the entire educational program (Kuhn, 1970).

PROBLEM-BASED LEARNING – A teaching – learning approach where "complex, real-world problems are used to motivate students to identify and research the concepts and principles they need to know to work through those problems. Students work together in small learning teams, bringing together collective skill at acquiring, communicating, and integrating information" (Duch, Groh, & Allen, 2001, p. 6).

PROFESSIONAL BACKGROUND – The number of years of teaching experience, types and amount of faculty development opportunities taken, and the professional or disciplinary organizations the faculty belongs to.

TEAC – Teacher Education Articulation Committee- a committee formed by the chief academic officers of Maryland institutions of higher education. This committee was responsible for the creation of the Associate of Arts in Teaching degree that will be offered by Maryland community colleges.

TEACHING PHILOSOPHY – A set of general beliefs and guiding principles that have developed during a faculty's career of learning and teaching. These beliefs and principles are manifested in how the faculty views teaching and learning, whether from an instructivist or a constructivist point of view.

Chapter Three: Research Design

The research design provides the logic that connects the data to be collected and the conclusions to be drawn to the initial questions of the study (Yin, 1984). It delineates how the researcher will go about finding the answers to the research questions. Yin further states that the research design defines the domain of generalizability of the study. According to Creswell (2003), there are three fundamental questions that the researcher must address when designing a study:

1. What knowledge claims are being made by the researcher (including a theoretical perspective)?
2. What strategies of inquiry will inform the procedures?
3. What methods of data collection and analysis will be used? (p. 5)

Two other fundamental concerns must also be addressed by the researcher: limitations to the study, and personal bias and subjectivity. This chapter of the dissertation covers the first two questions, limitations, and admissions of bias and subjectivity. In the next chapter (Chapter Four: Research Methods) the entire research process is delineated. This delineation includes answers to the third question.

Knowledge Claims

Knowledge claims inform the audience what assumptions the researcher makes about how he or she will learn and what will be learned in the course of the research study. Creswell (2003) discusses four schools of thought about knowledge claims: postpositivism, constructivism, advocacy/participatory, and pragmatism. I believe in and based my research procedures on the constructivist school of thought. My belief in constructivism stems from what fascinates me about people and my experiences as a learner, in both academic and non-academic settings. For example, reading the statistics on old tombstones - when someone was born, how many children she had, and when she died, is not enough for me. I want to know what this person did when she was alive and how she was affected by society and current events. I want to “construct” her life’s history from her point of view by studying any artifacts that are available. Similarly, I also want to learn about the personal stories of my research participants; to listen to their first-hand stories excites me. As far as my experiences as a learner, I now realize that I learn best when I am able to start the learning process utilizing my existing knowledge base. By altering and expanding this base, I can create my own new knowledge. This, as well as the previous example, exhibits the main themes of constructivism. Constructivism, in the form of inquiry-based learning, is one of the tenets of the AAT degree.

Constructivists maintain that learning, or creating knowledge, is an interactive, social process of building personal meaning from the information available in a learning situation and then integrating that information with what is already known to create new knowledge (Brooks & Brooks, 1999). Constructivism has deep roots in the philosophical discourse on knowledge. Polanyi (1958) identifies two types of knowledge. The first type is called propositional knowledge. This knowledge is composed of all statements that can be shared among people; most of these statements are about observations of objects and events. The second type of knowledge is referred to as tacit knowledge. Tacit knowledge is also based on events and objects, but it is knowledge that is gained from experience with these events and objects. Tacit knowledge is all that is remembered, excluding the words and symbols used to express this knowledge. It includes non-verbal associations that foster new meanings, new ideas, and new applications of old ideas (Stake, 1978). Perhaps the best way to contrast these two forms of knowledge is summed up in a statement by Stake: "Explanation belongs more to propositional knowledge, understanding more to tacit" (p. 6). Polanyi believed that each person, regardless of level of expertise, has a tremendous amount of tacit knowledge with which to build new understandings. This tacit knowledge is foundational for constructivism. Knowledge, both propositional and tacit, resides in individuals; it is not an external entity. People develop highly subjective, varied, and multiple meanings directed toward objects or things. These meanings are most often formed through interactions with others, within a context that is heavily normalized by cultural and historical influences (Creswell, 2003). In summary, according to the constructivist paradigm, knowledge and understanding are attained through personal experience.

Strategy of Inquiry

The strategy of inquiry provides the framework and directions for the research design and its implementation (Creswell, 2003). There were three main decisions to make when choosing a strategy of inquiry. First, I chose a strategy with underlying knowledge claims that are consistent with knowledge claims that I believe in. Second, I selected a strategy that enabled me to address the research questions as fully as possible. Third, I matched the strategy of inquiry to the audience for whom the research report was written. The strategy of inquiry that best fulfilled these three criteria for the current study was the qualitative, multiple case study. The following sections explore qualitative research and case study.

Qualitative Research

Qualitative or interpretive inquiry is founded in the social science theories of Weber and Dilthey (Soltis, 1984). Stake (1978) interpreted Dilthey's theory to imply that methods of studying humans should be guided by the natural powers of people to experience and understand. This constructivist statement gives direction to qualitative or interpretive research. Creswell (1998) defines qualitative research as a process of understanding social or human concerns. According to Crowson (1993), the main objective of qualitative research is to understand rather than to explain. Qualitative researchers claim that the traditional, statistical-based (quantitative) research leaves out much of what is human and important to understanding and building knowledge (Soltis, 1984). In this particular study, I am very interested in "what is human." I want to understand and share the experiences, perceptions, feelings, and opinions of my research participants.

Merriam (1988) states that interpretive inquiry should build understanding inductively, not deductively. Patterns or themes emerge from the data instead of being proposed before data collection and analysis (Patton, 1990). Therefore, in qualitative research, the researcher generally makes knowledge claims based on the constructivist paradigm in the search for a deeper understanding of the phenomenon being studied (Creswell, 2003). Since I was, and still am, a proponent of the constructivist paradigm, my beliefs were compatible with the qualitative research paradigm. I am confident that this was the best way to approach my study.

Case Study

Case study has been considered either to be an object of study (Stake, 1995) or a methodology (Merriam, 1988). Creswell (1998) defines a case study to be “an exploration of a ‘bounded system’ or a case (or multiple cases) over time through a detailed, in-depth data collection involving multiple sources of information rich in context” (p. 61). A community college undergoing a change process certainly falls into the category of bounded systems, both in terms of time and location. I chose to do multiple case studies instead of using another strategy for several reasons. Multiple cases provide a broader description of changes made in science courses in response to the AAT degree.

Case studies give the researcher the ability to deal with a full variety of evidence from multiple sources such as interviews, observations, artifacts, and documents (Yin, 1984). Comparing and contrasting data taken from several types of sources adds to the richness and depth of the understanding of the case. Incorporation of multiple types of data sources is a form of triangulation. Triangulation is done in order to increase the confidence in research findings (Denzin, 1970).

Case studies also allow the investigator to study meaningful characteristics of real life events. According to Yin (1984), the case study is preferred in examining contemporary events when the relevant behaviors of the events cannot be controlled or manipulated by the researcher. The change process that the selected science faculty at Maryland community colleges were attempting was certainly a contemporary event over which I had no control. I could not manipulate any of the variables involved in the study, nor did I want to.

Audience

My final reason for using case study harkens back to my anticipated audience and the knowledge base of constructivism. The people most likely to read this study are involved in education in some way or another and are familiar with verbal and qualitative descriptions of educational events. Educators have a great deal of tacit knowledge about their vocations. A case study "builds on the reader's tacit knowledge by presenting holistic and lifelike descriptions that allow the reader to experience the context vicariously" (Erlandson, Harris, Skipper, & Allen, 1993, p. 164). Stake (1978) also claimed that case study "will often be the preferred method of research because they (sic) may be epistemologically in harmony with the reader's experience and thus to that person a natural basis for generalization" (p. 5). The combination of building on the reader's tacit knowledge and harmonizing with the reader's experiences may partly explain Lincoln & Guba's (1985) claim that the case study elevates the reader's understanding of the main focus of the study.

Limitations to the Study

Although the qualitative, multiple case studies are consistent with my personal knowledge claims and address the research questions well, there were two types of limitations: the inherent limitations of the case study method and my own personal constraints I brought to the study.

There are some prejudices against the qualitative case study strategy including lack of rigor, confusion with case study used in teaching, and a lack of basis for scientific generalization (Yin, 1984). The first two of these prejudices can be overcome by careful research design and research conclusions that are well grounded in the data. But the lack of generalization can be more problematic. After reflecting on the literature I have read concerning qualitative research, I note both a perceived and fundamental problem with scientific generalization. The perceived problem deals with those who claim that one cannot make valid generalizations based on a single case study. Yin (1994) defends the use of qualitative, single case study and its limited generalizability by reminding us that generalizations also cannot be based on a single quantitative experiment either. Yin (1994) further states that case studies are meant to be generalizable to theoretical propositions, not to populations or universes.

The fundamental problem with scientific generalization lies in the legitimacy of knowledge. Many "traditional" researchers do not consider qualitative case study to be a legitimate or respectable scientific form of research. This lack of respect stems from the propositional versus tacit knowledge debate, the debate that spawned constructivism. Lincoln and Guba (1985) contend that there is no ultimate benchmark of truth in qualitative research. There are no statistically significant (or non-significant) relationships among discrete variables to be found in qualitative research. Lincoln and Guba continue their argument by stating that the naturalistic or qualitative research is a new paradigm, not a modification of traditional, statistically based research, and should not be judged by criteria used to judge traditional research. The best way to determine the legitimacy of the qualitative case study is to follow Garman's (1994, p. 9) advice: Consider the "unique intent the author seeks to achieve, the worthiness of the effort and the extent to which he/she accomplishes the challenge."

There were a few other restraints inherent in this study. First of all, I was constrained by the number of science faculty in Maryland community colleges that had made documented changes in science courses in order to accommodate the AAT degree mandate. Time constraints forced me to carefully choose only a small subset of the possible community colleges to include in my study. In some cases, I was not able to get all of the data that I had intended to get, although this did not become a major problem. During the course of my data analysis, I realized that I should have tried to interview more biology instructors who were not involved with the AAT degree. Lastly, case studies are difficult to do (Yin, 1984) and I was unsure of my ability to do a good case study. In order to minimize the limitations to the study, I searched the literature and found a few well-known case studies that I used as guides. I also conducted a thorough pilot study in order to test my instruments, gain familiarity with case study techniques, and to bolster my confidence.

Bias and Subjectivity

According to Toma (2000), qualitative researchers can view their subject of interest from two different points of view. One view holds that the researcher should conscientiously avoid personal involvement that might bias the study. I could not honestly do this, nor did I want to. My personal history did not allow this avoidance. I have been involved with education all of my life. I am an associate professor at Allegany College of Maryland and have been teaching there almost 20 years. I teach physics, physical science, and upon occasion, introductory biology and microbiology labs. I earned a Bachelor of Science degree in animal science from West Virginia University, a Master of Science in physical science from Marshall University, and am currently working on a doctoral degree in educational leadership at West Virginia University.

The second point of view discussed by Toma (2000) allows researchers to accept involvement and bias as part of the research process. Guba and Lincoln (1994) claim that there is a link between the subject and the researcher, and the researcher's values "inevitably influencing the inquiry" (p. 110). I have a very strong personal interest that links me to my research subject. Being an educator, I am naturally concerned with whatever may affect the teaching/learning process. I was, and still am, involved in the planning and teaching of a science course created for the AAT degree, so I too have experienced the same paradigm shift that my research participants might have been going through.

Even though I am closely linked to my research topic, I still had to be accountable for my bias. Since I, as the researcher, was the research instrument in my qualitative case study, I had to understand my personal biases and subjectivity, and how they skewed my research questions, data collection, and interpretation of the data. Even though pedagogy and content were equally stressed in my research questions, I did concentrate more on pedagogy because I am more interested in it than I am in content, and content did not seem to be much of an issue for my participants. I am very biased toward the new AAT degree, and I think that this degree program has the potential to improve the education of elementary education majors.

Subjectivity is an inherent quality of the investigator that affects the results of investigation. According to Peshkin (1988), one's subjectivity is active during the whole research process and needs to be carefully monitored by the researcher. The subjectivity that I became very aware of during the research process was a disdain for traditional or instructivist teaching methods employed by some of my participants. This puzzled me. I have no problem with my own instructivist teaching methods that I use in my traditional algebra- and calculus-based physics courses. Once I became aware of this subjectivity, I reassessed how I viewed some of my data. I was determined for this report to truly represent the opinions and feelings of my research participants and that my findings were well grounded in the data.

Chapter Four: Research Method

This chapter outlines the research method and gives details of my research study. This outline is not absolutely chronological because several steps of the research process were done simultaneously. The answer to Creswell's (2003) third fundamental question (see p. 37) on methods of data collection and analysis is answered in this chapter. In this chapter, site selection, site contact and approval, sampling procedures, sources and collection of data, assurances of trustworthy data, and data analysis are discussed. The chapter concludes with a summary and research timeframe.

Site Selection

This research study focused on faculty and students from four community colleges in Maryland. I initiated the site selection process by delineating several criteria that a community college had to meet in order to be included in this study. Obviously, the schools had to have offered an Associates of Arts in Teaching degree at the time of my site visit, as indicated in their college catalogs and then verified through personal contacts by phone calls and emails. Each participating school must have had at least one science course that supported the AAT degree being taught during the data collection period. The science courses could have been either existing courses that had undergone some revisions or new courses that had been designed to meet AAT degree mandates. I felt it was also important to choose a group of schools that represented varying levels of maturity of the AAT degree program. This would give me an opportunity to look at schools that were just beginning to develop or change courses in support of the AAT degree versus schools that were satisfied that all of the AAT degree requirements were being fully met by their science courses.

I originally proposed a sample of four schools to be studied. My first four choices were Bayview Community College, Beltway Community College, Lakeside Community College, and Oakmont Community College (fictitious names). The site selection process and reasons for choosing these four schools are described in more detail in the following paragraphs.

I was a participant in the Maryland Articulation Partnership for Teachers (MAPT) grant before my research proposal was complete. The purpose of this grant was to facilitate the adoption and implementation of the science and math requirements of the AAT degree. Faculty from ten community colleges participated in this grant. The principal investigator of the MAPT grant also served as the director of teacher education at Beltway Community College. Since this person was very knowledgeable about the AAT degree and the ten MAPT participating schools, I asked her which schools she recommended including in my study. She suggested a few specific community colleges because these schools had implemented science courses that supported the AAT degree (personal conversation held during a Fall 2002 MAPT meeting). A search through college catalogs verified that these schools were offering the AAT degree. After contacting personnel at these schools and learning about self-reported levels of AAT degree program maturity, I selected three of these community colleges: Beltway, Lakeside, and Oakmont. Oakmont had just started offering the AAT degree and reported that they had not fully developed science courses in support of the degree. The physical science instructor at Lakeside Community College indicated that they had not finished all of the changes they were going to make in science courses but had made significant progress, and the director of teacher education at Beltway indicated that this school had completed most of the changes they thought necessary to be in compliance with AAT degree mandates. So these three schools did offer the desired variety in the maturity levels of the AAT degree programs.

In reviewing documents pertaining to the AAT degree, I learned that the chair of the physics department at Bayview Community College participated in a National Science Foundation funded initiative called the Maryland Collaborative for Teacher Preparation (MCPT) that began in 1993. The goal of MCPT was "to design, develop, implement, and evaluate innovative interdisciplinary programs to prepare teachers who can provide exemplary mathematics and science instruction in elementary and middle schools" (Denniston, 2002, p. 5). The MCPT was the initial seed from which the AAT degree eventually developed. Since Bayview's physics department, under the leadership of its chair, was involved in the change to constructivist teaching methods for several years, the physical science course that supported the AAT degree was mature at the time of my site visit. Because the change process that was undertaken by the science faculty at Bayview Community College was thought to be similar to the process that science faculty at other schools may have been undergoing, I felt that it was important to include this school.

Once I decided on these four schools, and with the approval of my doctoral committee, I began the site approval process (described in the next section). I was able to obtain permission to conduct research at the originally proposed sites quickly and the site approval process took much less time than I had allotted. Since I was able to gain approval at the first four chosen sites, there was no need to look for more research sites.

In summary, it appeared that the four schools I proposed to include in this study were in various stages of curriculum development with respect to the science courses supporting the AAT degree. This variety of curriculum maturity and completeness of the change process was meant to add depth to this study, giving me the opportunity to compare and contrast the change processes of the four schools. This increased the trustworthiness of the data and the transferability of the results of this study to studies of other change processes.

Site Contact and Approval

Upon approval from my doctoral committee, formal letters seeking permission to conduct my study were sent to individuals at each of the community colleges involved in this study. A letter was sent to the head of the science department or dean (vice president) of academic affairs that briefly stated the purpose of my study. In this letter, I sought permission to do the study and assured complete anonymity for the school and the participants (see Appendix B). The letter included a copy of the student questionnaire so the school official knew exactly how the students were to be involved in this study. I included a template letter of approval that the school official could use in order to reply to my request (see Appendix C) and a self-addressed/stamped envelope. I received letters of approval from my four chosen sites. Only one college, Beltway Community College, required approval from an institutional review board. This board stipulated that students who participated in the research had to be at least 18 years of age and fill out a consent form before they completed the student questionnaire. I submitted copies of the consent forms to the board and kept copies for my own records.

I also sent a letter to each interview participant, formally requesting his or her participation in this study. This letter included the purpose of my study and outlined the types of activities the participants would be engaged in. Selected faculty (directors of teacher education, department or division directors, and teaching faculty) each received an appropriate letter (see Appendixes D and E respectively, for invitation letters sent to the director of teacher education/division chair and to the science faculty), including a response template and self-addressed/stamped envelope. The letter sent to the science faculty also included a request for permission to observe classes and survey students during class time.

Sampling Procedures

The participants and documents in this study were purposefully selected (Patton, 1990) in order to obtain rich data. All participation in this study was voluntary and participants remain anonymous. The faculty participants included teacher education directors, science faculty, and chairs of relevant science departments who participated in the planning and/or teaching of science courses that supported the AAT degree. The participating students were enrolled in the classes that I observed. The selected documents were obtained from the faculty participants and the formal documents pertaining to the AAT degree.

I interviewed 19 faculty and administered 149 student questionnaires at the four community colleges (see Table 3). The purposively selected sample of faculty was

Table 3
Research Participants

	Oakmont	Lakeside	Beltway	Bayview	Total
Dir. of Teacher Ed./Div. Chairs	1	1	1	3	6
Teaching Faculty	3	3	2	5	13
Students	36 *(24)	15 (10)	24 (16)	74 (50)	149

* number in parenthesis = percent of total students

chosen because my prior knowledge of the faculty led me to believe that they would be able to supply the data that would help answer my research questions (Fraenkel & Wallen, 2000). Directors of teacher education and/or department chairs from each school were interviewed since they were likely to have an awareness of the change process necessitated by the AAT degree requirements, and may have participated in the planning or teaching of the science courses. The chosen teaching faculty must have been directly involved in the planning and/or teaching of the AAT science courses, or have been teaching science courses that AAT degree students could have been taking in fulfillment of the AAT degree requirements. The student questionnaires were given to a selected group of students, the students who were in the classes that I observed.

Sources and Collection of Data

After I formulated the research questions and chose my research strategy, I had to determine what types of data were necessary in order to answer these questions. My research questions are as follows:

1. What are the science faculty's attitudes toward the science content and pedagogy requirements of the new AAT degree?

2. What changes (including the type and degree of the change) have faculty made in the course content and pedagogy in order to satisfy AAT degree requirements?

3. What changes have faculty made in student assessment techniques in order to satisfy AAT degree requirements?

4. What factors affect the science faculty's implementation of the changes necessary to comply with the AAT degree requirements?

5. From the perspective of the students, what course activities promote critical thinking?

Since my research questions were diverse, I needed several types of data in order to answer them and to provide triangulation. I selected personal interviews, document review, campus and classroom observations, and student questionnaires. This combination of data sources enabled me to provide a thick, rich description of each case and allowed me to study the case from several vantage points, thereby increasing the trustworthiness of the data and the conclusions that were drawn from the data. Each research question had at least two sources of data (see Table 4; see Research Questions and Concept Map with Links to Sources of Data in Appendix F for more detailed information). A justification and description of each type of data, and how it was collected, is given its own treatment.

Table 4
Sources of Data for Each Research Question

	Personal Interviews	Document Review	Campus/Class Observation	Student Questionnaire
Question #1	X	X	X	
Question #2	X	X	X	
Question #3	X	X	X	
Question #4	X		X	X
Question #5			X	X

Personal Interviews

According to Patton (1990), the purpose of an interview is to find out about things that cannot be directly observed, such as feelings, thoughts, and the meanings people give to events. I wanted to learn the stories of my research participants, what affected them, what their opinions were, and what was important to them. I decided that the individual, semi-structured, in-depth interview would be the best method to obtain information from my participants. The semi-structured interview is guided by a set of basic questions that shed light on the topics to be explored. The exact wording and sequence of questions are not predetermined (Merriam, 1988) but can vary depending on the flow of the interview. But, in order to help me with the interview process and to provide continuity from interview to interview, I employed two different interview protocols that provided the basic frameworks for the interviews. One interview protocol was geared toward the director of teacher education and chairs of the science departments (see Appendix G). The other interview protocol was designed for the teaching faculty (see Appendix H). These protocols had a list of specified questions that I intended to ask of the participants, but I allowed for the possibility of deleting questions if they were irrelevant to a participant. I also allowed the interview to be open enough so that I could include follow-up probes to gather data on unexpected leads (Glesne, 1999). All interview questions were designed to reflect the research questions and purpose of the study (Erlandson, Harris, Skipper, & Allen, 1993).

Each research participant was allowed to choose the time and setting for the interview. The length of the interviews ranged from about 20 minutes to over an hour. These interviews were audio taped (with the participant's verbal approval) so I did not have to take extensive notes during the interview and I could concentrate on the participant's body language and on what the participant was saying. All of the participants appeared to be comfortable and interested in answering the questions I posed. One participant was so eager for an opportunity to "vent" that he asked me to turn the tape recorder off for a while. I transcribed each interview, keeping the audiotapes, computer files, and paper copies, in order to facilitate the data analysis and provide an audit trail.

Document Review

Documents provide an unobtrusive way to obtain background and other relevant information; data from documents can also be used in the same manner as data from observations and interviews (Glesne, 1999; Merriam, 1988). I obtained documents that pertained to the AAT degree from the director of teacher education at Allegany College of Maryland. These documents gave me the history and the specific requirements of the AAT degree. I perused college catalogs and college literature, such as brochures, newspapers, and general handouts. I asked each faculty member that I interviewed to give me copies of course syllabi and other relevant documents such as exams and assignments. I would have preferred both pre- and post-AAT degree documents to determine if there had been any change in content, pedagogy, and student assessment, but these were not always available.

Information gleaned from documents that I received from the faculty was recorded and categorized in two different document analysis protocols (the syllabus analysis protocol and the non-syllabus document analysis protocol, see Appendixes I and J, respectively) for later analysis. This analysis centered on the use of constructivist teaching and learning techniques, emphasis on specific core critical thinking skills, and the instructor's belief in and use of instructivist or constructivist teaching philosophies.

Campus and Classroom Observation

Marshall and Rossman (1995) define observation as "the systematic noting and recording of events, behaviors, and artifacts in the social setting chosen for study" (p. 78). I spent three or four days at each research site collecting observational data. My observations began as I pulled into the parking lots of my research sites. I was interested in the overall layout of the campuses and the appearance of the buildings. I observed artifacts within the buildings, such as posters on the wall, laboratory equipment, and the layout of classrooms, in order to gain a sense of the culture of the research site. But my main focus of observation was the teaching and learning activities that occurred in the classrooms and laboratories. I wanted to learn about the types of pedagogy and teaching styles that were employed by the instructors and how the instructors interacted with their students. I also observed the students with respect to their levels of involvement in the learning process and other behaviors that gave me insight into how they perceived their learning activities.

My general campus and artifact observations were unstructured, often done when I was waiting for interviews or lunching in the cafeteria. Data recorded from my unstructured observations were recorded on legal pads. My classroom observations, however, were structured by the use of a classroom observation protocol, loosely based on Dr. Pat Basili's protocol found in her PROJECT OBSURVER. Dr. Basili had graciously given me permission to modify her observation protocol (see Appendix K for permission from Dr. Basili, and Appendix L for my classroom observation protocol). Dr.

Basili's protocol has been used numerous times, validated, and shown to be reliable. The data collected from the classroom observations were recorded and categorized for later analysis.

Student Questionnaire

According to Fraenkel and Wallen (2000), questionnaires are advantageous when the researcher needs to gather data from a large group of people in a short amount of time. My time at the research sites was limited and I felt that having students respond in writing would yield more useable data than what I could gather from personal interviews. The students needed time to reflect on their learning experiences. A written questionnaire that had no time constraints allowed the students to reflect at their own pace, without having to worry about the researcher getting impatient. The written questionnaire given in a group setting also afforded the students a better sense of anonymity than an interview would.

I chose to pattern my questionnaire (see Appendix M) after an existing one instead using an untested original instrument. The student questionnaire I used as a model is based on Dr. George Perry's (2004) *Web Site Analysis for Critical Thinking Development,* found in his doctoral dissertation (see Appendix N for permission from Dr. Perry). I used Dr. Perry's instrument to counter the disadvantage of questionnaires having unclear or ambiguous questions (Fraenkel & Wallen, 2000). Since his instrument had already been field tested, I was relatively sure that questions that I derived from it would not be ambiguous or hard for the student to understand.

The questionnaire was usually administered near the end of the observation period. The students were given ample time to complete the questionnaire and answer the open-ended questions. The only student reticence that I encountered when I surveyed the students was at Beltway Community College, where the students had to fill out a consent form that included a personal identification. But after I assured these students that their responses were absolutely anonymous, could not be connected to the consent form, and that their instructor would not see individual questionnaires, the students did agree to participate.

Assurances of Trustworthy Data

Trustworthy data is necessary for the final product of the research to be a true representation or analysis of what is being studied. Trusted representations or analyses can be used to "confirm, expand, and inform the works of others" (Glesne, 1999, p. 32). There are several methods I used to ensure that my data is trustworthy: verification that the research instruments were sensitive enough to gather the data I needed in order to fully answer the research questions, pilot studies with instrument tests, documentation (setting up an audit trail), member-checking and peer review, and triangulation.

Pilot Study

A pilot study was conducted during the Fall 2003 semester at Allegany College of Maryland, where I serve as a faculty member. I chose my home school because I was assured of full cooperation from the faculty and the vice president of instructional affairs. I interviewed six faculty members and eleven students responded to the questionnaire. This pilot study had all of the aspects of the real study, but was not a "dress rehearsal" for collecting data. My intentions for the pilot study were to learn about the research process, fine-tune research instruments, and to understand participant reactions (Glesne, 1999). Each aspect of the pilot study (letters, interviews and interview protocols, document review protocols, classroom observation protocol, and the student questionnaire) is explained in the paragraphs below. Any substantial changes to letters or research instruments are detailed in the appendixes.

Letters. Letters were sent to the vice president of instructional affairs, four science faculty, a former director of teacher education, and the current director of teacher education. All letters, such as requests for permission to conduct research and requests for faculty participation, were thoroughly discussed with the pilot study research participants and found to be clear and contained the necessary information. I only added that the schools would remain anonymous and had to make a few minor grammatical changes.

Interviews/interview protocols. I interviewed a total of six faculty members: four science faculty, the former director of education, and the current director of education. The interviews lasted 45 minutes to one hour, including the time spent on debriefing. None of the faculty indicated that the interview was too long and all of them maintained interest throughout the entire interview. Questions near the end of the interview were answered as fully and thoughtfully as questions closer to the beginning of the interview. Given this information, I was satisfied with the length of the interview. I was also assured that the participants were comfortable and did not feel threatened or intimidated. One participant noted that it would be helpful to somehow use body language (such as smiling or nodding my head) to indicate that the participants were giving me the information that I sought.

Each pilot interview ended with a debriefing; this debriefing included feedback on permission letters and interview questions. Most of the interview questions seemed clear to the participants, but they did ask for some explanations or elaborations on a few questions. When these requests for clarifications were combined with my analysis of the interview data, it was obvious that I needed to rephrase some questions and add a few sub-questions in both the science faculty and director of teacher education interview protocols. Based on the pilot study, the following types of changes were made in the science faculty interview protocol:

- Clarifications (e.g., *What are your feelings about how this request was made?* instead of *How do you feel about how this request was made?*)
- Additions (e.g., *How and when did you learn about the AAT degree?* instead of *How did you learn about the AAT degree?*)
- Omissions (e.g., *Could you describe your teaching philosophy?* instead of *Could you describe your teaching philosophy, before and after you worked with the AAT courses? Any changes?*)

The following types of changes were made to the director of teacher education/division chair interview protocol:

- Clarifications (e.g., *How do you see your role, if any, in working with the science faculty in planning or implementing the science courses that support the AAT degree?* instead of *Have you worked with the science faculty in planning or implementing the science courses that support the AAT degree?*)
- Additions (added sub-question, e.g., *Do you have a feel for how willing the science faculty are to work collaboratively with other faculty or*

administrators to implement and assess the science courses offered in support of the AAT degree?)

Document analysis protocols. I found the document analysis protocols, especially the syllabus analysis protocol, to be the most problematical instruments to use. It was difficult to determine the goals or objectives with respect to the core skills of critical thinking, or the teaching philosophy of the instructor. However, I did get some information on the type of pedagogy used in the courses. I did not change the syllabus analysis protocol because I believed other schools might have more useful information posted in their syllabi. The non-syllabus analysis protocol was a little easier to use, but in the table of describing the presence of core critical thinking skills, I found that I needed to add a section on lower order thinking skills: Knowledge or lower order skill, not core skill.

My main concern with the analysis of the documents was with my interpretation of the data. I was not sure if my classification of data was correct and consistent. In order to increase the reliability of this data, I determined that I needed to have my analysis of future research documents reviewed by one of my colleagues to determine if there was consistency in my coding.

Classroom observation protocol. I observed one class session and found that the classroom observation protocol was not easy to use. I could not concurrently keep track of the time and determine how to categorize classroom activities. So I kept a “running tally” of the sequence, time allotments of classroom activities, and behaviors of the instructors and students. I then found it much easier to categorize this data into the observation protocol. Part of this protocol focused on the presence of 4 of the Five E’s

(Engagement, Exploration, Explanation, Elaboration) (Miami Museum of Science, n.d.). In this protocol, the original recording column was either a "yes" (the E was present) or "no" (the E was not present). I found that just reporting the presence of the four chosen E's and the amount of time spent on activities that support them were not sufficient. I wanted a fuller picture of what actually transpired and how each activity supported on or more of the Five E's. In order to accomplish this, I added another section to the observation protocol that included spaces to record specific assignments and activities, and their objectives.

Student questionnaire. The student questionnaire was given to two small classes, with a total of 11 students responding. I was not able to give the questionnaire myself due to teaching commitments. The faculty teaching the science courses administered the questionnaire. The students did not have any problems in answering the demographic questions. But, I did not get as much data as I had hoped for in questions 6 through 13 because the students did not supply in-depth explanations. I believed that this was in part due to the lack of explanation about the questionnaire. I decided that when I administered the questionnaire to my student participants, I needed to give them brief instructions on how to answer the questions and what types of data I was seeking. I also determined that I needed more detailed demographic information in order to determine a more precise age grouping and enrolment status of the students, so I added this to the beginning of the questionnaire.

Documentation

The documentation process, or audit trail, included a record of the research process, field notes, recorded interviews, electronic files, student questionnaires, and paper copies of communications between myself and the participants and other relevant individuals (Glesne, 1999; Schuh, 2001; Miles & Huberman, 1984). Others can follow this audit trail and determine the rigor and accuracy of the research process.

Member checking and peer review

In member checking, the accuracy of the findings is verified by taking the final report, or parts of it, back to the participants and determining whether these participants feel that the findings are accurate (Creswell, 2003). I was only able to get a member check from two faculty from Beltway Community College. These faculty noted a few minor errors in their demographic information and in the layout of their classroom. I corrected these errors in the final draft of my document; the rest of the document was deemed to be accurate. I purposefully did not ask the participants from Oakmont Community College for a member check because they were just starting the change process and I felt that they would think that I was criticizing them. I could not get member checks from the other two schools due to the timing of the completion of their case studies. I felt the delay between data collection and finishing the written case study was too long for the participants to remember what transpired in the interviews. I was also concerned that they would confuse the current status of the AAT degree science courses with the state of these courses at the time of my site visits.

In order to overcome the lack of complete member checking and to add to the trustworthiness of the data, I used extensive peer reviews. Dr. June Bracken (personal communication, June & July, 2004) thoroughly analyzed the Oakmont case study. This analysis included reading all of the transcribed interviews, reviewing classroom observation notes, and checking student questionnaire responses. Since I was unsure of my consistency in the syllabus and non-syllabus document analysis, we both independently analyzed the same set of documents. We routinely categorized the data the same way and came to the same conclusions. This increased my confidence in the use of these instruments and in the accuracy and reliability of my document analysis.

After a complete study of my data and research process, Dr. Bracken then read the Oakmont case study. She found very few discrepancies and noted that the quotes taken from the interviews were consistent with the overall thoughts and feelings expressed by the participants. Dr. Bracken also read all of the other case studies, and my entire dissertation. Her insightful comments and identification of unclear statements allowed me to look at my data from a different point of view and clarify ambiguous passages in the text.

Triangulation

Triangulation, using multiple sources of data and methods of data collection, is a very important assurance of data trustworthiness and was critical for this project. I collected data from science faculty, teacher education directors, and students in four different ways: in-depth interviews, class observations, written questionnaires, and written documents. I also collected data from unstructured campus observations. These multiple sources of data allowed for the development of "converging lines of inquiry" (Yin, 1984, p. 92). According to Yin, "Any finding or conclusion in a case study is likely to be much more convincing and accurate if it is based on several different sources of information, following a corroboratory mode" (p. 92). The "converging lines of inquiry" also allowed me to use one source of data to "fill in the blanks" in another source of data, thereby allowing for a richer, thicker description of the case.

Data Analysis

According to Miles and Huberman (1984), data analysis consists of three types of activities that are concurrent and highly interconnected: data reduction, data display, and conclusion drawing and verification. In this study, the data reduction and display very often overlapped and sometimes were indistinguishable. Data reduction is the process of "selecting, focusing, simplifying, abstracting, and transforming the raw data that appear in written up field notes" (Miles & Huberman, 1984, p. 21). The data display is the organized "picture" of data and information. The purpose of the data display is to put the data in a readily accessible, compact form so that the researcher can begin the third step of drawing and verifying conclusions (Miles & Huberman, 1984). I considered the writing of the final report as a form of data display, since this was the form that the audience would read, as well as being analogous to Miles and Huberman's third step of drawing and verifying conclusions.

Data Display

The first step in my analysis was to determine how my data and its analysis were to be displayed. I decided that each case study would be presented as a separate chapter. The cross case analysis (answers to the research questions) and the set of recommendations were also given individual chapters. Since I had a large amount of data for each case, and diverse research questions, I devised an outline for each case that allowed me to present the data in an organized fashion and facilitated the cross case analysis and drawing of conclusions (see Table 5). However, this outline had to be modified for the study of Bayview Community College because the teaching faculty were not aware of the AAT degree and did not make any changes in curriculum in response to requirements of the degree. Once I had the case outline completed, I turned to the display of the raw data. The process of displaying the raw data merged into the reduction of the data.

Table 5
General Outline of the Case Study

Case Study
Background Information
Institutional context
History of the AAT degree
Faculty interviewed
Awareness of and Attitudes Toward the AAT Degree Requirements
Awareness and knowledge of AAT degree requirements
Attitudes toward AAT degree requirements
Changes Made in Course Content/Pedagogy by Individual Faculty
Changes in Assessment Techniques
Students' Perceptions of Constructivist Teaching Activities
Perceived improvements in critical thinking
Perceived helpfulness of teaching techniques
Potential Factors Affecting Implementation of Change
External factors
Organizational factors
Internal factors
Attitudes toward request, awareness, participation, and belief in change
Prior use of constructivism, faculty background, teaching philosophy
Students' attitudes toward learning and the faculty's attitudes toward students
Summary

Data Reduction

The data reduction began with the categorization of data into the protocols for the classroom observations, syllabus document analysis, non-syllabus document analysis, and the compilation of results from the student questionnaires. Pertinent campus observation data extracted from field notes were categorized. All interviews were transcribed. All of this reduced data were stored in an electronic database. Once all of this had been completed, the data was in an organized form, ready to be coded and analyzed again.

According to Miles and Huberman (1984), a code is an abbreviation or symbol that is applied to a group of data that express a specific idea or concept. Codes are used to classify the words and data. They allow the researcher to quickly retrieve and cluster all segments of data that relate to a specific research question or theme. I used an electronic coding system that was based on using different colors of text and of highlighting in order to identify and separate related groups of data. The coded data was then ready to be further reduced into the final conclusions, resulting in four individual case studies. After completion of the individual case studies, the data was further reduced into the cross-case analysis (answers to the research questions). This part of the analysis, which resulted in the individual cases and the cross-case analysis, was based on what Yin (1984) termed "converging lines of inquiry" (p. 92) that occur in the triangulation of data.

The writing of my research study was analogous to the way I find my destination when driving. I start out not sure of how to get to where I want to go, or exactly where my destination is located. I then drive in ever decreasing circles until I pinpoint my destination. Even though this may not seem to be an efficient way of finding where I want to be, I get a view of the surrounding area from several vantage points. I learn more about the region as I drive through it, and when I finally get to where I want to be, I have a very good sense of the region. I also know the locations of other destinations, and where these places are with respect to each other. In other words, I have completed a triangulation process, and am now confident that I know how to get to my destination starting from any point in the region, and am able to give directions to others.

I repeatedly used this process of "ever decreasing circles" at three different levels in the analysis of the data. The first level was in writing each section of the main body of the report of an individual case study, fleshing out the bones, or headings, of the case outline. I identified the heading of interest and carefully searched though the data and color-coded all of the data that was possibly relevant to that section. I began to circle through this coded data, identifying the most important data, and finding how data from one source fit together with pieces of data from other sources. I then wrote a rough draft of that section of the report. I repeated these circles, refining the draft after each circle, until I was convinced that I had gotten as rich a description as possible for that section. I repeated this process until all of the sections of the report (except the summary) were completed.

The next level of decreasing circles went through the sections of the report. In this level, I tied the sections together and found data from one section that reinforced data from other sections. Again, after each circling, I modified the rough draft of the report, and circled until the final report was as complete as possible. I was then able to complete the summary of that particular case.

The third level of "ever decreasing circles" was done in order to complete the cross case analysis—the answers to the five research questions. The answers to the research questions were taken directly from appropriate sections of each case study (see Table 6 and Table 7 for links between research questions and sources of data).

Table 6
Research Questions Linked to Data from Oakmont, Lakeside, and Beltway Case Studies

General Case Study
Background Information
Institutional context
History of the AAT degree
Faculty interviewed
RQ 1 Awareness of and Attitudes Toward the AAT Degree Requirements
Awareness and knowledge of AAT degree requirements
Attitudes toward AAT degree requirements
RQ 2 Changes Made in Course Content/Pedagogy by Individual Faculty
RQ 3 Changes in Assessment Techniques
RQ 5 Students' Perceptions of Constructivist Teaching Activities
Perceived improvements in critical thinking
Perceived helpfulness of teaching techniques
RQ 4 Potential Factors Affecting Implementation of Change
External factors
Organizational factors
Internal factors
Attitudes toward request, awareness, participation, and belief in change
Prior use of constructivism, faculty background, teaching philosophy
Students' attitudes toward learning and the faculty's attitudes toward students
Summary

As I circled through the case studies several times, I pulled out the most salient points from each case. I then compared and contrasted these points until I was convinced that I had all of the information necessary to give thick and rich answers to each research question. I was then ready to begin the rough draft of the penultimate chapter of my research project. My final spiral ended in Chapter 10, the last chapter of the dissertation, where I developed a set of recommendations that were well grounded in the data, and identified possible subjects for future research.

Table 7
Research Questions Linked to Data from Bayview Case Study

Case Study of Bayview Community College
Background Information
Institutional context
History of the AAT degree
Faculty interviewed
RQ 1 Science Courses that Support the AAT Degree
Development of the science courses
Present state of the science courses
RQ 1 Awareness of and Attitudes Toward the AAT Degree Requirements
Awareness and knowledge of AAT degree requirements
Attitudes toward AAT degree requirements
RQ 5 Students' Perceptions of Constructivist Teaching Activities
Perceived improvements in critical thinking
Perceived helpfulness of teaching techniques
Summary

Summary

My intention for each case study was to provide as rich, thick, and complete description as possible, such that if one were to visit all of Maryland's community colleges, one could identify each college included in my study. The cross case analysis was done in order to answer my research questions. Although case studies are often designed to inductively create theory (Merriam, 1988), I did not collect enough data to, nor intended to create theory. However, I did get sufficient and trustworthy data that allowed me to produce a set of recommendations well grounded in the data. As stated before, one of the prejudices against qualitative studies is a perceived lack of rigor. I have made the data collection and analysis as thorough and transparent as possible in order that each individual reader may judge the rigor and determine generalizability (or transferability) of the results of my study.

Research Timeframe

August 2003	Defend Prospectus, begin IRB approval
September –October 2003	Gain Site approval, IRB approval
November 2003	Conduct Pilot Study
January-March 2004	Collect Data and begin Data Analysis
April 2004-September 2006	Continue Analysis, complete Dissertation
February 2007	Defend Dissertation
May 2007	Graduate

Chapter Five: Case Study of Oakmont Community College

This case study will be divided into seven major sections. The first section includes all of the necessary background information and will describe the institutional context, history of the Associate of Arts in Teaching degree at Oakmont Community College, and backgrounds of the faculty interviewed. In the next three sections, the faculty's awareness and knowledge of, and attitudes toward the Associate of Arts in Teaching degree (AAT) requirements, individual changes to course content and pedagogy, and changes in assessment techniques will be explored. In the fifth section, the discussion will center on the students' perceptions of teaching activities. Potential factors affecting faculty implementation of changes will be reviewed in the sixth section. This section is further broken down into three separate types of factors: external, organizational, and internal. The seventh and final section will summarize the key findings in this case study.

Background Information

Institutional Context

Oakmont Community College is a small, rural college located in the hills of western Maryland. A total of 3207 credit students enrolled in the fall semester, 35 % of whom are full time, enrolled in over 100 programs of study. The campus is situated on a large tract of land. About half of the buildings are clustered around and on a lightly wooded hillside with the rest of the buildings on the level ground surrounding the hill. Many of the roads running through the campus have academic names such as Scholar Drive and Academic Boulevard. Even the hallways in the Learning Resource Center are given names that reflect the collegiate or academic atmosphere of the college; one such name is Responsibility Drive.

The hallways of the academic buildings that I visited have pictures and short biographies of successful graduates. Many of the classrooms have large posters of the school's Code of Honor:

> I promise to uphold Oakmont Community College's Honor System and to understand all written provisions pertaining to its application. As a member of the College community, I hold the qualities of honesty and integrity in the highest regard and will not violate them nor tolerate those who do.

The students seem to take this creed to heart. For example, the Science Club members leave boxes of candy for sale sitting on the counter in the Science Learning Center. When a student purchases a candy bar, he or she just tosses the price of the candy into an unsupervised cardboard box. The money and candy are left sitting in the open but it did not appear that any one stole any money or candy.

History of the AAT Degree at Oakmont

Maryland's Associate of Arts in Teaching degree (elementary option) follows the current conceptualization of teacher preparation by stating outcomes for elementary teacher candidates that should be achieved within the first sixty credit hours of a Bachelor's degree in education. The science outcomes for the elementary teacher candidates were established by science faculty from two- and four-year colleges and universities in Maryland and were based on the National Council for Accreditation of Teacher Education (NCATE) standards, since the Maryland four-year colleges follow

NCATE guidelines (see Appendix A). The *Maryland Outcomes for Teacher Preparation – The First Sixty Hours, Elementary/Middle School* (TEAC, 2001, p 19) states that the "professional development of teachers of science requires learning essential science content through the perspectives and methods of inquiry. *Inquiry is so basic to science that every activity should support it in one way or another* [emphasis in the original]." Since inquiry is such a critical component of the AAT degree requirements, I would like to remind the reader of the difference between constructivism (which includes inquiry) and instructivism. Constructivism is an interactive, social process of building personal meaning from the information available in a learning situation and then integrating that information with what is already known to create new knowledge (Siebert & McIntosh, 2001). Inquiry refers to the abilities students should develop to be able to design and conduct scientific investigations, and to the understandings they should gain about the nature of scientific inquiry (National Research Council, 2001). Inquiry based learning or pedagogy can be defined as the teaching and learning strategies than enable scientific concepts to be mastered through investigations (National Research Council, 2001). In a constructivist classroom, the student generates his or her own knowledge. On the other hand, in an instructivist classroom, the student receives information and knowledge from the instructor.

Using the guidelines found in the *Maryland Outcomes for Teacher Preparation – The First Sixty Hours, Elementary/Middle School* (TEAC, 2001) as a basis, individual schools organized their own programs of study for elementary teacher candidates that would meet the designated outcomes, and then submitted these proposals to the Maryland Higher Education Commission (MHEC) for approval.

Before the AAT degree was introduced at Oakmont Community College, elementary education majors followed the traditional education AS degree transfer program. This degree required 64 credits for graduation, including 7 to 8 credits of science. Students could choose science courses from the biological or physical sciences, with at least one of the science courses needing a laboratory component. This degree is still available to students who plan to transfer out of state or to those who cannot fulfill the requirements of the new AAT degree.

The AAT degree was initiated at Oakmont in the fall of 2002. The director of teacher education learned about the AAT degree from her division chair: "Originally our division chair was attending the TEAC (Teacher Education Articulation Committee) meetings and that's where he learned … about it and then basically shared the idea with me and thought it was something we might want to get on board with." The following excerpt from the 2002-2003 college catalog describes the new degree:

> The AAT degree is designed for students who plan to transfer to a four-year institution in the state of Maryland. To earn an AAT degree, students must complete each required course with a C or better and achieve a minimum 2.75 cumulative grade point average. In addition, students must complete a professional portfolio and pass the Praxis I examinations.

The catalog also lists the courses needed for the degree, including the following science courses: BIO 106 Unity and Diversity of Living Things – 4 credits

PHS 104 General Physical Science – 4 credits

PHS 111 Earth and Space Science – 4 credits.

This program was ultimately approved in 2002. The total hours needed to graduate increased from 64 to 67 (2003-2004 Oakmont Community College Catalog). The science courses listed in the approved proposal are the same ones that were listed in the school's original proposal. A few course offerings were changed in order to accommodate the AAT degree requirements. An entirely new earth and space science course was created and included in the 2004-2005 college catalog. The way in which the well-established physical science and biology courses were offered was also slightly altered. In the past, students could take the physical science course in either of two different formats. The students could either enroll in a three-credit lecture course that did not include a laboratory segment, or enroll in a four credit course (the same lecture course) that included a separate laboratory segment. Now all physical science course students must enroll for a four credit course where the lab is to be a fully integrated part of the course. Instead of modifying all of the sections of Biology 106 (a popular course taken by many students) in order to conform to AAT pedagogy standards, an evening section of this course was designated as the one to be taken by AAT majors.

Faculty Interviewed

I interviewed the director of teacher education and the three faculty who were currently teaching the science courses associated with the AAT degree (see Interview Protocol for Director of Teacher Education and Interview Protocol for Science Faculty in Appendixes G and H, respectively). When I interviewed the director, I was mainly interested in her knowledge of and perceptions of the AAT degree and did not obtain any background information such as types of degrees and number of years she had taught. The director of teacher education has limited interactions with the science faculty and does not perceive herself to be in a position to exercise any control over the way the science courses are taught, either in terms of content or pedagogy. She also indicated that the faculty did not really seek her out for any advice on how to teach the AAT science courses.

The three faculty involved in teaching the AAT science courses worked independently of each other, and were autonomous in the day to day teaching of their courses. Their academic backgrounds and teaching experiences were very diverse. The instructor who teaches the AAT earth and space science course worked in private industry for several years before becoming a part-time instructor and has a Bachelor's degree in land surveying. After serving as a part-time instructor, she was hired full-time to coordinate and teach computer related courses. At the time of the interview, she was working on a Master's of Science degree dealing with geography and global imaging systems. This is her second year of being a full-time faculty and the first semester she has ever taught a non-computer related course.

The instructor who teaches the AAT physical science course has taught this course at Oakmont Community College for eleven years. He has a Bachelor's degree in physical science and a Master's degree in physics. He has over twenty years of teaching experience in the Maryland public school system and in various colleges, both as a full-time and a part-time instructor, and retired from full-time teaching about five years ago. All of his teaching experiences are in the physical sciences. When interviewed, he indicated that he is teaching part-time at three different institutions (one course at each institution): Oakmont Community College, a neighboring four-year institution, and a local penal institution. But he has decided to cut down his teaching load and only teach at Oakmont Community College in the future.

The third AAT science instructor (biology) is the youngest of the three instructors. She has a Bachelor's degree in biology (with a minor in chemistry) and a degree in plant pathology. After working in a research lab for five years, she began a doctorate in science education, which she has not yet completed. She has served as an adjunct at Oakmont Community College for four years and is currently working full-time in the Science Learning Center and teaching part-time in the evening. She has experience in teaching chemistry and biology courses, anatomy laboratories, and science method courses in education. She is the third instructor who has taught the biology course associated with the AAT degree.

Awareness of and Attitudes Toward the AAT Degree Requirements

Awareness and Knowledge of AAT Degree Requirements

Before the researcher could determine the faculty attitudes toward the AAT degree and its requirements, it was necessary to understand faculty awareness and knowledge of the degree requirements. The director of teacher education and only one of the three science instructors, the biologist, seemed to be very aware of the content and pedagogy requirements of the AAT degree. As mentioned earlier, the director of teacher education learned about the AAT degree from her department chair but she also had extensive experiences with the details of the degree through her work with MADTECC (Maryland Association of Directors of Teacher Education at Community Colleges) and in the development of the *Guidelines for Portfolio Development* (Oakmont Community

College Education Department. The director of teacher education indicated her awareness of the content of the science courses in the following quote:

> I have their syllabi and I know basically which outcomes … that they address. But I don't teach the course so I don't really know exactly what goes on; I haven't actually observed any of their classes. But I know that the outcomes, we have all the outcomes listed that are required for the program. And I know which courses meet which outcomes, I just don't know the details.

As far as the pedagogy requirements, the director of teacher education knew that the science classes were "supposed to be hands-on" and described the pedagogy as being "a little bit more experientially learning based … sort of a discovery learning … inquiry based."

The biology instructor's initial awareness of the AAT degree came from two sources, but I am not sure of the sequence of her contacts with these sources. One source was conversations with a science faculty colleague who attended the MAPT (Maryland Articulation Partnership for Teachers) meetings and who knew that she would be interested in the degree. The other contact concerning the AAT degree was her department chair. This instructor stated that she was aware of Maryland's standards and had a list of the life science standards that she thought came from the biology group of the MAPT initiative. I was unable to get more information from this instructor as to who gave her this information or when it was given to her. Although she is trying to gear her course toward those standards, she stated that the content of her course is very similar to the content of Oakmont's traditional biology course but not as detailed. As far as constructivist or inquiry based pedagogy is concerned, this instructor stated, "No one's ever said you need to teach them this way. So what I think is that they need to be having more hands-on experiences and they need to see different ways of learning science, just different ideas."

The earth and space science instructor and the physical science instructor either did not fully understand or misinterpreted the requirements of the degree. The instructor teaching the earth and space science course volunteered to teach the course, but she was vague about how she actually learned about the degree. It was not clear if she was initially asked to teach the course by the director of teacher education or if she offered her services to the director. This was the earth and space instructor's first semester of teaching a science course and she tried to follow a syllabus that she obtained from one of the community colleges in this research study whose earth and space science instructor I know to be very knowledgeable about constructivism and inquiry. She was frustrated with using that syllabus because she could not determine what really went on in the other course and felt that the syllabus did not really fit the text she was using:

> So I am kind of using someone else's stuff but then I'm having to teach it and I am seeing some places where there is no emphasis and other places where there is probably less than what we are going to do…. Here in the description is data collection; I'm not really sure what data we are going to collect yet…. If I am putting it on paper I would like to be able to address it, and again, I am kind of using someone else's guide, and I am feeling a little left out of the loop here. It was nice, it was certainly useful to have somebody else's guide but now as I kind of get into the thick of it, it's like – what does that mean?

The earth and space instructor was not totally aware of the content requirements of the AAT degree but she did have information obtained from Oakmont's *Guidelines for Portfolio Development* and read some topics found in this booklet:

> The ability to distinguish between natural objects made by humans, ability to take logical design, understanding about science and technology, indicators, know terms and concepts, to select, define, recall, use in another context, describe and classify them.… To me it's quite general.

This instructor did not realize that the outcomes listed in the *Guidelines for Portfolio Development* were based on those listed in the *Maryland Outcomes for Teacher Preparation – The First Sixty Hours, Elementary/Middle School* (TEAC, 2001), the document that defines the AAT degree requirements. When asked if she could describe the pedagogy requirements, she responded,

> Not really. I know that they are supposed to have three hours of lecture, three hours of lab, which we don't necessarily observe in that order. But no, I couldn't describe beyond that. I know it would appear that I got some very general information.

This second quote shows that the earth and space instructor did not fully understand the requirements because she does not accurately describe that the learning experiences should be integrated, with a decreased emphasis on the lecture, and an increased use of discovery and student-centered learning.

The physical science instructor learned about the AAT degree when the department chair told him that they would be changing the course:

> But the way I heard about what they were doing was through the department chair, and she said, you know, we are going to do this. It's going to be one of those sequential courses for the elementary majors and that's what we are going to do. You have to do it if you are going to teach physical science.

He indicated that he was happy with having physical science as a required course for the elementary education majors. Even though the physical science instructor had gone to MAPT meetings with a science faculty colleague, he was not very aware of any state guidelines for content but relied on his experience in public schools to judge that his course generally covered what he thought teachers would be required to teach in elementary school. As far as his knowledge of pedagogy requirements, he commented,

> Well, they only said that we shouldn't have formal lab periods when we get into it. We should do demonstrations and try to stay away from strictly lecture business; that's the only information I've gotten so far…. I think it's a good deal that they are getting into this idea of less and less lecture and more activities.

He appeared to be interested in using more activity-based instruction, but he didn't seem to understand constructivism or inquiry as a pedagogical practice. When asked about pedagogy, he stated, "It's more going back to the way I taught middle school science years ago in that they want to have more demonstrations, they want to have more activities, short activities rather than big long labs." This quote shows his misinterpretation of inquiry because in inquiry based learning, students do much more than just watch demonstrations or do short activities. The students actually build their own knowledge through experimentation and use of the scientific method.

Upon review of faculty responses to interview questions, it is clear that the faculty vary in their knowledge and awareness of the content and pedagogical mandates of the AAT degree. Information about the degree requirements apparently had been misunderstood, or there has been an on-going lack of effective communication among the participants as the information filtered down from the director of teacher education or the chair of the science department, and then finally to the instructors of the individual courses. It appeared that the degree requirements were not carefully explained to the instructors, and, in the case of the physical science instructor, the instructor's preconceived ideas about content and pedagogy were not taken into account or amended by the department chair. The biology instructor's academic experience of working with some feminist-constructivist faculty in the education department at the University of Idaho seemed to enable her to better understand what content and pedagogy were required by the AAT degree. The manner in which information about the degree was communicated to the faculty may have had an effect on how important the faculty felt the requirements were and could have affected their attitudes toward the degree.

Attitudes Toward AAT Degree Requirements

The director of teacher education had a very positive attitude about the AAT degree and believed that this degree, in comparison to the old AS degree, would improve the education of elementary education majors:

> The biggest plus, is that first of all … it's raised the bar for one thing. I mean 12 credits of science, 12 credits of math…. And I think that what's going to happen is, we still have that program [the old AS degree] and some people still go through it, but I think what is going to happen in the next several years is the bar

> is going to be raised so the kids who aren't in this program are not going to meet the qualifications. They are not going to have the background that's basically coming from the state saying you need this background in math and science or whatever. They're not going to meet the expectations that the four-year schools are wanting for their entry-level teacher. So I think that's a plus…. It's outcome based, so the courses that make up our program meet the outcomes that are expected. So they are ready to go as entry-level juniors without having to do make up stuff, which I think is a real plus both financially and time wise…. I think, it's definitely, it's both academically more rigorous than the previous programs and it is also more uniform as far as it will go various places. You can come in here and out of the AAT program; you know that you have what [any of Maryland state schools] want when you finish here, which I think is a real plus.

Although the earth and space instructor was not very knowledgeable about the content and pedagogy requirements of the AAT degree and did not communicate a well-defined attitude toward them, she did display a positive attitude toward active learning. It was clear from classroom observations and the following comment that she really preferred students to be more active (constructive) in the learning process: "I guess because I have always taught hands-on type classes, I'm not a big fan of the lecture, traditional lecture mode." This instructor was very unsure about the future of the earth and space science course and whether or not she would teach it again. This uncertainty is reflected in the following quote:

> And it would be nice to qualify what their intentions are with the class as well because if I am going to teach it again then I'm going to go about things

> differently than if I'm not going to teach it again. If I'm done, that's one thing; if I'm not done, then that's a whole different thing. It would be nice to know wherever it's going.

This uncertainty of the future may have contributed to or reinforced her ambiguous attitude toward the AAT degree requirements.

The physical science instructor, who also did not appear to be well informed about the requirements of the AAT degree, was satisfied with and had a positive attitude toward what he perceived to be the requirements of the AAT degree. He stated that he was surprised that physical science had not been a requirement in the traditional AS degree in teacher education at Oakmont Community College. He went on to say that it was a required course at the college he graduated from in 1964 and stated, "I think they are getting back to the way it was and the way I feel that it should have been all along." When asked what he would do if he were in complete charge of designing the physical science course for the AAT degree, he replied,

> Well, I guess I would do about the way that they want it. I think it's a good deal that they are getting into this idea of less and less lecture and more activities so I would probably wind up about with the same results. I don't have any problem with it.

As stated earlier, this instructor does not realize that constructivist or discovery-based learning requires more than just short activities and demonstrations. In contrast, the biologist provided a very different answer when asked what she would do if she were in complete control of the design of the AAT biology course:

> I would like to have more time … to have more experiments that they could do all the time … and have … [the students] learning continuously … they could collect the data, and analyze the data, and they could go back and alter it.… Just try to make it … more constructivist, even where they could design [experiments], but … you just need a lot of time and resources.

The biology instructor had a very positive attitude toward the content requirements of the AAT degree and stated,

> Oh, I think they're legitimate. I think they are in line with all the other standards that we have in place in the country. To me they seem, for what they are going to have to teach, I think they are going to be OK…. I think it's realistic.

She also showed a strong, positive attitude about the pedagogical approach to the AAT science courses and stated,

> For me I think it's good, especially for the students.… I thought it was neat and would be a good time to do different things, to do hands-on activities and get out of the lecture mode with some students … to feel free to get out of the lecture mode and not be criticized for it or people think that it's out of line.… So I thought it was going to be really cool, really interesting.

This instructor appears to value constructivism since she regularly utilizes this pedagogy.

In summary, the participants varied in their degree of knowledge about the content and pedagogy requirements of the AAT degree, but they all seemed satisfied with their current level of knowledge. The earth and space science instructor, however, indicated that she would like to know more about the pedagogy if she were to teach the course again. Even though their knowledge of the AAT degree requirements varied, all of the faculty had positive attitudes toward the degree. It is interesting to note that the two faculty with the strongest positive attitudes toward the requirements of the AAT degree (the director of teacher education and the biology instructor) were also the ones who knew the most about the degree and constructivist pedagogy.

Changes Made in Course Content/Pedagogy by Individual Faculty

Since the earth and space science course was a new offering for Oakmont Community College students, and it was the first time the earth and space science instructor had ever taught this course (or any other non-computer science course), everything she did was relatively new and I cannot say that she purposefully made any changes to satisfy the AAT degree requirements. Although the instructor had never taught earth and space science, she was very familiar with the content of the course because astronomy and geology were her favorite hobbies. Her course syllabus (patterned after an inquiry-based course from another college) indicated a constructivist approach to learning because her syllabus focused on active and collaborative learning, and required students to create action plans. The objectives, or outcomes, listed in this syllabus include terms that are associated with critical thinking: "characterize landforms from photographs and maps," "evaluate and classify earth materials," "interpret a rock record," and, "interpret weather data and analyze weather systems based on underlying chemistry and physics principles." Classroom observations revealed that the majority of class time was spent on constructivist activities such as making a scale model of the earth's layers, but no time was spent on inquiry or discovery-based activities requiring the use of the scientific method.

Unlike the earth and space science course, the physical science course already existed when the AAT degree was introduced. When asked if this course's content had changed in response to the AAT degree mandates, the physical science instructor replied, "Not really, except that we're doing now more activities where we didn't do it. We did simply a few activities with lecture and demonstrations and we had a separate lab period. So the content hasn't really changed any." As stated before, the physical science instructor misinterpreted the intent of the constructivist or inquiry-based pedagogy. He thought that in order to satisfy the intent of the AAT degree he should be reverting to instructional methods more like what he used when he taught in junior high school. The only change in pedagogy that was noted in the syllabus was that AAT students were required to evaluate educational websites as part of their journal assignment whereas the other students did not have to include this as part of their journals. The journal assignments were designed to have the students critically think about and reflect upon their learning. Five of the six general course objectives appeared to be instructivist in nature, using phrases such as: to provide an opportunity for the student to see (used twice), to illustrate how, to show, and to acquaint the non-science major. The only outcome that could be considered to be constructive included the phrase, "to provide opportunities for the student to use." Two classroom observations showed a very traditional college lecture and a standard "cookbook" lab where the scientific principle under study was verified, not discovered. This laboratory accounted for about half the instructional time of one period and, since the students were doing hands-on activities, could be considered partially constructivist in nature, but not inquiry based because the scientific method was not included in the exercise.

Changes made to the biology course in response to the AAT degree were more evident than changes made in the other courses. The instructor teaching the AAT section stated that the content was the same as the traditional course but the material was not presented in as much detail. Although the course content was very similar, the AAT section used a different laboratory manual than the other sections used. This manual was introduced by a public school teacher who taught the AAT section the first time it was offered. It has different activities than the traditionally used manual and more activities that can be done in the classroom. The biology instructor discussed changes in pedagogy:

> I try not to lecture to them. I try to do different things and try to make them more active in what they are doing and don't just let them sit there and take notes…. I try to give them different ways to learn it, not necessarily having somebody lecture and then we go to the lab and they are very isolated. I try to have it integrated so they are actually using it.

The two class sessions that I observed verified this statement because the students spent at least 75% of their time on constructivist activities such as group or individual problem solving, graphing of data, and collecting data during a laboratory exercise. Although a large percentage of time was spent on constructivist activities, none was spent on inquiry processes.

In analyzing the two syllabi obtained from different sections of Biology 106, I noted a stark difference between the syllabus describing one of the sections of the traditional biology course and the syllabus for the section that is geared for AAT students. All of the sections of the traditional biology course share the same basic syllabus. This syllabus states that the student learning outcomes vary according to the individual instructor. In the syllabus that I analyzed, the instructor did not list any course objectives or student learning outcomes. In fact, there was not any mention of the student or student learning. This lack of information about student learning outcomes strongly implies an instructivist teaching philosophy and pedagogy. In contrast, the syllabus for the AAT section included many constructivist phrases in the course objectives: "utilize and integrate knowledge obtained from previous science courses," "encounter science at work in the context of common real-life experiences," "come to know science as a process of inquiry rather than just a body of knowledge," "inquiry learning, cooperative/collaborative learning," "event-based learning," and "develop an enthusiastic attitude about this area of science." These phrases clearly express a constructivist philosophy and pedagogy, with a clear reference to discovery or inquiry-based learning.

Overall, when looking at the three AAT degree science courses, the only real change in content came from the inclusion of the new earth and space science course. There was no demonstrable change in content in the other two courses. The biology course seemed to have undergone the most change in pedagogy.

Changes in Assessment Techniques

In order to see if an instructor has fully embraced constructivism, one can look to the type of student assessment that the instructor uses. Complete constructivist pedagogy (which includes inquiry or discovery) calls for multiple methods of authentic student assessment such as projects, performances, and portfolios. Authentic assessments evaluate higher order thinking and require students to explicitly demonstrate desired learning outcomes (Huba & Freed, 2000). The earth and space science instructor uses a variety of student assessments in all of her courses. In the AAT earth and space science course, the exams and quizzes (which compromised 30% of the final course grade), mainly tested for lower order skills such as recall of information, knowledge of major ideas, and mastery of subject matter. Attendance and class participation made up 20% of the final grade. Other assignments (50% of course grade) such as student presentations, projects, and portfolios, assessed the core critical thinking skills of interpretation, analysis, inference, evaluation, explanation, self-regulation, but not critical thinking dispositions. The earth and space science instructor uses constructivist pedagogy and bases half of the course grade on authentic types of student assessment.

The student assessment in the physical science course has not changed except for the journal. AAT students evaluate educational websites and describe how they would use them in their own classrooms as part of the journal, whereas non-AAT students do not have to include this as part of their journals. According to the syllabus, tests count for 75% of the overall course grade, written assignments are worth 15%, and class participation is 10% of the course grade. I was not able to obtain a sample exam so I do not know whether or not the format of the exam supported any assessments of core critical thinking skills or constructivist learning.

The syllabus of the traditionally taught biology section indicated that the students were assessed by their performance on exams (about 47% of course grade), quizzes (2%), laboratory reports (29%), a final exam (21%), with up to a 3% bonus for attendance. The format of the exams was objective in nature: multiple choice, matching, true-false, and fill in the blank. About 25% of the exams were short essay questions or problems in which the answers were to be written out longhand. Since almost 70% of the course grade is based on objective exams, it would appear that student assessment in this biology section is more compatible with instructivism rather than constructivism. I was unable to obtain any sample exams but the stated format of the exams would suggest that they mainly tested for knowledge and lower order skills.

The differences in student assessment between the traditional section and the AAT section of the biology course were not quite as pronounced as the differences in their syllabi. According to the AAT syllabus, quizzes, tests, or exams constituted 40% of the course grade and were objective in nature. An analysis of sample quizzes and exams showed an almost exclusive reliance on multiple choice questions that tested for recall of knowledge, not higher order critical thinking. The syllabus of the AAT section did indicate that some authentic assessment was taking place. All core critical thinking skills appear to be assessed in the assignments (presentations, lessons, evaluations, critiques) that count for 30% of the final course grade. The biology instructor explained,

> I'm trying to have them do more different things. I am going to have them teach, and then I am going to have them assess each other.… I'm going to assess their teaching, and have them do some website evaluation, different education and science websites. We still have lab reports [30% of the course grade], but we also have activities that they do that I grade. I give exams and quizzes still … but I don't have portfolios or anything like that.

Although the instructor for the AAT biology course conducts constructivist-based classes, evidence from her syllabus and interview reveals that she had not fully integrated constructivist techniques in her assessment of student learning.

Thus far, this case study has concentrated on the faculty attitudes toward the mandates of the AAT degree and on the changes they have made in their courses in order to support these mandates. It is also important to note the way that students perceive constructive learning activities and the critical thinking that is necessitated by constructive or discovery-based learning.

Students' Perceptions of Constructive Teaching Activities

The students who attended the classes that I observed were asked to voluntarily fill out a student questionnaire studying aspects of critical thinking and student behavior (see Appendix M). Thirty-seven students filled out the questionnaire, but the questionnaire from one biology student was not included in the data set because this student was not yet eighteen years of age. The students were asked if the science course they were enrolled in helped them to improve their abilities in different aspects of critical thinking: interpreting written information, analyzing numerical data, explaining scientific information to others, and evaluating strengths and weaknesses of information or arguments. For each question a student answered affirmatively, he or she was asked to name a specific course assignment, such as one particular essay, or an entire classification of assignments, such as laboratory reports, that helped in the improvement of critical thinking skills. The student was then asked to elaborate on how that course assignment was helpful. Students were also asked to explain what their instructor did in terms of teaching that helped them to learn. The last question of the survey asked if students preferred working in groups or working individually, and they were also asked to explain their responses.

Perceived Improvements in Critical Thinking

Of the 144 possible yes or no responses to the core critical thinking skills questions, only 34% (49 responses) indicated that students perceived that aspects of critical thinking were taking place, while 66% (95 responses) showed that students were not aware that aspects of critical thinking were taking place (see Table 8). The students in the physical science course (the course observed to be the least constructive or student-centered) overwhelmingly perceived that activities in this course did not help them improve any of their core critical thinking skills. Only one physical science student thought that interpretive skills were improved and none of these students noted improvements in analysis or evaluative skills. However, 43% (six students) stated that their skills in explanation had improved.

The responses from the students in both the earth and space science course and in the biology course indicated that these students were more aware of improvements in their thinking skills. All six of the earth and space science students noted gains in interpretation skills and 83% of them perceived gains in explanation skills. But only 17% of them noted gains in analysis skills while 33% of them felt their evaluation skills had improved. The overall percent of biology students that reported gains in critical thinking, about 44%, was less than the percent of the earth and space science students (about 58%) but the perceived gains showed the same pattern in both classes. Slightly over half of the biology students indicated gains in interpretive and explanation skills as compared to the 100% and 83%, respectively, of the earth and space science students, while less than 40% of the biology students were aware of gains in analysis and evaluation skills.

The differences in perceived improvements in critical thinking between the physical science students and the group of students in the other two science courses may partially be due to the type of course pedagogy and assessment. According to the Joint Task Force on Student Learning (1998), learning involves the ability of students to be aware of their own ways of knowing and to understand how knowledge is acquired. Perhaps the students in the earth and space science course and in the biology course became more aware of learning when more constructivist pedagogy and authentic assessments are used because they had to actively think about how to acquire their own knowledge.

Table 8
Oakmont Students' Perceptions of Critical Thinking

	Earth and Space Science (6 students)				Physical Science (14 students)				Biology (16 students)			
Core Critical Thinking Skill	Yes		No		Yes		No		Yes		No	
	N	%	N	%	N	%	N	%	N	%	N	%
Interpret	6	100	0	0	1	7	13	93	9	56	7	44
Analyze	1	17	5	83	0	0	14	100	6	38	10	62
Explain	5	83	1	17	6	43	8	57	9	56	7	44
Evaluate	2	33	4	67	0	0	14	100	4	25	12	75
Ttl (N) Pcnt (%)	14	58	10	42	7	13	49	87	28	44	36	56

When looking at the entire group of student participants at Oakmont, it is difficult to discern an overall pattern of which course activities the students thought were most influential in promoting critical thinking, or which type of assignment stimulated a specific facet of critical thinking. I believe that the students had difficulty in discussing what course activity helped the most in perceived improvements in critical thinking skills. I was only able to categorize 30 of the 49 positive responses given by the students. The frequency of specifically mentioned assignments must be tempered by the size of the classes and the types of activities and assignments used in the different courses.

In general, 10 responses (33% of the categorized responses) from the students indicated that Internet assignments were very useful in perceived improvements to critical thinking. Sixteen responses implied that both various instructivist (for example, lectures) and constructivist (students teaching lessons to each other) activities were perceived to increase critical thinking skills. Four of the student responses (13%) clearly related the importance of laboratory work in perceived gains in critical thinking, but I think this number is misleading. Six students mentioned laboratory activities, such as making models or graphing data, that required critical thinking skills. These responses were not tallied in with the positive laboratory responses because the students did not specifically mention the laboratory. If these responses were included, the number of students who perceived gains in critical thinking due to laboratory assignments would equal the number of students that indicated the importance of Internet assignments.

Perceived Helpfulness of Teaching Techniques

Although the majority of students did not perceive improvements in critical thinking within these science courses, they were still able to experience and recall some positive learning experiences. All of the students were able to cite an example of teaching techniques or instructor attributes that helped them learn. An earth and space science student said, “We do many hands on experiments, are given good visual aids, and the information from past lessons is brought up in later lessons.” A physical science student stated, “Our teacher gives us lots of examples. If we have a question he always answers them.” A biology student commented, “The instructor makes us do group work that makes us learn in different ways. The instructor does activities that we can study by, like making cells out of candy … and that makes me learn better.” This last student comment (as well as the comment from the earth and space science student) reflects the students’ appreciation of the opportunity to be actively involved in the class, even though the students may not have been aware that they were critically thinking.

The majority of students, thirty-two of the thirty-six, preferred working in groups. The most common reasons why students preferred working in groups were that group work enabled them to communicate with each other, to compare and contrast ideas, and to obtain help from each other—in other words, actively use critical thinking skills (even though the students may not have been aware of their critical thinking). One very plaintive reason for preferring group work was given by a male biology student, “Because being alone sucks.”

I was only able to observe two class periods for each instructor, but I believe the behaviors I observed to be representative of what typically occurred in these classes throughout the semester because the students seemed to be very familiar with the structure of the classes. It was difficult to determine what activities stimulated the most critical thinking from the students by just observing their classroom behaviors, especially the five or six students in the earth and space science course. The students in the physical science course appeared to be the least active learners; in the lecture that I observed the students sat and passively listened. They only asked the instructor two questions. Both of these questions pertained to what materials would be covered on the exam. They also were not enthusiastic about the laboratory exercise they performed. For example, two female students were very reluctant to become engaged in the exercise and complained about not understanding what was going on. In general, students in the biology course seemed to be the most animated, engaged, and comfortable learners. During one observation period, many of the students in the classroom interacted in small groups to complete a study sheet while others were working on computers in the Science Learning Center.

The director of teacher education was able to supply some information on student attitudes toward constructivist learning. When she was discussing inquiry or discovery-based learning, she stated, "I've heard a little bit of just anecdotal comments … students aren't as comfortable with [inquiry-based learning] as they are with just sitting and listening to a lecture." She continued, "Kids go into that kicking and screaming, they want to be told by the teacher, 'this is what you need to know.' That's what they are used to." The director of teacher education has listened to complaints about instructors from two students in different AAT science classes. These students were very frustrated because their instructors had them teaching lessons. They did not think that they knew or understood enough to be able to teach a lesson and felt that their instructors should be teaching the lessons.

Potential Factors Affecting Implementation of Change

The students' attitudes toward critical thinking and constructivist learning may have an effect on how open or resistant they are toward student centered learning

(Bonwell & Eison, 1991; Hansen & Stephens, 2000). This in turn could influence their instructors as they plan course activities. According to the literature, there are several other factors that may come into play as the science faculty implement changes in their courses in response to the AAT degree mandates. Stark and Lattuca (1997) identified three spheres of influence on college curriculum: external, organizational, and internal. These sets of influences can also affect faculty as they try to implement academic change, and will be discussed in detail in the following sections.

External Factors

Stark and Latucca (1997) defined external influences on college curriculum to be beyond the control of the college. Some examples of external influences given by Stark and Latucca include society as a whole, accrediting agencies, publications, concerns of employers, and the media (1997). Mandates of the AAT degree are the external driving force that initiated the need for changes in science courses at Oakmont Community College. The intent of the degree is spelled out in *Maryland Outcomes for Teacher Preparation – The First Sixty Hours, Elementary/Middle School* (TEAC, 2001), the document that outlines expected outcomes in the elementary teacher education program. This document clearly lists the content elementary teachers are expected to teach, and therefore, what they should learn as undergraduates in their science courses. It also mentions pedagogy. According to the Professional Development Standard in *The First Sixty Hours* (TEAC, 2001), "Professional development of teachers of science requires learning essential science content through the perspectives and methods of inquiry. *Inquiry is so basic to science that every activity should support it in one way or another* [emphasis in the original]." However, inquiry or discovery-based learning is not defined anywhere in this document and, like constructivism in general, is subject to much interpretation (Siebert & McIntosh, 2001).

The National Science Foundation funded MAPT initiative was the second external factor that had the potential to affect faculty in making the transition to discovery learning. Science and math instructors received significant financial support to attend meetings where they could see examples of discovery and constructivist teaching methods. Two Oakmont Community College instructors attended these meetings, but only one of these instructors (physical science) actually taught an AAT related science course. However, this instructor held preconceived ideas about how the science courses should be taught and was not positively influenced by his participation in this grant. Neither of the other two faculty participants attended the MAPT meetings. The biology instructor was aware of the MAPT meetings but said that she did not have the time to attend any of them and the earth and space science instructor did not mention the MAPT grant during her interview.

Organizational Factors

In Stark and Latucca's model (1997), organizational factors such as the college mission, financial stability, resource availability, and opportunities for faculty renewal may be either supportive or non-supportive influences on curriculum planning and change. Organizational factors affecting change at Oakmont Community College include administrative awareness of the intent of the AAT degree and administrative support for the necessary courses and the faculty who teach these courses. The director of teacher education is very aware of the intent and purpose of the AAT degree as well as of what outcomes are expected from students graduating with this degree. I was not able to interview the chair of the science division so I do not know her level of awareness of the mandates of the AAT degree nor do I know her opinions of discovery-based learning. But it is evident that the mandates of the degree, especially as far as inquiry is concerned, were either not communicated clearly to the faculty teaching the science courses or were not well understood by them.

There has been mixed administrative support (and reception of this support) for the science courses and the faculty who teach them. For instance, the fact that a different part-time instructor taught the biology course each of the first three semesters shows a lack of support or commitment of resources on the part of the administration. The director of teacher education feels that her supporting role is to make sure that the science courses servicing the AAT degree are offered on a regular basis and to act as a source of information for the science faculty. She is willing to offer advice to the science faculty but has not actively engaged them in any discourse, possibly because they have not sought out her advice. The academic dean controls the very limited funding available for faculty development and has not offered any on-campus faculty development directly related to the AAT degree. There have been some in-house workshops on authentic assessment. The biology instructor was encouraged to participate because she is an adjunct, and she found the workshops to be very beneficial. No other AAT science faculty participated in the workshops on authentic assessment. The physical science instructor indicated that the academic dean had sent him some information. He stated, "I received little notes every now and then from the dean about, you know, this would be a good thing to read, blah, blah, blah. I haven't had to do a lot of reading as far as the AAT program is concerned." His mannerisms and tone of voice led me to believe that this instructor was not receptive to the assistance that the dean was trying to provide.

Other types of administrative support appear to have been available to the faculty. The biology instructor stated that the laboratory equipment she needed was satisfactory and that there was an on-staff technician who would prepare the standard biology labs. However, if the biologist wanted to do anything different from the standard labs, she would have to prepare them herself. The physical science instructor was able to request the purchase of equipment but had not done so at the time of the interview. He did not know if money would be available for the necessary equipment. The earth and space science instructor has purchased inexpensive items for the students to keep and assumes that she will be reimbursed for the cost of these items.

A very important potential form of administrative support takes the form of release time. The director of teacher education stated that the dean has dramatically cut the amount of release time available to faculty. The earth and space science instructor was able to get release time in order to initiate her course, but she did not think this time was adequate. The biology instructor felt that she would not be eligible for any release time since she was an adjunct, even though she worked full time staffing the Science Learning Center. This instructor felt very pressed for time, especially time to prepare the labs. When asked if she belonged to any professional organizations, she replied, "No, I don't have the time.… I'm like hanging on by threads." This instructor perceived that she would even be charged leave time if she wanted to attend a meeting that conflicted with her work schedule.

Internal factors

According to Stark and Latucca (1997), internal factors that exert influence on college curricula include faculty backgrounds, disciplines, educational beliefs, and student characteristics and goals. Relevant to this study, I have discerned nine internal factors (and their interactions) that could affect faculty as they transition into the AAT science courses. The relevant factors are summarized in the Concept Map (see Figure 1, page 31). These factors can be divided into three interrelated groups. The first group includes attitudes toward the manner of the request for change, the awareness of the intent and purpose of the AAT degree, participation in the change process, and belief in the change. Prior use of constructivist pedagogy, academic and professional background, and teaching philosophy are the components of the second group. The last group brings together the students' attitudes toward learning and the faculty's attitudes toward students.

Attitudes toward request, awareness, participation, and belief in change. It appears that the introduction of the requirements of the AAT science courses to the science faculty at Oakmont Community College was done very informally and individually. When asked to discuss the manner in which they were requested to teach the courses, none of the science faculty mentioned anything about being upset or influenced in any way by how they were approached to teach the science courses. However, I got the impression that the faculty did not understand that I was interested in finding out their attitudes toward the manner of how the request was made, not the request (to teach the course) itself, so the information here may be incomplete.

As stated earlier in this study, the participants varied in their degree of awareness of the content and pedagogy requirements of the AAT degree. I believe that the biology instructor had the most awareness of intent and purpose of the AAT degree, but this awareness was somewhat tempered by lack of communication with the administration and follow-up by the administration. The biology instructor was not sure that she was fulfilling the requirements of the degree, as evidenced by this quote about the standards, " I guess because I have been involved in other education programs… I guess I have my own ideas about what they needed. But I don't know if that's the right idea." She was not aware of any planning or formal development of the biology course. She stated, "its kind of been, 'here it is, teach it with best methods. Try to teach it the way you think.'" Later in the interview, she continued,

> No one's ever said you need to teach them this way. So what I think is that they need to be having more hands-on experiences and they need to see different ways of learning science, just different ideas. I don't know how well that jibes.

The other two instructors either did not fully understand or misinterpreted the requirements of the degree. As stated earlier, information about the degree requirements apparently got lost or misunderstood as it filtered down from the director of teacher education or the chair of the science department, and then finally to the instructors of the individual courses. This lack of communication may have diminished the perceived importance of the degree requirements and affected the science faculty's belief in the changes needed to accommodate the AAT degree requirements.

None of the science faculty were involved in the decision to offer the AAT degree at Oakmont Community College. The administration decided to institute the degree and then the science faculty were approached to teach the courses. It appears that the instructors were left to their own devices as to the design of their syllabi, course content, activities, and assessments. The instructors did not perceive any oversight on the part of the administration and operated rather independently. They felt free to make changes (or not) as they saw fit. This indicates that they could have participated in the change process if they were so inclined.

Since the faculty attitudes toward the degree as a whole were somewhat undefined, and the only real, purposeful changes were made by the biology instructor, I used the science faculty viewpoints on assessments and student learning as guides to their beliefs in the changes necessary for the AAT degree. If the faculty used authentic student assessments as a basis or partial basis for the final course grade, and they believed that the AAT science courses would benefit even non-education majors, I then could say that the faculty believed in the pedagogy required by the AAT degree mandates. The biology instructor did include some authentic assessments, and, when asked if her AAT science class would help the non-education major, she replied, "… I believe it will. I think they are going to get better or at least the same as the other students. And maybe they will understand more when they're trying to put their kids through school." The physical science instructor had a very limited amount of authentic assessment built into his course. He also did not perceive that non-education majors would see much of an effect on their educations, as evidenced by his statement, "It isn't that much different so I don't know whether they are going to see any big differences or not." In comparing the quotes from the biology and physical science instructors, it is clear that the biologist had a greater belief in the impact of the AAT science courses (and therefore a greater belief in the need for change) than the physical science instructor. Since this was the first time the earth and space science course had ever been taught at this school she was not asked to directly comment on her beliefs in the necessary changes. However, she did display a positive attitude toward constructivism.

Prior use of constructivism, faculty background, teaching philosophy. The three science faculty had varying degrees of exposure to and use of constructivism. The biologist had the most exposure to constructivism in her academic career. She was very impressed with the feminist-constructivist instructors she met in the education department at the University of Idaho, and said this about them:

> So they were just different. They kind of thought outside the box … I was in…. They just saw things differently…. I learned from them and I don't know that everything I do would fit their beliefs, but they wouldn't care because that's just the way they are. But they also showed me that a lot of things have to apply to what they already have in their brain.

The earth and space science instructor had extensive experience with hands-on learning both as a student and as an instructor. Learning how to use computer programs such as CAD/CAM programs requires many hours of hands-on work with the computer. Even though this type of learning is certainly an active form of student centered learning, I would not describe it as necessarily being constructivist in nature. But this instructor did not like a lecture format and included student centered learning techniques in her classroom. The physical science teacher did not appear to have had any background in constructivist teaching or learning, except for a brief exposure at the MAPT meetings.

He confused the short activities he would do with his junior high school students with constructivist learning.

The faculty had mixed academic backgrounds. The earth and space science instructor has a bachelor's degree in a technology related field and at the time of our interview was currently working on a master's of science degree in a geography field. She indicated that her favorite hobbies were astronomy and geology, and she had taken courses in these fields. This interest in geology and astronomy may well have spurred her to teach the earth and space science course. When asked about what she liked about the content of the course, the earth and space instructor replied, "Well … I am learning a lot myself. So I like that because … I am learning more about the universe." The physical science instructor has a bachelor's degree in physical science and a master's degree in physics; he also has 30 credits in physics and chemistry beyond his master's degree. The biologist has a bachelor's degree in biology, and a master's degree in plant pathology. She started pursuing a PhD in science education but has not completed that degree, and is not currently actively working on the degree. The earth and space instructor and the physical science instructor both reported fluctuating memberships in numerous professional organizations, but none of the faculty indicated that memberships in professional organizations influenced their teaching or teaching philosophies.

It appeared that two of the science instructors did not have well formed teaching philosophies. The biologist was the closest to having a well-formed philosophy. When asked to place herself on a continuum between instructivist and constructivist, she replied,

> I think I'm closer to the constructivist end … but I'm not Dewey, that's for sure … because I still have to have control. Like we have to know the labs, they're not going in there and inventing their own. But I am trying to get closer to the other, to where they are starting to build their own.

She also stated, "I think they all can learn and I want to teach them to think more.… I want them to learn to be more, better consumers of science.… I want them to understand more." The earth and space science instructor said that she did not have a "concrete" teaching philosophy. She cited two influences that affected her teaching: teachers of the past and information she has obtained about learning styles. She believes, "Whatever gets taught needs to be relevant to them or they are not going to be that interested in it, so I try to make connections to their lives." The physical science instructor said that he formed his teaching philosophy based on his own experiences in teaching at different levels and areas. He defined his philosophy as,

> do whatever I have to do to help the students to understand the processes.… I want them to understand the stuff and I want them to be able to manipulate things, not necessarily that they can memorize things and take the test.

Although some teaching philosophies may not have been well defined, it was clear throughout the interviews that the science faculty were interested in getting their students to learn and had good attitudes toward the students. The faculty's attitudes toward the students and the students attitudes toward learning are the last of the internal factors to be addressed in this case study.

Students' attitudes toward learning and the faculty's attitudes toward students. The students in the three AAT science courses were a typical mix of community college students. They ranged in age from 18 to over 50 years of age and were predominantly (69%) female. The physical science and earth space science students were mostly full time students while the biology students were almost equally split between full time and part time. The biology course had proportionally more older (24 years of age or older), non-traditional students than the other two courses. One third of the physical science and biology students had never taken a college level science course before enrolling in their current AAT science course. I do not have any information as to whether or not the students in the three science courses had any prior exposure to constructivist or inquiry-based learning but it appeared that these science students exhibited a mixed reaction toward student centered learning.

The director of teacher education stated that students were used to, and wanted to be told by the teacher, 'this is what you need to know.' The biology instructor confirmed this in her interview when she stated that some students just like to sit and take notes, "just like, 'tell us.' … They want to memorize it and just get through their science classes." Students have complained about student led lessons to the director of teacher education. The director stated,

> [students] are doing the lessons and it's like to them, that's wrong. 'The teacher should be teaching me this.' It's a new model, it's a new paradigm for them and they are having a lot of trouble with getting a handle on it. It's a whole new way of learning for them and they often, this is the first experience they have had with it, and they just think it's the teacher copping out.

As a group, the six students in the earth and space science course had more experience in science courses than the students in the other two AAT science courses, with all of them having had at least two courses and four of the six reporting having taken three or more college-level science courses in their academic career. Interestingly though, these students were also relatively the youngest in the three courses observed. Half of these students noted aspects of critical thinking in their questionnaire comments pertaining to what the instructor did to help them learn, showing they were not totally averse to constructivist learning and appreciated the opportunity to use aspects of critical thinking.

However, the instructor implied that these earth and space science students at times were reluctant learners, or had trouble adjusting to a more student-centered classroom, and did limit her preferred method of teaching. For example, the earth and space science instructor initially tried using a seminar type structure with the class where the students would read articles that would then be discussed during the next class. In the beginning, the class discussions satisfied the instructor but later in the semester she did not think the discussions were going well and related what she had told the students,

> I don't know whether it's because you don't know how to prepare for discussion, or that you read the stuff and then you don't make notes … about what you want to discuss, or points or questions; or you come in on Tuesday and haven't read anything and so you can't remember anything. Here's what you need to do and if we can't get these discussions working then I'll just give you writing assignments or something else.

The instructor said that she then gave the students an article from the *Journal of Science Teaching* that was titled "Helping Students Succeed in Science Courses." She explained her reasons for giving this assignment:

> So I gave them this to read as homework, kind of a way to hopefully encourage them a little bit….. [the article's author] makes the point that … responsibility begins with the students' simplest decisions and whether they attend and prepare for class. Trying to get them to think about their behaviors in that light, so hopefully we will have a good discussion about this article …

Classroom observations revealed that only about half of the students read this article and spontaneous discussion was very limited. The instructor had to provide a framework of relatively easy questions that could be discussed by the students. Even the students who did not read the article were able to participate in the discussion, but they had to be drawn into the discussion by the instructor. Although I was not able to get the instructor's opinion of the class discussion and I do not know if she decided to revert to other forms of assignments, it was obvious from comments made during the interview and from class observations that student behaviors or attitudes toward learning did affect this science faculty as she tried to use constructivist teaching techniques in her class. But even though the earth and space science instructor was at times frustrated by the lack of preparation on the part of some of the students and was somewhat surprised by a lack of focus and study skills exhibited by some of the students, she still maintained a positive attitude toward them and stated, "All but the one who is flunking are pretty good students."

About 40% of the physical science students were taking the physical science course as their first college level science course. None of these students noted any aspects of critical thinking in their questionnaire comments pertaining to what the instructor did to help them learn, perhaps indicating a reluctance to use the higher order thinking skills required by constructivist learning. At least one student, and, judging from behaviors observed in class, probably more students, in the physical science class did not react well to student centered learning. The director of teacher education related this story during our interview:

> I had a student who is in the physical science class here this semester and she is just so frustrated with it. I need to sort of see how it is going, I don't know, it could be just this one student. She said that everyone is doing real badly in the class. She said everybody failed the first test, and whether that is true or not, I don't know, but that is her perception. Everybody failed the first test and he got really frustrated with it, so he just told us that, so she said, 'so now what we are doing, is we're, he has us teaching the lessons. You know, and we are doing it. Now how can we teach the lessons if we don't even understand it?' But I'm thinking, I'm sure what he's trying to do is more of this inquiry kind of thing.

The physical science instructor did not mention anything about students teaching the lessons and this was not indicated in the syllabus. Classroom observations did not support the student's claims that they were presenting the lessons, but perhaps this was a short-lived change in pedagogy and the instructor reverted back to his normal pedagogy by the time I was observing his classes. In talking with this professor, I did not get the impression that he would give control of the classroom over to the students. The director of teacher education may be misinterpreting what is occurring in the physical science course.

Although the physical science professor may have gotten frustrated with his students, he never criticized them during his interview. According to the literature, some science professors tend to believe that education majors are generally not good students or are capable of learning science (Murray, 2000). This was not the case with the physical science, or the other two science instructors. The physical science instructor stated,

> … I really haven't tried to correlate what their test grades were with whether they are an AAT major or not. They seem to be about the same in ability. I have had students tell me that they were glad that I did some of my little demonstrations or I gave them some kind of information about what they could use when they get into their teaching but I haven't seen any real difference so far in the level of the students.

This instructor did have a good attitude toward the students and was interested in helping them to learn, as evidenced in the following quote,

> In order for students to really learn, they have to think that you are interested in them, and that you are going to be able to bend or compensate for them as an individual, because they don't want to be put into a mold.… [I] try to do the best job I can for them as individuals.

The students in the biology course appeared to be the most animated learners and were able to work independently. They seemed comfortable with working in groups. Results from the student questionnaire indicated that at least three of these students appreciated opportunities to use critical thinking skills. They interacted with the instructor frequently, more so than the students in the other two science courses. The biology instructor indicated in her interview that her students did influence the way she taught and that she tried to respond to their learning needs and would repeat material as necessary, but she did not appear to have had the types of problems encountered by her colleagues. This instructor believed that all students could learn and said that her AAT students had good attitudes, but other than that, she did not see any major difference between the AAT students and non-AAT students in her class. She did note that evening students generally tended to work harder than day students. In looking across the three AAT science classes, all of the instructors had good attitudes toward the students and the students had mixed reactions to student centered learning. The students also had both positive and negative effects on how their instructors conducted their classes.

Summary

At the time of the site visit at Oakmont Community College, the science courses supporting the Associate of Arts Degree in Teaching (elementary option) had not had enough time to be fully implemented or to become robust, inquiry-based classes. From the data I collected, I saw two main challenges for Oakmont's full implementation of the AAT degree: a lack of communication, and a lack of stability or continuity.

All of the science instructors whom I interviewed indicated that they had not completed the changes that they thought should occur in order to meet the mandates of the AAT degree. For example, the earth and space science instructor indicated that she would do things differently in the future if she taught the course again, and the physical science instructor wanted to add more activities. However, in general, the science faculty (except for the biologist) did not fully understand the tenets of the degree, especially the inquiry-based pedagogy, and none of the faculty were currently using discovery based learning. There was an obvious lack of ongoing and effective communication between the administration and the science instructors, and among the science instructors themselves. Little was being done to help faculty who did not understand inquiry or discovery learning. In fact, the director of teacher education was unaware of the lack of understanding of inquiry that two of the science instructors exhibited. Oakmont did not offer any in-house faculty development on inquiry or fund any types of off-campus faculty development opportunities, but the director of teacher education thought that it would be beneficial if the science instructors could get a model to follow as they design their courses.

Even though the administration made a commitment to offer the AAT degree, its support was somewhat weak, as evidenced by the lack of faculty development opportunities and a critical lack of stability in the science faculty teaching the AAT science courses. The section of biology designated for the AAT majors had three different part-time instructors in the three semesters that it had been offered. This lack of continuity could be very disruptive, although the current biology instructor thought that the input from the previous two adjuncts was positive and gave a good foundation that she could build upon. The earth and space instructor was not sure if she was going to teach this course in the future and, at the time of her interview, there did not appear to be anyone on campus who would like to teach the earth and space science course on a continuing basis.

Chapter Six: Case Study of Lakeside Community College

This case study will be divided into seven major sections. The first section includes all of the necessary background information and describes the institutional context, history of the Associate of Arts in Teaching degree at Lakeside Community College, and the backgrounds of the faculty interviewed. In the next three sections, the faculty's awareness and knowledge of, and attitudes toward the Associate of Arts in Teaching degree (AAT) requirements, individual changes to course content and pedagogy, and changes in assessment techniques are explored. In the fifth section, the discussion centers on the students' perceptions of teaching activities. Potential factors affecting faculty implementation of changes are reviewed in the sixth section. This section is further broken down into three separate types of factors: external, organizational, and internal. The seventh and final section summarizes the key findings in this case study.

Background Information

Institutional Context

Lakeside Community College is a small college located in an affluent section of a large metropolitan region of eastern Maryland. A total of 6,435 credit students were enrolled in the fall semester (2,273 full-time, 4,162 part-time). The smoke-free campus houses eight academic buildings, with five of the buildings (library, nursing, arts and administration, theater, and science and technology) connected together to form one very large structure. The airy library complex and science and technology building are separated by a large, two-level galleria where students can gather. This galleria is the focal point of this complex. One end of the galleria houses the Student Activities Center on the second floor and a cafeteria in the basement. The other end of the galleria opens into a hallway that connects to the nursing building. The hallway continues and connects the arts and administration building and the theater. From the inside, this complex of buildings appears as if it were one large, continuous building.

The spacious buildings look to have been built in harmony with the landscape. One corner of the science and technology building overlooks a small lake, complete with fountains and waterfowl quietly skimming along its surface. The second floor of this corner has many large windows and comfortable seating for students and faculty. The view of the lake and the quietness of this corner offer a serene and tranquil space for students to relax and study. The science faculty offices are located along the hallways that form this corner. The physical science lecture room is currently located fairly distant from the faculty offices. The physical science instructor must walk through the galleria, past the library complex, and across the hallway from the outer wall of the library complex to reach this room. This room has ceiling-to-floor windows that flood the room with natural light. The new, well-appointed instructional laboratory building houses several modern computer laboratories and classrooms. There is a large glass-enclosed student lounge in this building where students can relax or study, buy coffee from the Starbuck's kiosk, and enjoy a view of the central quadrangle of the campus.

But what struck me the most was the attractiveness of the physical science laboratory. The instructor who teaches the earth and space science course was actually allowed to pick the color scheme for the walls. She chose a scheme of four horizontal bands of blue; the lightest blue was the lowest band and the bands got increasingly deeper blue toward the ceiling. This laboratory has six tables, with four students per table. There are two computers at the outer edge of each table.

History of the AAT Degree at Lakeside

Maryland's Associate of Arts in Teaching degree (elementary option) follows the current conceptualization of teacher preparation by stating outcomes for elementary teacher candidates that should be achieved within the first sixty credit hours of a Bachelor's degree in education. Using guidelines found in the *Maryland Outcomes for Teacher Preparation – The First Sixty Hours, Elementary/Middle School* (TEAC, 2001) as a basis, Lakeside Community College, as did other community colleges, organized its own program of study for elementary teacher candidates that met the designated outcomes. The director of teacher education at Lakeside was on the planning committee for the AAT degree and actually helped design *The First Sixty Hours* document mentioned above, and was able to recall some of the contentious process between two- and four-year colleges that led up to the creation of the degree:

> First we started talking about courses. "Well, why does not the community college Intro. to Special Ed. transfer to all your four year colleges?" And we would hear things like, "Well, you don't use the same textbook we use," "You don't have a field experience and we have a field experience," "Your instructors don't know the same amount of material as my instructors do," and on and on and on. And there was not consistency among the four-year colleges….The four-year colleges were not all requiring similar things….We could not get all the four year colleges to say, yes, we will take all the community colleges Intro. to Special Ed. courses. We would sit at meetings and I would come back and say to my vice

> president, "I'm just not sure where we are going to go with this." We just agree to disagree and the meeting is over and we have been there three hours, and we come back and go ok, what are we going to do the next time? And we set another meeting date and we talk about another course and we still are not getting a lot of collaboration. So then [a committee member from] Salisbury said, "Why don't we stop looking at courses and why don't we design what we think is the ideal first two years for a teacher ed. major at a community college?"….So the committee thought, oh that's a good idea, because we needed common ground, we needed something to talk about to try and deal with this issue. And so then the focus changed from let's look at my course and see if it's the same as your course and whether everybody will accept it, to a much more broad based vision of what should a teacher ed. major at a community college, what is their ideal first two years of teacher education and then to have them totally ready to enter a teacher ed. program at a four-year college. And the bottom line is, that [approach] worked….I was right there at the beginning, and it was very exciting, frustrating at times, and we're very proud of what we've accomplished with *The First Sixty Hours* and the development of the AAT degree.

Prior to the addition of the AAT degree, Lakeside offered an Associate of Arts degree in elementary education. Students pursuing this degree were required to take two laboratory science courses. These students would usually opt for biology and one other science course that did not necessitate them having a strong background in mathematics. So, not many elementary education majors would take chemistry, physics, or physical science. This degree is still offered, but incoming students are steered toward the AAT degree. The AAT degree is a more difficult degree for students to attain because they must take three four-credit laboratory science courses (biology, physical science, and earth and space science) and twelve credits of mathematics.

Faculty Interviewed

I interviewed a total of four faculty members. Two of these faculty were currently teaching the earth and space science course and the physical science course (see Interview Protocol for Director of Teacher Education and Interview Protocol for Science Faculty in Appendixes G and H, respectively). Both of these instructors modified or created science courses for the AAT degree. The third respondent taught introductory biology, but this course was not modified in response to the AAT degree. The fourth faculty interviewed was the director of teacher education. I did not garner any academic background from the director of teacher education since I was only interested in her knowledge of and perceptions of the AAT degree. However, I did get detailed academic backgrounds from the other three faculty members.

The physical science instructor is the most seasoned of the faculty that I interviewed, with thirty-five years of experience behind him. Of these thirty-five years, all but the first three have been spent at Lakeside Community College. This instructor obtained a bachelor's degree in education from Western Illinois University. His aim was to teach at the high school level. After graduating with a four-year degree, he went on to Michigan State University for a master's degree. In 1993, he was awarded an Advanced Graduate Specialist from the University of Maryland. When asked what subjects he had taught, he replied,

> All kinds. I guess alphabetically from astronomy to anatomy and physiology, and physical science. Physics is my major area, I even [did] an earth science course at one point. Statics, dynamics, some engineering courses. But lately I've been pretty much concentrating in physics and the physical science for teachers. I've also developed a lot of courses, all kinds of different physics courses: one we had for our cardiovascular technology people, and then we had one for the biomedical technology people for a program that is going on. We try to meet the changing needs of the students for degrees or certifications. [Currently], I'm teaching calculus and non-calculus physics…and a physical science course for teachers.

The earth and space science instructor received a Bachelor of Science degree in geology from William and Mary in 1979. She then went to the University of North Carolina and obtained a master's degree in geology. During the eight years serving as an adjunct at Lakeside, she took additional courses in order to become certified to teach in the public schools in the state of Maryland. She stopped two courses short of certification in order to accept a full time teaching position at Lakeside. Her teaching background includes physical geology, meteorology, world geography, astronomy lab, and earth and space science.

The biology instructor has bachelor and master degrees in biology. Her master's research focus was entomology. She was very happy to explain how she got her education and how she came about teaching at Lakeside:

> Well I went to school for two years when I was a traditional 18 year old in a liberal arts education, so I had two years of liberal arts. Then I got married and started a family, decided I wanted to go back to school when my kids were in

elementary school. So I actually came here and I took math and science classes because that was all I needed to complete my two years before I transferred. So I spent two years here finishing all of my biology, physics, chemistry, and math. And then I transferred to Towson and got my bachelor's degree. And then [the physical science instructor] actually called me and asked me to interview for a lab instructor's position here. So I did. And I taught one year as an adjunct faculty lab instructor and then was hired the following year full time. And I taught as an assistant instructor in the labs: in biology, microbiology, [and] genetics. I taught chemistry labs; I did some anatomy and physiology. I did just about everything we offered except astronomy. And I taught full-time from 1987 until 1990. And then I completed my master's, so I was working on my master's part time while I was teaching full time. Once I graduated, a full-time position for a lecture instructor opened up here and I applied and got that position. So from 1990 until now I've been full-time lecture instructor.

In summary, the faculty I interviewed had very diverse background, but all of them had been teaching at the college level for several years.

Awareness and Knowledge of and Attitudes Toward the AAT Degree Requirements

Awareness and Knowledge of AAT Degree Requirements

Before I could determine the faculty attitudes toward the AAT degree and its requirements, it was necessary to understand faculty awareness and knowledge of the AAT degree requirements. Since the director of teacher education was involved with the creation of the AAT degree, she was aware of the content outcomes that are expected for an AAT graduate to master. When asked if there were any specific requirements that science courses should meet, she replied,

> They need to cover the outcomes, and what I've done, and what the department chair [has done], is look at the AAT outcomes in all the science areas and we have, beside each outcome, I write the course or courses [that address that outcome]. Some of the outcomes are covered in more than one course. That's great; they can get it in multiple ways. And then we designed the program of study so that these are the three science courses that we picked. We have earth-space science, physical science, and biology as the three courses, and they are all lab courses. And they are the three courses at [Lakewood] Community College where the students will cover all the [science] outcomes in *The First Sixty Hours* document.

Although the director of teacher education seemed well aware of the content requirements, she did not appear to be as well informed about the pedagogy mandated by the degree. She was somewhat confused when I asked her to describe pedagogy requirements. After I explained that I was asking if there was any particular manner in which the science courses should be taught, she indicated that she understood the question yet gave a somewhat contradictory answer:

> Yes, there are, but not necessarily. As long as we cover the outcomes, the answer is the students have been exposed to all the outcomes and they have learned the content. We would like it to be this hands-on approach where they're, I forgot what it's called, [could] you refresh my memory?

I offered the term constructivism, and she continued her explanation, using the term inquiry method. She stated that she knew the physical science and earth and space science courses were taught using inquiry, but she did not believe the biology course was taught with this method. She was interested in getting all of the science courses taught using constructivist methods, and said that she would try to get inquiry infused into biology courses after the retirement of the current biology instructors. Although the director of teacher education knew that the inquiry method was important for the AAT science courses, she did not appear to realize that it is a central component of the degree.

Because the physical science instructor was very interested in, and had a great deal of experience in, teacher education, the director of teacher education requested that he represent Lakeside Community College at the Maryland Articulation Partnership for Teachers (MAPT) workshops. The physical science instructor confirmed that this was the case and offered more detail:

> I was on that original committee that was convened by [the director of teacher education at Beltway Community College] and others, and I guess it goes back about three years ago.… Our teacher education person is very active with curriculum and knows all the people in the state, does a lot of testifying and so forth on behalf of teacher education, a real advocate, and told me that she knew I was really interested in working with teachers since I have done a lot of Eisenhower grants over the summers and other types of teaching for teachers, and said that I would be a good person to represent Lakeside Community College because that was up my alley.

I did not feel the need to specifically ask this instructor if he was aware of the content and pedagogy requirements of the AAT degree because I interacted with him during the MAPT workshops and knew that he was well aware of the mandates of the degree.

The earth and space science instructor learned about the AAT degree and its requirements from the physical science instructor, and was aware of both the content and pedagogy requirements. I do not believe that this instructor was initially involved with the MAPT grant, but she did a presentation on POE Centers (Predict, Observe, Explain) at the last MAPT workshop. The biology instructor that I interviewed did not know much about the AAT degree, and, when asked if she had any elementary education majors in her classes, she replied,

> We do, we have the general biology since the community college has a 7-credit science requirement. The lab science they normally select is general biology. And for the education majors, they need to take a life science and they need to take physical science. Their science courses are actually increasing in number because they want them to be well rounded. In our general biology classes we have non-majors, which would include education majors. The percentage, I've never really broken it down to analyze what percentage of education majors and then what percentage of those are [in] elementary education. But I know we have them in our classes every semester.

In summary, Lakeside Community College's director of teacher education and science faculty have varying degrees of awareness and knowledge of the AAT degree requirements, with the physical science instructor being the most knowledgeable of the four faculty that I interviewed.

Attitudes Toward AAT Degree Requirements

The director of teacher education had a very positive attitude toward the AAT degree for reasons that were implicitly and explicitly stated. Before the AAT degree, Lakeside offered a sort of generic general education program for elementary education majors and did not offer many actual education courses. The director of teacher education could not even be sure that the few education courses they did offer would be accepted by the four-year institutions. With the advent of the AAT degree, Lakeside now offers five education courses within the AAT degree, with a surety of transferability to the four-year colleges in Maryland. Although she did not say so, it appeared that the director was very proud that Lakeside can now offer an associate degree in teaching that is much more specific to the needs of elementary education majors than a general education degree.

She was also very excited about the transferability of the degree and how it helped her students. She offered this positive statement:

> [The degree] is very exciting and it's wonderful for the students. And it's wonderful; particularly, it's wonderful for both the community college students and the four- year colleges. It's wonderful for the community colleges because we used to just say to the four-year colleges, just tell us what you want our students to take and we'll have them take those courses so they can transfer to you. But the problem was they couldn't all agree so students had to be early deciders to get into the campus they wanted to go to, or they took the wrong program of study in the old model. And so this way it's all coordinated. The students know that if they finish the AAT, they've taken the ideal first two years

> and every four-year college [in Maryland] has to accept that as the ideal first two years, and then they move on into the last two years of teacher ed. So it's wonderful for the community colleges; we know how to advise the students. It's wonderful for the students because they don't have to be an early decider. They don't have to decide in their freshman year that they are going to College Park, UMBC, WVU, or whatever.

She added that there were more benefits that the AAT degree offered to the four-year schools too, as evidenced by this quote:

> And then it's wonderful for the four-year colleges because the other requirements are the students need a 2.75 [grade point average], they need to pass Praxis I, and they have 45 hours of field experience, and they have the teacher ed. portfolio. So they're getting our best, brightest students who are outstandingly well prepared, and they can pick and choose the best students they want to enter into their programs. I will tell you that it is very competitive in elementary ed. The lowest GPA that Towson University accepted in elementary ed. last fall was a 3.21. If students had below that they went on a waiting list for the spring program. They had to wait out a semester, or take other courses, just electives.

The director of teacher education clearly felt that the AAT degree would improve the science education of the elementary education majors and she detailed the reasons for her optimism:

> Absolutely. The one thing that is very exciting about the AAT is that in our old AA they were only required to take 8 hours of science with labs. And now in the AAT there is 12 hours of science with labs. And I just think that it's an area that

> most early childhood, elementary and now early childhood, people do not feel strong in, and the more we expose them to science…and [they] see that science can be fun and it's something they can do, and it's not something you should be frightened of….So not only are they taking four additional credits that they did not have in the old AA, but we are presenting the content in a way that is not that overwhelming and makes the student feel that they are able to do it….We don't want our elementary teachers to be weak in science….But it's definitely raising the science skills and knowledge of the students coming out of the AAT that they never had before.

The physical science instructor has a positive attitude toward the AAT degree and thinks that the AAT science courses will improve the education of the elementary education majors. He pointed out a particular aspect of the science courses that he thought was especially important, a change in student attitudes toward science. Initially, the AAT students reported that they were afraid of science. But after having had the physical science course, the students told the instructor how much they really enjoyed science, and that they had lost their fear of science. The physical science instructor also believes that the course he teaches will be useful to non-education majors. He related that, after some pushing, the environmental science students were told to take the physical science course because it would be very beneficial to them. He explained the rationale behind this requirement:

> Because in environmental science you are an educator. No matter what you do, you are somewhat of an educator. You might not be a teacher, as such, but you are educating the community, the public, or the people you work with. So I

> thought that it was very important to have them come in and take a course like that for physics and chemistry.

When I asked this instructor if he would be involved with the AAT science courses if he did not have to be involved, he gave an affirmative answer. He stated that he had always liked teachers and teacher education, and had conducted many workshops for public school teachers. He also held summer workshops in the past that were funded through Eisenhower grants. This instructor was also comfortable with the expected content outcomes, although he did feel the need to consider the essential curriculum in the local county public schools.

The earth and space instructor shared the physical science instructor's enthusiasm for the AAT degree science courses. She, too, thought that these science courses would improve the education of the elementary education majors because they were exposed to a larger span of science curriculum. She felt that the content was more than adequate for elementary school teachers and thought that the content was in line with what the teachers would be expected to present in the local county. She hoped that her students would see some other teaching methods, such as constructivism and inquiry, and use these methods in their own classrooms. She complained that her own children were getting a poor science education in the public schools,

> [The teachers] got a science kit and they pretty much stuck to the kit, that kind of thing for the elementary. For the middle school, all I ever saw was worksheets, worksheets, worksheets. I thought, "Isn't there something else they could do?"

She thought they did do some labs, but the inquiry that was being infused into the science classes was minimal, and only used as extra projects. This instructor hoped that her earth and space science course would also benefit non-education majors because they should be able to apply practical science in their everyday lives. When asked if she would be involved in the AAT science courses if she did not have to be, she replied that she would, but her reasons were more personal, as seen in the following statements:

> Oh, would I? Yes, definitely. It's also broadened my background because I really didn't have that space piece, so it has forced me to learn stuff that I really didn't know before….I just like the different method, to be able to infuse the inquiry. Not that I couldn't do that in geology, and I do, but not to the extent that I do in earth and space.

Since the biology instructor was not aware of all of the requirements for the AAT science courses, I did not ask about her attitudes toward the degree. She related that she knew the number of science courses the elementary education major needed was increasing in order to make the students more well-rounded. Although she did not specifically state that this increase was beneficial, I could infer from her mannerisms and tone of voice that she thought this was a good thing to do.

When comparing statements from the faculty that I interviewed, I noted a relationship between their attitudes toward the degree requirements, especially the pedagogy requirements, and the level of enthusiasm about the degree. The physical science instructor was the most knowledgeable about the AAT degree and he had a strongly positive attitude toward the degree. The earth and space science instructor was also enthusiastic about the degree, being especially excited about being able to freely use constructivist activities in her course. The director of teacher education was positive toward the degree but from an understandably different viewpoint. She was not as focused on the science courses, especially the pedagogy; she was more interested in the overall effect that the AAT degree had on her teacher education program. The biology instructor, who was the least aware of the degree requirements, was fairly neutral in her attitude toward the degree.

Changes Made in Course Content/Pedagogy by Individual Faculty

The physical science instructor began changing the existing physical science course in 2001, and related the process he followed in modifying the course to meet AAT standards:

> I went to those [series of workshops] at Beltway Community College and then what I also did is, I looked at the local county essential curriculum for K-8. And, as I will show you in this course, the students have to lesson plan and so forth based upon that curriculum. So they will be ready to, if they do any student teaching or a little presentation they could do in a methods course, that they will have something all ready to use. So I make sure it fits in with that. I also looked at Project 2061 because I've been somewhat aware of what's going on with that program…. I also looked at the scope and sequence that the National Science Teachers Association (NSTA) works with. So I try to put in some of the things that were key threads throughout the national curriculum in addition to what we had developed.

He felt that he was not finished making changes and wanted to do some minor adjustments, such as streamlining some new material and adjusting the amount of time spent on different topics presented in the course. He also wanted to change the class structure to three two-hour periods per week. Again, this instructor was very careful to include what was needed in the local county curriculum because that is where most of his students will be employed. The scope of the county curriculum seemed to take a little bit of precedence over the outcomes listed in *The First Sixty Hours* and the curriculum guidelines developed in the MAPT workshops, although these various standards were very much in agreement with each other. He did not feel compelled to include all of the topics listed in *The First Sixty Hours* that he had covered in previous physical science courses. When asked to describe changes in course content, he replied,

> Previously in the physical sciences…you want to cover all of the topics [but now] you want to espouse “less is more.” Still the books want to, [and] students want to cover all these different topics; I give in to that sometimes. But now I’m really concentrating more on major concepts and not doing as much, say, in chemistry as I would in a typical physical science class because they don’t need it for what they are doing. And integrating it together more so that they have already studied density…. I have them study chemistry; they study pressure and volume and temperature relationships…. So it is more integrated, which is how it should be. I’d like to also include some biology, [to which I make references], and try to relate to other things [such as] the earth and space course.

A review of two course syllabi (one from 1992 and one from 2004) confirmed changes in content. The current physical science instructor deleted or generalized some topics, such as rotational motion and specific types of electromagnetic radiation. He added more emphasis on conservation laws and on gravitational effects. He has also reduced the amount of chemistry covered in the course.

Along with the changes in content, the comparison of the two syllabi revealed some significant changes in pedagogy. The 1992 syllabus indicated an instructivist approach to learning, as evidenced by the following excerpt from the Course Orientation section:

> This course will consist mainly of two… lecture/discussion periods where information to assist in studying the course material will be presented….In the laboratory period each week, students will observe physical science principles.

This excerpt was also included in the Course Orientation of the current syllabus. But the addition of the terms "hands-on," "inquiry-based activities," and "students will construct models (using a constructivist approach) of what they observed to apply and explain the outcome of new situations" show that the current instructor has made a major change to inquiry and constructivist teaching techniques. The Overall Course Objectives in the current syllabus lists all of the objectives found in the 1992 syllabus, as well as two additional objectives that reinforce the constructivist nature of the course:

> Upon completion of the course, the student should be able to:
>
> 1. Identify and address their physical science concepts and alternate concepts (misconceptions).
> 2. Use activity-based learning and the constructivist learning model to learn physical science concepts.

Classroom observations confirmed what was noted in the syllabus. Although the instructor spent about 88% of the two observed lecture-session class times lecturing, these lectures were very conceptual in nature, informal, and interspersed with short group problem-solving sessions. Over 50% of the laboratory session I monitored was spent on a fully inquiry-based laboratory on static electricity, with about 20% of the period devoted to the introduction and summary discussion of the experiment. The rest of the period was consumed by the administration of a quiz.

The Lakeside earth and space science course is a new offering specifically designed in response to the AAT degree mandates. The physical science and the earth and space instructors were both initially involved in the start-up of this course, but the earth and space science instructor now appears to be in charge of the course. The earth and space science instructor spoke of how the course was designed:

> [The physical science instructor] had a list that came out of these [MAPT] meetings of curriculum objectives, well not objectives, just topics that we should cover. And then we also went through the local county curriculum too.…to see what they teach, to see what we should cover. So I had those couple of things and sat down and tried to break it down. He took the astronomy part, because he has taught astronomy, and I've only taught astronomy lab. So he really did the astronomy portions and then I did the earth and I did the water parts.

This instructor indicated that the course had evolved during its four semesters of existence and that she is still adjusting topics and the amount of time spent on each topic.

The course syllabus specifically stated that this course has "more emphasis placed on hands-on, inquiry based activities than on extensive textbook reading." In the syllabus's Course Description, the instructor states that the course will enable the student to learn basic concepts in a wide array of topics. Laboratory techniques and investigative skills that are needed to solve science-related problems are included in this list. Use of the terms "hands-on," "inquiry based activities," and "investigative skills," show that the instructor of the earth and space science course tends toward a constructivist and inquiry approach to teaching. But she still feels the need to retain instructivist techniques. When asked about the pedagogy for AAT courses, she replied,

> I think you need to do a variety of things. You can't do inquiry all the time because you'd never get through that big list of topics that you have to cover….So you have to do different things. You have to, and you have to do some lecture; you just do. Or if you have all cooperative learning, then the person who doesn't work well in a group will get stomped over, or just ignored, or whatever. So you have to have to use all different kinds, different methods.

She had previously described a few of these methods:

> Well, like the story puzzle that I did, [where I write a story, cut it up, and the students have to put the pieces together]. Teaching with games. I always review before a test and usually use a game. Like we played Geopardy, [a take-off from Jeopardy], for the last test….I played rock bingo, where we do the minerals and the rocks.

Even though the students are more active when they are involved in these activities than they would be if they were just listening to a lecture, the methods that the instructor mentioned are still instructivist in nature. They are used as memory aids. The students do not construct their own knowledge, the instructor has really dispensed knowledge using a different format.

Class observations revealed a mix of instructivist and constructivist techniques with not as much emphasis on true inquiry, where students use the scientific method to discover their knowledge. I observed one block of classes where the lecture and laboratory sessions were held back to back. About 78% of the time, the students were engaged in various instructivist/constructivist activities, including a game about the life cycle of the salmon. In this game, the students used marbles to represent the fish and "migrated" through the streams and determined the survival rate of the fish during migration. There were several stations set up where students read given information about hazards, and simulated the fish mortality at each hazard. This game was a combination of instructivist and constructivist learning, but not what I would consider true inquiry. Other activities appeared more constructivist than instructivist, such as the exercises that had the students look at a stereogram while reading articles about streams, glaciers, and oceans/coastlines. The students were required to answer questions based on the text, articles given in the laboratory exercise, and the stereogram. The true inquiry or discovery-based activity (20% of the class time) had the students designing and carrying out their own experiments on ground water. The students worked in pairs or small groups and had to determine significant variables and how to test those variables. I was able to obtain handouts for some of the other laboratory sessions. These handouts revealed a very structured approach to learning, where students followed explicit instructions in what to do and what information to gather. Students had to manipulate and interpret models but were only asked to retrieve factual information.

Although there had not been any changes made in the biology course that the AAT students take, and the course syllabus suggests an instructivist approach to learning, it is important to analyze this course and compare it to the other AAT science courses. The biology course at Lakeside was very different from the other courses that I observed, both at Lakeside and at the other schools involved in this study. The two full-time biology instructors, including the one I interviewed, have spent the last ten years or so modifying the original course and changing its format. The biology instructor explained the impetus for change,

> The year that I began teaching full time as a lecture instructor we were challenged by our dean to come up with a mechanism of instruction that will engage students, keep their attention, if there was a need to increase class size. Until that time we tried to keep our class sizes as small as possible but they were creeping up because of the enrollment. So [the dean] thought,…"What if we could do something that would keep students attention and not have their success rate drop, but allow us to increase the class size?" So it was a challenge grant, and [a colleague and] I decided to take up the challenge.

The biology instructors ultimately devised what they call "Multimediated Lectures in Biology." This is an instructional package that consists of a CD and a study guide that is used in conjunction with the CD, as described by the interview respondent:

> The CD is used on the big screen in an auditorium type classroom so it's quite large (about 50 – 60 students). And then each student gets a study guide that corresponds with this. It's the textbook but also it's a note-taking manual. And what it is, it's very visual; we in fact call it Multimediated Lectures in Biology….Each student gets a copy of that so they can go home and review the entire lecture on their own, remembering what I was doing, as I was demonstrating something. And it has drills and practice, animation and things that they can use to help them study as well. [Although] we use it in class,…it can be used by students with additional features after class or they could view the whole

> lecture after class….And the students like it. We found that…when they buy the [usual biology text] book they never read it anyway. So this way we know they are using the study guide….So we find it's a valuable instructional tool. I can't imagine going back in the classroom any more without it. Because it really is so complete. So there was a definite plan and the development of the Biology 101 course was based on that plan, how we could incorporate animations, charts, diagrams, images. Everything in it is copyright free. The photographs are our own; all of the diagrams are our own. It was very time intensive, but the product is worth it I think.

Notwithstanding the fact that students could use the learning package on their own to supplement their learning, the course format clearly is based on instructivist methods of teaching. The only constructivist pedagogy that occurred in the lecture was that the instructor would often ask the students to predict outcomes of events. The instructors did most of the background, organizational, and investigative work for the students, and the biology instructor was very pleased with the results of all the work put in to the design of the course, as evidenced by the following quote:

> Students really love it too. They want this kind of thing in all their classes and you have to tell them, "You can't do that because when you transfer from here you're not going to have something like this. You have to learn to make your own study guide and make your own images that help you remember things."

This quote also reinforces the biologist's instructivist teaching philosophy, but this philosophy did not fully carry over some of the homework assignments and into the laboratory component of the course. The biology instructor gave "ask and answer" assignments where students were required to generate a question and research the answer. The question was to be relevant to the biology topic under study, but not one that had been answered in class or in the study guide. The students would then write one page papers based on their research of their original questions.

The laboratory component was highly structured and followed guidelines and instructional materials found in the in-house laboratory manual. But what differentiated the laboratory from the lecture is that the scientific method was frequently employed throughout the manual. The students were asked to think about situations, construct hypotheses, design and carry out experiments, and go through all of the other steps associated with the scientific method. Even though not all of the laboratory activities were constructivist in nature, the active use of the scientific method in several experiments interspersed throughout the course of the semester shows that there is a strong infusion of inquiry-based learning in the laboratory.

Changes in Assessment Techniques

In order to see if an instructor has fully embraced constructivism, one can look to the type of student assessment that the instructor uses. Complete constructivist pedagogy (which includes inquiry or discovery) calls for multiple methods of authentic student assessment, such as projects, performances, and portfolios. Authentic assessments evaluate higher order thinking and require students to explicitly demonstrate desired learning outcomes (Huba & Freed, 2000). In comparing the 1992 physical science syllabus to the current course syllabus, it is evident that the physical science instructor has modified student assessment in order to include some authentic assessments. The student evaluations given in the 1992 course include homework assignments, a comprehensive exam on each of three units, and weekly laboratory evaluations. According to the syllabus,

> The student will be tested on his/her knowledge of basic physical science facts; ability to solve simple problems; and the understanding of physical science principles, concepts and terms, etc., in a multiple choice, matching, and short-answer essay, etc. format.

This type of assessment clearly indicates an instructivist pedagogy. The laboratory evaluations, however, appeared to be more constructivist in nature. These evaluations required the student to manipulate equipment in order to collect data that was then analyzed and interpreted by the student.

The current physical science instructor still has three hour exams but with the addition of a comprehensive final exam. These exams account for half of the final course grade. The syllabus lists the same statement concerning test materials and formats that was found in the 1992 syllabus (see previous excerpt) but with the inclusion of another testing format, that of problem solving. I was able to review all the exams given in the spring of 2003 and found them to be almost entirely testing for lower order thinking skills. Most questions addressed the competencies of knowledge, comprehension, and application as defined in Bloom's Taxonomy (Bloom, 1956), although the student did have to show a high level of conceptual mastery of the material. The core critical thinking skills of inference (Facione, 1990), dispositions, and self-regulation (Jones, 1995) were not assessed at all. Lab/homework packets, which comprise about 30% of the final course grade, consist of worksheets and lab handouts that cover each of the major topics. From the course materials that I analyzed, and having a personal knowledge of the physical science instructor's methods, I am confident in saying that the physical science laboratory activities are fully constructivist and inquiry based. However, I only had one sample of what the students actually turned in to be graded, and this sample was indicative of an instructivist assessment. I do not know if all of the lab/homework assignments were similar, so I can not determine if this portion of the final course grade addressed any critical thinking skills or is congruent with the constructivist paradigm.

But what mainly differentiates the current student assessment from what was done in 1992 is the inclusion of evaluations of lesson plans/projects and a teaching notebook (12.5% and 3% of the final course grade, respectively). Each student was required to write a lesson plan that would meet an objective in the local county's essential curriculum. This lesson plan had to include an age appropriate activity that would engage the students and spark their interest in the subject. Then the student, as a project, actually presented the lesson to the rest of their laboratory group, with the group members participating in the activities. Although the students were given very specific guidelines as to what to include in the lesson plan and were allowed to modify published lesson plans, the combination of the lesson plan and project required the students to use all aspects of critical thinking and was constructivist in nature. The teaching notebook was an orderly compilation of all notes, labs, quizzes, homework, and handouts maintained in a three ring binder. The instructor thought that this would be a good reference for the students to use when they became teachers. Since the students had to make sure that the information was well organized, accurate, and complete, the notebook gave the student a good opportunity to reflect on his or her learning.

In order to determine if the earth and space science instructor made any changes in student assessment, I compared the assessments done in the non-AAT geology course (taught by the earth and space science instructor) to the assessments in the AAT earth and space course. The assessments in the geology course consisted of homework, class work, and four multiple-choice examinations. All of these assessments are instructivist in nature. The geology laboratory is a stand-alone course. Students can take the lecture without having to take the laboratory component. I was not able to obtain any information on student assessment in the geology laboratory.

In the earth and space science course, the instructor employed multiple methods of assessment: POE (predict, observe, explain) centers and a lesson plan/project (each about 4.3 % of the final course grade), field trips and a sky-watch (almost 11 % of the final course grade), laboratory/homework packets worth 39% of the final course grade, and four tests which accounted for the remaining 41% of the course grade. The students could turn in a teaching notebook similar to the one kept by students in the physical science course. The notebook counted as extra credit, but could only affect the final grade by less than 1%. In perusing two of the three the exams I was given, I did not discern any higher order critical thinking skills being assessed in the mostly multiple-choice format. These tests only assessed the students' knowledge of the subject material. The third exam consisted either of answering essay questions where the student had to explain basic information, or designing a board game for use in an elementary classroom. Although the essay questions did require the critical thinking skill of explanation, the explanations were very low-level descriptions and did not require explanations of any abstract ideas. But the exam option of building a board game, the POE centers, and lesson plan/project required the students to use most of the core critical thinking skills, with the exclusion perhaps of numerical analysis skills.

Since there were no changes to the biology course in response to the AAT mandates, I did not expect any changes in student assessment. Almost 75% of the course grade was based on exams. The two exams given to me by the biology instructor were each 90% multiple choice and 10% short answer. These exams appeared to test mostly for lower order thinking skills. Three written assignments, the "ask and answer" exercises previously mentioned (6% of the final course grade), could possibly involve higher order thinking skills. The assignments that involved the most critical thinking, and required the student to use all of the core critical thinking skills, except for dispositions (Jones, 1995), were the laboratory experiments using the scientific method. However, this accounted for only a small portion of the final course grade.

Thus far, this case study has concentrated on the faculty attitudes toward the mandates of the AAT degree and how their courses support these mandates. It is also important to know the way that students perceive constructivist learning activities and the critical thinking that is necessitated by constructive or inquiry-based learning.

Students' Perceptions of Constructive Teaching Activities

Both the physical science instructor and the earth and space science instructors initially agreed to allow voluntary student participation in the Student Questionnaire. However, the physical science instructor seemed somewhat hesitant and did not set aside time for the questionnaire. I am not sure why he was reticent, perhaps because he needed the full class periods in the lectures I observed in order to cover the required material. There was some time left over at the end of the observed laboratory session, but it was the Friday afternoon before spring break, and the students were more than anxious to leave. The instructor empathized with the students and I sensed that he felt it was heartless to make them stay in the lab any longer.

The students in the earth and space science course were asked to voluntarily fill out a student questionnaire studying aspects of critical thinking and student behavior (see Appendix M). Fifteen students filled out the questionnaire, nine males and six females. These students were asked if the science course they were enrolled in helped them to improve their abilities in different aspects of critical thinking: interpreting written information, analyzing numerical data, explaining scientific information to others, and evaluating strengths and weaknesses of information or arguments. For each question a student answered affirmatively, he or she was asked to name a specific course assignment, such as one particular essay, or an entire classification of assignments, such as laboratory reports, that helped in the improvement of critical thinking skills. The student was then asked to elaborate on how that course assignment was helpful. The students were also asked to explain what their instructor did in terms of teaching that helped them to learn. The last question of the survey asked if students preferred working in groups or working individually, and they were also asked to explain their responses.

Perceived Improvements in Critical Thinking

Of the 59 possible yes or no responses to the core critical thinking skills questions, only 41% (24 responses) indicated that students perceived that aspects of critical thinking were taking place, while 59% (35 responses) showed that students were not aware that aspects of critical thinking were taking place (see Table 9).

The only aspect of critical thinking in which over half of the students perceived gains was the core skill of explaining scientific information to others. An impressive 80% of the students perceived gains in this skill. Half of the twelve individual affirmative comments students offered indicated that the students actually used this skill often in class. Three students said that explaining material to classmates was very beneficial and another two students mentioned that the POE centers they created were helpful. In the POE centers, students are asked to predict, observe, and explain. The students need to be able to defend their predictions and explain predictions and results to others. One student said that the instructor always encouraged them to share what they learned with their families. Along with encouraging students to share learned material in order to reinforce their explanation skills, the instructor based about 19% of the final course grade directly on assessment of explanation skills.

Table 9
Lakeview Earth and Space Science Students' Perceptions of Critical Thinking

Core Critical Thinking Skill	Yes		No	
	N	%	N	%
Interpret	7	47	8	53
Analyze	2	13	13	87
Explain	12	80	3	20
Evaluate (only 14 resp)	3	21	11	79
Totals	24*	41	35	59

* Three "maybe" responses were included in the yes column.

In contrast to the perceived high gains in explanation skills, only 13% of the students noted any improvements in their ability to analyze numerical data. The single comment from one of the two students who indicated a gain in analysis skills involved scale conversions with maps. It was very obvious that the instructor did not feel the need to emphasize numerical analysis in the design and implementation of her course. It appears that most of the topics covered in the syllabus are non-mathematical in nature. None of the exams I studied had any mathematics at all. The sample laboratory handouts I analyzed also showed minimal use of mathematical skills or processes. In fact, in the laboratory that I observed, the instructor did the calculation of the percentage of salmon that survived to the end of the game about the migration of the salmon.

Results for the remaining two core critical thinking skills (interpreting written information and evaluating strengths or weaknesses of information or arguments) show that most of the students did not perceive gains in these areas. More students noted gains in interpretive skills as opposed to evaluation skills (47% and 21%, respectively). Again, the differences may be traced to what the teacher emphasized and what she did not emphasize. The study of earth and space science naturally entails the use of both physical and conceptual models. The student must be able to interpret the information found in these models. Several laboratories involved looking up material in the text and using this information to help interpret and answer questions about some conceptual models used in geology and astronomy, such as maps, stereograms, diagrams, and other written information. Although the instructor asked the students to interpret information from models and scientific articles, I found no evidence that she required the students to evaluate any of the written materials. For example, in the laboratory that I observed, students read articles selected by the instructor and answered questions based on these articles. But all of the questions pertained to scientific information found in the articles. The instructor did not ask the students to critique the information or compare and contrast information from different articles. Nor did she ask the students to question the validity of arguments put forth in the selected articles.

Looking at the positive student responses as a whole, I could only count 11 of the 24 student responses that gave definite mention of course activities causing perceived gains in critical thinking skills. Five student comments (45% of the total positive comments) indicated that the laboratory component of the course stimulated all aspects of critical thinking except the analysis of numerical data. This number may be an understatement of the importance of the laboratory because 4 more student comments explicitly contained references to laboratory-type exercises. But these comments were not included in the positive laboratory responses because the students did not specifically mention the laboratory in these 4 responses. If these responses were included, then 9 of the 11 (82 %) categorized positive responses would indicate that the laboratory was important in causing perceived gains in critical thinking.

Perceived Helpfulness of Teaching Techniques

Although overall, only 41% of student responses indicated perceived gains in critical thinking skills, all the students were still able to give an example of teaching techniques or instructor attributes that helped them learn. A quote from one student serves as a good summation for most of the comments offered by the students:

> She provides lots of hands-on experience. Most of our labs aren't just bookwork but we see/use the concepts. For example, to teach us about the rock cycle she set

up stations and as a group we moved around the different stages of the rock. She also applies to the differences in which we learn better. For example, she supplies us with a visual power point that she goes in depth auditorialy.

Four students specifically mentioned the use of hands-on experiences. About half of the class cited that the use of diagrams and visual aids was very helpful. Putting these comments together, eleven of the fifteen students appeared to be very visual learners, and were well accommodated by the instructor.

The students generally seemed to appreciate the opportunity for active-learning within small groups. Only one student did not like working in groups because of the unequal participation of the group members. The rest of the students preferred working in groups because they could easily exchange ideas and get information from others that they themselves would not have gotten. However, two of these students qualified their positive responses by saying sometimes they actually preferred to work alone, specifically when the concept was not difficult, or when groups lost focus and they became distracting. I was only able to observe one lecture/laboratory period with these students, but my observations were consistent with the student comments. The students appeared comfortable and familiar with group work and the structure of the laboratory. They went about their assignments willingly and freely interacted with the instructor. Within the class session that I observed, the activity that involved the most critical thinking, and that the students seemed the most engaged in, was the inquiry-based activity on groundwater and relative permeability of different soils. The students were given guidelines and a prediction question. From this, they designed their own experiments and decided what variables that they wanted to test in order to answer the prediction question. Although the game involving the students following the life cycle of the salmon had some engaging aspects, such as recognizing the odor of the home stream, several students appeared to just be going through the motions. This exercise did not stimulate much critical thinking and was more informative in nature.

Potential Factors Affecting Implementation of Change

The students' attitudes toward critical thinking and constructivist learning may have an effect on how open or resistant they are toward student-centered learning (Bonwell & Eison, 1991: Hansen & Stephens, 2000). This in turn could influence their instructors as the instructors plan course activities. According to the literature, there are several other factors that may come into play as the science faculty implement changes in their courses in response to the AAT degree mandates. Stark and Lattuca (1997) identified three (sometimes overlapping) spheres of influence on college curriculum: external, organizational, and internal. These sets of influences can also affect faculty as they try to implement academic change, and will be discussed in detail in the following sections.

External Factors

Stark and Lattuca (1997) defined external influences on college curriculum to be beyond the control of the college. Some examples of external influences given by Stark and Lattuca include society as a whole, accrediting agencies, publications, concerns of employers, and the media (1997). I found three external factors that affected the faculty at Lakeside as they designed the science courses associated with the AAT degree.

The set of mandates of the AAT degree is the major external driving force that initiated the need for changes in science courses at Lakeside Community College. The

National Science Foundation funded MAPT initiative was a supportive factor with the science faculty at Lakeside. This grant supplied funding for the faculty to attend workshops where curricula and inquiry based teaching methods were discussed and modeled. The director of teacher education praised these workshops, stating,

> They were wonderful because they got to meet with other people from other community colleges around the state, teaching the same courses they were teaching, seeing that modeled demonstrations of how to teach particular lessons or how to introduce a concept in an inquiry mode. So they were learning from other faculty as opposed to just learning, doing it on their own, and [the participating science faculty] found it very energizing and very exciting.

The physical science instructor was very active in this grant and helped develop curriculum guidelines for the physical sciences. He related that participation in this grant had been a great experience, and said, " [I was] able to meet other people in the state, meet old friends and new people, and share ideas. I think this is real helpful to me, the support that we are going through this together and share ideas." The earth and space science instructor also participated in this grant. She presented a brief discussion of POE centers and brought an example that was done by one of her current students. She also benefited from these workshops, and was able to use and modify lessons that were demonstrated. For example, a presenter went through a lesson using a dichotomous key for seashells, the physical science instructor commented,

> And this is taken from that Saturday meeting when we did those seashells; I decided to do the clouds. So I made this key up and now I am working on getting photographs… good enough for them to identify the clouds. So instead of

> standing there and lecturing on clouds, I'm going to give them [a dichotomous key that they can use to identify clouds].

The third external influence was the local county public school curriculum. This was deemed to be important by both the physical science instructor and the earth and space science instructor when they planned the content of their courses. These instructors wanted to be sure that their students were familiar with the essential curriculum for K-8.

Organizational Factors

In Stark and Latucca's model, organizational factors such as the college mission, financial stability, resource availability, and opportunities for faculty renewal may be either supportive or non-supportive influences on curriculum planning and change (1997). Organizational factors affecting change at Lakeside Community College include administrative support for the AAT degree and the faculty who teach the science courses for the degree, financial support for faculty renewal, constraints of course scheduling, and academic inertia. Both the director of teacher education and the chairman of the science department were very supportive of the science faculty. They showed their confidence in these two instructors by giving them a free rein in the design of the physical science and earth and space science courses. Both faculty were given modest summer financial grants in order to develop the earth and space science course. When budgets permit, faculty are allowed five hundred dollars for travel expenses. For example, the chair of the science department paid the expenses for the earth and space science instructor when she attended an NSTA (National Science Teachers Association) national convention.

Although there was strong support for the AAT degree, there were some obstacles that had to be overcome in order for the faculty to schedule the earth and space science course and to implement the changes in the existing physical science course. The physical science instructor noted that scheduling new courses was difficult because these courses always had to be squeezed in around existing courses. The scheduling is also complicated due to working around both the existing faculty course load and schedule, and the problem of somehow fitting classes into a very heavily booked physical science laboratory. The physical science instructor successfully overcame the barrier of academic inertia. First, it took about one year just to get his course changed around through the committee that oversees curriculum and instruction. Part of the difficulty stemmed from the structure of non-major science courses. Ten years ago, non-major science courses were split into lectures with separate, optional labs, and the physical science instructor said, "It was hard; I had to fight that for a while so that the lab was required for [the physical science] class."

The director of teacher education felt that she was not successful in getting the biology faculty to teach using the inquiry method, and admitted that she did not pursue this aggressively. Near the end of the interview, she shared her thoughts about this, and stated,

> I would like to try and figure out how to encourage faculty who are not teaching in the inquiry method to do that….I've not made an enormous effort because [both of the biology instructors] are outstanding, excellent faculty members, and I don't want to make their job unhappy, and I don't want to try and make their lives miserable. And I know, if I felt that they weren't doing a quality job of teaching the content in biology, I would worry….I find that it is not so easy to get people to change how they teach and how they organize their instruction….There has to

> be a buy-in, and…if they feel they're doing it 100% the right way, there is not going to be an impetus for change.

Although the director of education perceived a lack of inquiry done in the biology course, the interview with a biology instructor and casual observance of snippets of a biology laboratory revealed that there was some inquiry-based learning experiences in the biology courses.

Internal Factors

According to Stark and Lattuca (1997), internal factors that exert influence on college curricula include such factors as faculty backgrounds, disciplines, educational beliefs, and student characteristics and goals. Relative to this study, I have discerned nine internal factors (and their interactions) that could affect faculty as they transition into the AAT science courses. These factors are summarized in the Concept Map (see Figure I, p. 31) and can be divided into three interrelated groups. The first group includes attitudes toward the manner of the request for change, awareness of the intent and purpose of the AAT degree, participation in the change process, and belief in the change. Prior use of constructivist pedagogy, academic and professional background, and teaching philosophy are the components of the second group, and the last group brings together the students' attitudes toward learning and the faculty's attitudes toward students.

Attitudes toward request, awareness, participation, and belief in change. The introduction of the AAT degree and the science courses needed to support it came from the director of teacher education and the chair of the science department. The physical science instructor learned about the degree directly from the director of teacher education and then passed his knowledge on to the instructor of the future earth and space science course. But the chair of the science department was the one who actually asked the earth and space science instructor to help develop that course for the AAT degree. I do not believe that the biology faculty (at least the one I interviewed) were given full knowledge of the degree by the director of teacher education. The director stated that the two full-time biology lecture instructors were invited to attend the MAPT meetings but she had been unable to get either one to go. When I asked the biologist I interviewed if she had any knowledge of the AAT degree, she stated that she did not.

I did not directly ask the physical science or the earth and space science instructors about their reaction to the manner of the request to teach the science classes for the degree. It was obvious that these two instructors were happy to have been asked to participate in the degree program and did not have any problems with the way they were approached. The physical science instructor was pleased to be able to teach an AAT science course, and said, "I always liked to do teachers, teach teachers because they are helping students in the future and getting them interested in science, which is where my passion is." The earth and space science instructor was excited to be able to design the earth and space science course for a totally different reason than that of the physical science instructor. The earth and space science instructor was an adjunct at the time she was approached to help design the earth and space science course. Her reaction to the department chair's request is as follows: "Oh, yes, I was excited about it. He asked me to design the course with [the physical science instructor] before I had been hired full time and I thought, 'Oh, well, this couldn't hurt!'" This instructor reasoned that since she was the one designing the course, she would be the one most familiar with it and therefore, would be the best candidate to teach it, and this might help her to gain a full time position within the college.

As noted before, the director of teacher education, the physical science instructor, and the earth and space instructor were all aware of the intent and purpose of the AAT degree, although the director of teacher education was not fully aware of the pedagogy requirements of the degree. All three of these faculty had full participation in the change processes necessitated by the AAT degree requirements. The director of teacher education participated in the initial, state-wide design of the degree. Both the physical science instructor and the earth and space science instructor were involved with the MAPT grant and were allowed to design their courses as they saw fit. I believe that this large degree of both participation and freedom in the change process are factors that may have reinforced these three faculty's belief in the changes needed to satisfy the mandates of the AAT degree.

The director of teacher education was convinced that the AAT degree was beneficial to all concerned: the four-year schools, the two-year schools, the students, and the public school children who eventually will be taught by AAT graduates. This is evidenced by the quotes given earlier in this study. The physical science instructor thought that having elementary education majors take physical science was very important because the elementary education majors would now be exposed to physics where most of them would not have in the past. This exposure was beneficial because it would give the students a chance to learn materials that they would be expected to teach. The instructor of the earth and space science course felt that the AAT degree science courses would give elementary education majors a well-rounded view of the sciences.

She also stated that topics that she taught in her course were relevant to the local county curriculum. All three of these faculty mentioned that the AAT science classes seemed to lessen the fear or dislike of science classes that most students seemed to harbor. The physical science and earth and space science instructors both noted an improvement in attitudes toward science. The latter instructor related this example of attitude change in students:

> We actually do have surveys that the students take at the end of the year, and one of the questions is, '[Did] your overall opinion of what the class, of science, whatever, improve?' And I'd have to look back to see; generally it doesn't necessarily. For this [AAT] class it does, but for science in general, usually not.

Prior use of constructivism, faculty background, teaching philosophy. The physical science and earth and space science instructors were the only two participants that I obtained any information about prior use of constructivism. The physical science instructor had more experience with constructivism, and inquiry in particular. In fact, inquiry was stressed in the latter part of his academic training. He did not have any learning experiences based on constructivist teaching methods when he was in public schools or in his undergraduate studies. It was during the time when he was pursuing his advanced graduate specialist program (1988) that he was made more aware of his constructivist tendencies. He worked under the aegis of John Layman, one of the most influential leaders of the constructivist school of thought in physics education. Dr. Layman convinced the physical science instructor that he was already using many constructivist methods, but just needed to go a few steps further in order to make the transition to inquiry-based teaching. During this time, the physical science instructor was also introduced to more modern microcomputer-based labs, which became a passion. The earth and space science instructor related that she was not taught under the constructivist or inquiry paradigm, and did not use constructivism when she first started teaching. Her initial exposure to constructivism occurred when she began taking courses toward public school certification. She recalled,

> When I first started teaching…I didn't know about different learning styles. I hadn't read about them; I hadn't heard about them. I hadn't taken any education courses. So once you learn that people learn differently, then you realize you can use different methods.

Initial exposures to constructivism were important to both the physical science instructor and the earth and space science instructor, and sparked a desire for more knowledge and use of this type of pedagogy. Their use of constructivism and their professional activities seem to form a positive feedback loop. The more active these instructors were in professional organizations, the more they wanted to learn about constructivism. The physical science instructor is very active in the national and sectional levels of the American Association of Physics Teachers (AAPT). This association has a very strong component of physics education that promotes constructivist and inquiry based pedagogies. The physical science instructor has received additional training in microcomputer-based laboratories from the local AAPT section and has presented an AAPT sponsored workshop for teachers. Because of his initiatives and work in improving physics education at Lakeside Community College, the college was awarded the prestigious designation as being one of ten schools in the nation with exemplary programs in physics. During the site visit by three physicists representing an initiative sponsored by the AAPT, the Two Year Colleges in the 21st Century, the physical science instructor described the AAT degree. The physicists were impressed with the degree and thought that it would be a good program for other states to follow. However, the physical science instructor's professional activities are not limited to the AAPT. He occasionally goes to National Science Teachers Association conventions and is also very active in the county, serving as the chair of the science advisory committee. He has been awarded several Eisenhower grants in past summers; these grants promote the teaching of teachers.

The earth and space science instructor has membership in several organizations: NSTA, National Earth Science Teachers, National Geo-science Teachers, and the American Association of Petroleum Geologists. She mentioned the NSTA as being a particularly important resource. Her enthusiasm is evident in this quote:

> If I could, I would go to that NSTA convention every year because it is just fabulous. We have a lot of training here in house, but it is not necessarily on inquiry-based science….But the NSTA conventions are just fabulous because they are what you need—they focus on science teaching, "this is the way you should do it."

As mentioned before, this instructor's participation in the MAPT grant also provided ideas for the classroom and increased her desire to learn more.

It is evident that the backgrounds of these faculty helped to shape their teaching philosophies. The physical science instructor quickly described himself as being a constructivist when I asked him to describe his philosophy of teaching. He contends that it is very important for students to understand the theory and major concepts in physics, and takes a conceptual and hands-on approach in his physical science class. This instructor also thinks that it is important to integrate chemistry and biology into his physical science course, and he makes references to topics important in the earth and space science course. I asked him if teaching an AAT science course influenced his philosophy, he replied, “Probably no….It’s given me the freedom to really pursue the constructivist approach….I have more control [over the content] so I really can see they really understand the topics we cover.”

The earth and space science teacher gave a different type of description of her teaching philosophy:

> I don’t know if I have anything standard or patent or whatever, but I try to teach everybody in the classroom, not just the kids that are excelling in the front, but the kid that’s shy, that’s in the back, that is really struggling. I try to use lots of different methods to teach everybody in the classroom.

She stated in the following quote, that, along with her affiliations with professional organizations, her experience in the classroom was also a major influence on her philosophy:

> Well, part of the major influence is lecturing and looking out at the class and they all look like [zombies]. And you realize that you are just not getting through. They are all asleep. And then seeing other techniques modeled. When I took methods [courses] and someone would come in and they would do cooperative learning, and I would see…the people taking the class, and we were all teachers; they are excited about it, about doing it. And I thought, “Gee, that would work better than me standing up there”….So it’s seeing it modeled….And [the physical

> science instructor] has helped me a lot, and just going to those MAPT meetings. Just seeing when [a science faculty from Beltway Community College] came around with a bag of rocks and had us [begin to categorize them], I said, "Wow, look, I can try this with…clouds!"

Even though I did not ask the biology instructor about her experiences with constructivism, I thought it important to understand her philosophy of teaching. From her description of the learning materials that she helped author, and from how the lecture is structured, it seems reasonable to categorize her as being an instructivist. She is clearly the dispenser of information in the lecture hall. But, I also think there are latent constructivist tendencies within her teaching philosophy. For example, the laboratory associated with the lecture has components of inquiry based learning, as evidenced by the students' use of the scientific method and the testing of hypotheses. A more telling hint of constructivism can be found in her response to my question about how she would design a biology course for elementary education majors:

> I would incorporate all sorts of kind of whiz-bang-wow things to grab their attention and make them have fun. So I think it would be a lot of hands-on, real colorful kinds of visual things. Have them look through a microscope and see something moving and…where it would just be a lot of fun so that they would be excited about science instead of being scared of it.

So in this aspect, she is very similar to the other instructors I interviewed, especially the earth and space science instructor, who likes to use games to pique her students' attention and to allow them to have some fun in the learning process.

Students' attitudes toward learning and the faculty's attitudes toward students. The students in the two AAT science courses appeared to be a typical mix of community college students, although I do not have any demographic information about the seventeen students (5 males, 12 females) in the physical science course since they did not take the student questionnaire. The students (9 males, 6 females) in the earth and space science course tended to be of traditional age for beginning college students; nine of the fifteen students were between 18 to 20 years old. Only four of the students were 24 years of age or older. The majority of these students, 87%, were going to school full time. The earth and space science course was the first college-level science course for four of the students. I doubt that most of the students in both classes had been exposed to inquiry based learning, but I do not have any direct data on this. However, it appeared that the students in both classes were amenable to student centered learning, as evidenced by their level of comfort and behavior in the classes, especially in the laboratory periods that I observed.

I observed two lecture periods and one laboratory of the physical science course and one back-to-back laboratory/lecture period of the earth and space science course. In the laboratory, where most of the inquiry-based learning was occurring, the students worked in groups and appeared to be engaged in the various activities. I could hear discussions between students, and the instructors freely interacted with the students. From my observations, I can conclude that the students generally seemed receptive to inquiry-based learning. Comments obtained from the faculty interviews and from the interview with the director of teacher education confirm my observations. The physical science instructor told of the initial attitude of the typical AAT student, and how that attitude usually changed throughout the course of the semester:

> They are really afraid of science, especially physics and chemistry. They hear the horror stories of how they are going to burn themselves with the chemicals, or how the janitor had to evacuate the building because somebody is pouring bleach and ammonia together, and it still happens. So they are really afraid of the chemistry. Physics, they're afraid that they are going to get electrocuted or shocked or something like that, even with batteries….The hands-on thing is helpful for most students….They come out [of the physical science course]… saying how much they really enjoyed science after it.

The earth and space science instructor said that the elementary education majors seemed to be more dedicated and generally put more effort into the course than non-AAT students. She attributed this to the AAT students having a definite major, having more of a goal than undecided students. The director of teacher education noted that the elementary education majors that she has spoken with are willing to work in the AAT science courses. She summed up student attitudes, relating,

> I just hear that they feel that the science courses are very accessible. They don't come to me and say, "I'm so scared in physical, I know I am not going to pass"…. The students feel that it is work that they can handle.

However, the earth and space science instructor has heard a different story from some of her students: "I think the physical science is a little difficult for the elementary, the real elementary, at least that's the feedback I get. For the ones who want to teach kindergarten, they think it's really much."

Summary

At the time of the site visit at Lakeside Community College, the science courses supporting the Associate of Arts in Teaching (elementary option) were in various stages of development. The physical science course was the most mature course as far as inquiry-based pedagogy is concerned, and the instructor was for the most part satisfied with the course. He was in the process of fine-tuning the content and getting the class meeting times to be more fully compatible with inquiry learning. The earth and space science course had strong components of constructivism, but not as much inquiry as the physical science course. The director of teacher education was not satisfied with the biology course because she felt there was not any inquiry-based learning present. But I think the director of teacher education was not fully aware of what actually happens in the biology course. According to the biology instructor I interviewed, although the lecture mode is instructivist, there are components of constructivism in the lecture. But this constructivism is more of a "brains-on" rather than "hands-on" form. The biologist does ask students to make predictions and think about outcomes of situations. The biology lab incorporates a strong component of inquiry-based learning because the students use the scientific method to test hypotheses. Although the earth and space science instructor employs more constructivist activities than the biologist does in lecture, the biology course and the earth and space science course appear to be very similar in terms of true inquiry-based learning. Even though the pedagogies of the instructors were diverse, they, and the director of teacher education, were all very interested in helping the students overcome their fear of science.

The administration offers strong support for the AAT degree. This is evidenced by financial support for faculty renewal and professional development. The MAPT workshops, which were promoted by the director of teacher education, have been very helpful to the science faculty who attended them. Both the director of teacher education and the chair of the science department are committed to helping the physical science and earth and space science instructors as they negotiate their way through the change process. All four of these faculty have good rapport with each other and mutual respect is evident. The relationship between the physical science instructor and the earth and space instructor is especially harmonious. The two science faculty mentioned here are excited about the AAT degree, and in teacher education in general.

Even though the AAT degree was introduced to the faculty by the director of teacher education and the science department chair, the physical science instructor is the linch-pin of the degree's science component. He is the driving force that really got the AAT science courses organized and implemented (except for biology). He has spent many of his 35 years in the profession in promoting science education; this is obviously one of his passions. The earth and space science instructor is younger, and I believe the administration should seriously consider grooming her to take the leadership position of the physical science instructor, should he decide to retire.

Chapter Seven: Case Study of Beltway Community College

This case study will be divided into seven major sections. The first section includes all of the necessary background information and will describe the institutional context, history of the Associate of Arts in Teaching degree at Beltway Community College, and the backgrounds of the faculty interviewed. In the next three sections, the faculty's awareness and knowledge of, and attitudes toward the Associate of Arts in Teaching degree (AAT) requirements, individual changes to course content and pedagogy, and changes in assessment techniques will be explored. In the fifth section, the discussion will center on the students' perceptions of teaching activities. Potential factors affecting faculty implementation of changes will be reviewed in the sixth section. This section is further broken down into three separate types of factors: external, organizational, and internal. The seventh and final section will summarize the key findings in this case study.

Background Information

Institutional Context

Beltway Community College is a very large, multi-branch metropolitan college located near our nation's capital. Beltway's fall enrollment included 3,352 full time credit students and 9,212 part time credit students, for a total of 12,564 credit students. These students are enrolled in more than sixty different programs of study. The average class size is around twenty students. This college is proud of its ability to fulfill its mission of service to the community by each year hosting more than one thousand events sponsored by community organizations. It is situated on a fairly flat tract of land that is dominated by huge parking lots separating an expanse of outdoor recreational facilities and the rest of the campus. Most of the academic buildings are large, imposing brick structures that seem to dwarf the students, but this coldness is offset by the presence of a few very large, old trees and many comfortable outdoor benches inviting students to relax outside.

The science building is a new, modern building with a multi-story, glass-enclosed foyer dotted with a few sculptures. This sunlit area also has many places where students can sit and relax or study. Photographs and short biographies of successful alumni are displayed on the walls. The laboratories that I was able to look at are modern and well appointed. The room that houses two of the AAT science courses was actually designed to accommodate a constructivist, inquiry based class science class. The front of the room is covered with white boards and a projection screen. There is a computer at the front of the room for the instructor to use in conjunction with a ceiling mounted projection system. Moveable, individual student desks are centered in the middle of the room. Laboratory benches are situated on each side of the room. These benches have water and electricity and can comfortably accommodate four to five students. A ventilation hood is located near the center of the back wall of the room. There is ample storage space in the form of drawers and cabinets, and both sides of the room have countertop space. A small storage and preparation room adjoins the rear of the classroom.

History of the AAT Degree at Beltway

Maryland's Associate of Arts in Teaching degree (elementary option) follows the current conceptualization of teacher preparation by stating outcomes for elementary teacher candidates that should be achieved within the first sixty credit hours of a Bachelor's degree in education. The science outcomes for the elementary teacher candidates were established by science faculty from two- and four-year colleges and universities in Maryland and were based on the National Council for Accreditation of Teacher Education (NCATE) standards, since the Maryland four-year colleges follow NCATE guidelines (see Appendix A). The *Maryland Outcomes for Teacher Preparation – The First Sixty Hours, Elementary/Middle School* (TEAC, 2001, p. 19) lists the content and pedagogy requirements for the AAT degree and emphasizes that the "professional development of teachers of science requires learning essential science content through the perspectives and methods of inquiry."

Using the guidelines found in the *Maryland Outcomes for Teacher Preparation – The First Sixty Hours, Elementary/Middle School* (TEAC, 2001) as a basis, individual schools organized their own programs of study for elementary teacher candidates that would meet designated outcomes, and then submitted these proposals to the Maryland Higher Education Commission (MHEC) for approval. The director of teacher education at Beltway Community College was actually co-chair of the Teacher Education Articulation Committee (TEAC) that was in charge of creating the AAT degree, and she gave some historical background:

> We were appointed by the chief academic officers; they are the vice presidents of instruction for the two- and four-year colleges.… Our mission was … to find a way to simplify the transfer of two-year teacher education students from the two-year schools to the four-year schools…. At that time there existed close to 300 individual articulation agreements between the two- and four-year schools in teacher ed. alone. And even with that, students were having terrible problems [with transfer to four-year schools] and we also had no way for the two-year

> schools to recruit students because we had no programs for them…. the four-year schools would not accept in transfer any pre-professional course that we might offer [at Beltway]. So we did not have any because they wouldn't accept them.

She also related that it was a very long and difficult process to finally agree to the outcomes-based AAT degree, with most of the opposition to the degree coming from the four-year schools that did not want to change entrenched programs considered to be educational models. These schools did not want to lose control of any pre-professional courses or field experiences. But TEAC's efforts to include these types of offerings at the two-year schools were bolstered by a document called *Maryland Redesign for Teacher Education* (MHEC, 1995). This document states that teacher preparation should be a four year program, with frequent field experiences provided early in the program, which none of the four-year schools were doing. With this, and support from other state agencies, the AAT degree was finally approved by the Maryland Higher Education Commission (MHEC), and Beltway Community College was in the initial group of six community colleges to gain MHEC approval to offer this degree.

According to the director of teacher education, the earth and space science and physical science were already in place before the AAT degree was instituted:

> We were a little ahead of the game. Prior to the AAT we saw a need because we were familiar with national standards … a need for courses for teachers. There are a lot of teachers who are uncertified in the county who are coming back to us to take science and math courses because they need twelve [hours] to be certified. We wanted a course that would model this new [inquiry] teaching style. I developed the first one, that was the PSC 120, and it was chemistry and physics,

> [the physical science course]. We knew we had to get chemistry, physics, earth and space science content and biology content for the teacher. So therefore you might have five courses. So it became necessary to blend the content of chemistry and physics into one course and earth and space science into another. This way it was manageable; they were both four-credit courses. The biology was four credits and, lo and behold, it met the twelve credit requirement for elementary teachers for the [Maryland State Department of Education]…. [The earth and space course and the physical science course] are running now. They have been running continuously since about 1995.

There is no distinction between lecture and lab in the two above courses. The biology course that Beltway students take as an AAT science course has separate laboratory and lecture sections, and the two are not integrated. But, according to the director of teacher education, there is more investigative, hands-on work in the biology laboratory than there was before the AAT degree was instituted at Beltway.

Faculty Interviewed

I interviewed the director of teacher education and the two faculty who were currently teaching the earth and space science course and the physical science course (see Interview Protocol for Director of Teacher Education and Interview Protocol for Science Faculty in Appendixes G and H, respectively). However, I was not able to interview any of the biology faculty. All three of the faculty I interviewed were very experienced with constructivism and inquiry based pedagogy. When I interviewed the director of teacher education, I was mainly interested in her knowledge of and perceptions of the AAT degree and did not obtain much specific information about her academic background.

She does have a BA in chemistry for St. Joseph's College, an MEd in secondary science education from the University of Texas, and a PhD in chemistry education from the University of Maryland and has been at Beltway Community College for well over twenty years, first as a teaching faculty, and for about the last five years, the director of teacher education. She maintains a close relationship with the two other instructors who I interviewed and has a strong influence in the field of science education.

The instructor who teaches the earth and space science course has been teaching for thirty years, with the last twenty-eight years spent at Beltway. She described her education as follows:

> I have a BS in Chemistry, an ACS degree from Catholic University. I have a Master's in analytical chemistry from the University of Maryland, and my doctorate is in curriculum and instruction with specialty in science education from the University of Maryland. For that degree you have to qualify as a PhD candidate in chemistry and as a PhD candidate in education, so you have to meet both sets of requirements. You have to take qualifying exams in both areas and then you do a dissertation in one area or the other and my dissertation was on problem solving with emphasis on … equilibrium….

She has taught a variety of courses including general chemistry, chemistry for allied health majors, chemistry in society, a course emphasizing chemical evolution, and honors colloquia. She has also taught chemistry laboratories, astronomy and astronomy laboratories, and actually developed the AAT earth and space science course. In fact, she has been the only instructor to have ever taught the earth and space science course at Beltway Community College.

The instructor of the physical science course has thirty-five years of teaching experience. He has a Bachelor's degree in biology, majoring primarily in physiology. He obtained a Master's degree in food technology from the University of Miami and studied food chemistry at the University of Maryland. This instructor has taught a wide range of ages and types of students: from high school biology, chemistry, and physics to a graduate course in chemistry for education majors. He has taught as an adjunct professor at Beltway for about fifteen years. At the time of the interview he was teaching advanced placement chemistry and honors physics in high school, and a new conceptual physics for ninth graders. He also was teaching general chemistry and the AAT physical science course at Beltway.

Awareness and Knowledge of and Attitudes Toward the AAT Degree Requirements

Awareness and Knowledge of AAT Degree Requirements

Before the researcher could determine the faculty attitudes toward the AAT degree and its requirements, it was necessary to understand faculty awareness and knowledge of the AAT degree requirements. All of the faculty interviewed were either explicitly or implicitly very aware of both the content and the pedagogy requirements of the AAT degree. As mentioned before, the director of teacher education actually was quite instrumental in the creation of the AAT degree. When I asked her if there were any specific requirements the AAT science courses should meet in terms of content, she replied,

> In writing the content we looked at the Maryland outcomes, the Maryland core curricula, the national … content standards, we looked at all the ones we could

> find…. But the content, what should be taught at the different grade levels, we went by state and national guidelines.

She was very knowledgeable of the pedagogy mandated by the AAT degree, as evidenced in the following quote:

> It states very clearly the method of instruction should be inquiry-based, student-centered. Start with a research question that either you generate, have the students generate or you generate for them, guided inquiry in that case. And it should be hands on activities and, it's more than just us; … again, national standards have said that this is the way to go. Research has shown that students have greater achievement if they do this.

The earth and space science instructor discussed her initial involvement with the AAT degree:

> I probably have known about [the AAT degree] since its inception because a lot of the foundational work came from work that [the director of teacher education] has done, and of course [she] is a colleague of mine here at the institution. So we have been working on teacher education programs for over 20 years. And so I knew what, that it was in the process when she was working on it so I guess I've known about it, I knew about it even before it became accepted by MHEC as a state wide program…. So I worked with her on setting up the chemistry objectives in the program and also working with her on the earth and space science, what they needed to do. I didn't work on some of the committees but worked with her independently on those.

This instructor volunteered to develop and teach the earth and space science course. She explained her reasoning for wanting to teach the course:

> Actually, I went to [the director of teacher education] and said we've got one [course] in chemistry and physics, we need one in earth and space science. So I approached her and said, "If you want that in the program I'm willing to do it." Because, I thought, although geology isn't my strong suit, I know I have a fair number of credits in geology and astronomy; I don't have a Master's or anything equivalent to that, but I have a fair number of credits in both of those areas. And there really wasn't anybody else who had the same educational philosophy who taught in those disciplines. So I said to her that I would be willing to set it up and do it, and she was very receptive.

The physical science instructor's awareness of the AAT degree mandates is somewhat implicit in nature, yet he is well versed in the content and pedagogy requirements. He stated that he has not read anything about the degree and did not know specifically what courses students needed to take, but he had been in some sessions where science course content was discussed. His awareness of the degree requirements seems to be a natural consequence of two related activities. The first influence was his involvement in running summer institutes for science teachers for many years in conjunction with the other two faculty that I interviewed. Secondly, his long service as a science teacher in the public schools and his position as the science coordinator for his school naturally made him aware of the science content and pedagogy required for the AAT degree.

When asked how he learned about the AAT degree, he stated,

> Well, probably when I first began teaching this course, which was several years ago. But [the director of teacher education] and I have been working with teachers for a long time. In fact, the concepts of this course were probably derived a lot from institutes that we've worked over the last fifteen years. We do an institute every summer for physics and chemistry for elementary school teachers. We did sessions in science, which was the teachers came during the school year after school to take specific topics…. And when it finally came about to say they want us to get a course for elementary school teachers, it was just an easy thing to do because we had done so many of the things already.

He went on to say,

> I'm the science coordinator for my [high] school and I have to go to middle schools and elementary schools to coordinate how the high school works with them. And I've become very much in tune with the scope and sequence of what these children have to have in science. And the more I looked into it, the more I said "we need to have this [content] for the course" … because I see … what these teachers are going to have to know.

Upon review of faculty responses to interview questions, it is clear that these three faculty work closely with each other and seem to communicate very well with each other. All three of these faculty were involved in one way or another in the beginnings of the AAT degree, and they have worked with each other in the field of teacher education for a very long time, so one would expect them to have a great deal of knowledge about the content and pedagogy requirements of the AAT degree and have positive attitudes toward the degree.

Attitudes Toward AAT Degree Requirements

The director of teacher education had a very positive attitude about the AAT degree for two major reasons. The first reason the director mentioned was the inclusion of field experiences in the first two years of the teacher education program because she said this helps the student decide early on if teaching is an appropriate career. The second reason was because she thought that the rigor of the AAT degree program prepares the students well for work in the public schools. She also felt that the outcomes for the degree were very well matched to educational standards. She was convinced that the AAT science courses would improve the science skills of the elementary education majors, and explained what would probably occur if the AAT science courses were not available:

> Well, they'd have to … take biology and that would be good. They'd probably take astronomy, which here is a lecture … and watch slides. And what else would they take? Nutrition. Where would they get the chemistry and the physics and the geology that they need to know to teach the elementary curriculum? So I think without these courses they would have been at loose ends. They would not have been any where near meeting the kinds of national standards that is [sic] expected. And of course they wouldn't have had the modeling of the inquiry approach that they get. They know what it is to learn by inquiry. They know the benefits that students have by doing this and how much more interesting it is…. they are more likely to turn around and do the inquiry with their own students than the student who has only experienced lecture and confirmatory laboratories.

The instructor of the earth and space science course was strongly positive, and admittedly biased, toward the AAT degree. When asked if the AAT science courses would improve the education and science skills of the elementary education major, she replied,

> I think so. I'm probably prejudiced because I've been involved with it from the beginning. But I think, particularly science skills, confidence with science, and the ability to do process I think is where they are really going to gain. They may not gain as much in the content area … may not know the names of as many minerals or as many rocks … I don't have them memorize the names of tons of minerals because I just don't think that's necessary, but they need to know the characteristics to identify one mineral from the other, what's good and bad, and how they would go about that. I think probably my emphasis is more on process than it is on the knowing a lot of content. And in that respect I think it will make them stronger teachers because they are going out and they are using the methodology that they should use with their students…. They'll have hopefully some patience with students who are struggling because they have had to go through and struggle themselves and they have to deal with not knowing what the answer is but not letting that stop them, letting them go on.

She also thought that exposing the AAT major to five areas of science instead of just three would be beneficial. But she said that the most benefit would be gained due to the constructivist philosophy that serves as a foundation for the AAT science courses:

> I will say that particularly at our institution, if they took geology or astronomy here [instead of the current earth and space science course], they would not get

> any inquiry; it is not inquiry at all. In fact, there is not very much critical thinking even, in my judgment, in the classes that they took. So the difference with mine is of course less content material but it's also that we are giving them at least a way to … see the constructivist philosophy in action, do some inquiry, and learn techniques in the laboratory and be actively engaged in their own learning…

Although the physical science instructor was not directly asked if the AAT science courses would improve the education of the elementary education major, it was obvious he was very enthusiastic about his course, and how it could help elementary teachers present science to their students, as evidenced by this quote:

> Well, I'm just looking at the teachers who have had this course and courses like this, like [the earth and space science course], and we get a lot of feedback … [from students who] are already teaching. I always give them my phone number and email, and they're emailing, phoning me. They might need to see something and I just see such a difference in their attitude about teaching science after they have had this course, which is, to me, non-threatening. I've designed the course in such a way that I think that it's relaxing and allows the people to really get into the fun part of science as opposed to memorizing tremendous numbers of formulas and plug and chug, as I always call it. I'm trying to get really an understanding of the concepts more than the way a lot of science courses have been taught before this…. And so I think the things we're doing in these courses is the right stuff because we are starting to get a lot of feedback from teachers saying that they really feel a lot more comfortable teaching science.

When asked if he would volunteer to be involved in the science courses for an AAT degree if he moved to a different college, he replied,

> One thing I thought of was when I "retire" from the high school teaching, I would like to go to … colleges … considered to be really good colleges for teachers and really show them this class and say this is something I think you critically need.

Changes Made in Course Content/Pedagogy by Individual Faculty

Neither the earth and space science instructor nor the physical science instructor thought they had any problems in meeting AAT content or pedagogy requirements. They did not have to make changes in their courses because they had made the transition to inquiry-based learning prior to the emergence of the AAT degree, and they also based their course content on local and national science standards. The earth and space science course was already in place a few years before the AAT degree for Beltway Community College was approved. The instructor explained some of the process that she went through when she was designing the course:

> We, I guess before we even designed the course, committees went through and looked at the elementary curricula. They looked at the national standards and the state standards in Maryland and statewide put together a set of outcomes that they wanted to see for the AAT program. Prior to that [my colleagues] and myself had been through the county and the statewide standards and looked at what was in the curricula. And we've been doing that particularly because we've also run teacher institutes in the summer. We're always concerned about what's there. So we knew what the big concepts were that we would have to put into the courses, what the big ideas were. So that had been done before I even looked at the class.

And then I went back, … you can't do everything, but you want to try to do as much as you can, because I had to put earth and space science together, I looked at what were some of the big ideas that needed to be in there, the big concepts. But I also looked at what kinds of processes I wanted in there, what kind of science processes. I wanted them to be able to make observations and design experiments and do predictions, all of the basic and integrated process skills…. So my idea was to put in process as well as content, heavy on the process because that's what they are going to need to do, they need to become comfortable with it. I tried as I do these experiments, in each one to put something a little bit different. There is some redundancy, but there are different kinds of operations that they do: sometimes there's graphing, sometimes they are collecting data, and they are designing experiments, always observing. Not a lot of number crunching because there isn't a lot to do. But [the course was designed toward] … directed inquiry or guided inquiry. I don't do open inquiry because I don't think these kids have time or the discipline to be able to be successful at that. They just don't have enough experience with it. When I looked at them, that's what I really looked at. I looked at the content that would be in the curriculum and also the kinds of processes I wanted to put in. So I had to make some decisions about what topics I put in. I'm sure that other people at other institutions would make other decisions based on what they wanted to do. There is a lot of thought that went into it before I did it. We didn't just take a course and modify it; we just didn't take a geology course and modify it. It's really from scratch, looking at the things I wanted them to do.

Her course syllabus indicated a constructivist and inquiry-based approach to learning, with statements encouraging students to become actively involved in the guided inquiry exercises and to "develop the ability to face new material with more confidence and skill." Classroom observations confirmed that the majority of instructional time was spent on guided inquiry activities. All core critical thinking skills were addressed in one form or another as the students worked through the guided inquiry activities and other course assignments (e.g., portfolios, performance tasks, journal writing, and reflection). The earth and space science instructor had complete control over the content and pedagogy of the course and continues to modify exercises. She has gone through a couple of iterations of her laboratory manual, adding more inquiry based activities.

The physical science course was started in the spring of 1999, and has been taught continuously since that time. The director of teacher education, who is also a member of the chemistry faculty, started the physical science course as a natural progression from the summer institutes in chemistry and physics for elementary teachers. She (and the current physical science instructor) designed this to be a course for teachers, and it met the content and pedagogy requirements of the AAT degree. She taught the course about four times, modifying the course as she went, and wrote the activity book that went with the course. When she became the director of teacher education, the current physical science instructor became fully responsible for the content and pedagogy of the course. This instructor has continued to modify the course, especially adding more inquiry based activities in physics. He has improved upon, and added to, the activity book and says that it is just about ready to be published.

Even though the physical science instructor fully believes in inquiry-based learning and constructivism, his syllabus did not list any learning objectives or explicitly express anything about constructivism. The only hints of inquiry-based learning were found in the first assignment listed in the course schedule and in the grading policy. The first assignment included writing about the 5 E's (the characteristics of the constructivist learning cycle: engagement, exploration, explanation, elaboration, and evaluation). It was worth 10% of the final course grade. Four hands-on performance tasks, such as determining focal lengths of and images formed by lenses, were included as 20% of the final course grade. However, classroom observation showed that the physical science course was a fully robust guided inquiry, discovery-based course, with students working in groups and devising means of testing hypotheses.

Since I was unable to interview any of the biology faculty, I do not have any first hand information about how the biology courses are taught and whether or not they meet content and pedagogy requirements of the AAT degree. But I do have some anecdotal information from the faculty that I interviewed. According to the director of teacher education, a small group of biology faculty were determined to put hands-on work in the biology laboratories, but they did not want to change the structure of the course from its lecture-laboratory format since there were so many (about 35) sections taught each semester. They also did not set aside any sections geared for AAT students. She went on to say,

> They do do more investigative hands-on work in the laboratory than they used to. And that's true of all sections. So although it's not as hands-on as I would like it, they do do a lot of inquiry.

When I asked the earth and space science instructor if she knew if any changes occurred in the biology course in response to the AAT degree, she replied,

> Probably that's our weakest point. There aren't a lot of biologists who are constructivists, and so what we've done with biology … is that we try to track the teachers to one particular instructor … who, of anybody, probably is a little bit more friendly to this technique. At one time, we taught earth science with biology in one class…. So we really only had half a semester of biology and half a semester of geology/astronomy…. He [the particular instructor] did that [biology] half…. So I don't think he's done anything to modify significantly what they do down in biology; they just use their standard program… That course is learner centered in the sense that there are activities that they engage in in the laboratory, but I wouldn't say it's inquiry, and I don't think it comes from a constructivist perspective particularly.

The physical science instructor agreed with the earth and space science instructor and said that he thought the biology course was still a typical Biology 101. He said there may be small changes, but the biology course was definitely not taught the way the other two AAT science courses were taught at Beltway.

Changes in Assessment Techniques

In order to see if an instructor has fully embraced constructivism, one can look to the type of student assessment that the instructor uses. Complete constructivist pedagogy (which includes inquiry or discovery) calls for multiple methods of authentic student assessment, such as projects, performances, and portfolios. Authentic assessments evaluate higher order thinking and require students to explicitly demonstrate desired learning outcomes (Huba & Freed, 2000). The earth and space science instructor uses a variety of authentic student assessments. In the explanation of student assessments found in the course syllabus, the instructor reminds the students that, “Not all assessments of learning need to be traditional paper and pencil examinations. Any of the work you do in acquiring concepts in a course may become part of your evaluation by the instructor.” Over half of the final course grade in the earth and space science course is based on authentic assessments, including performance tasks (28%), application problems (approximately 7%), and portfolio assignments (21%). The performance tasks measure students’ understanding of subject material and science process skills. These tasks are done in the laboratory and may involve collecting and processing data and information, or analyzing a given scenario. Half of the final exam was an interesting application problem where students went on a hypothetical camping trip and used knowledge and processes gained in the course to enrich their camping experiences. The rest of the course grade is comprised of mostly objective quizzes and a final exam (35%), and extra things the instructor evaluates, such as projects and attendance (approximately 7%). It appeared that students were assessed on all of the higher order critical thinking skills.

The syllabus of the physical science instructor indicates that he also bases over half of the course grade on authentic assessments. The students have four performance tasks to perform over the course of the semester. The scores on these tasks make up 20% of the students’ final grades. These tasks are laboratory-based and students are required to manipulate equipment, and collect and analyze data in order to come to a solution or answer to a question. The midterm and final exams each account for 20% of the final grade. These tests have combinations of mathematical problems and essay questions.

The remainder of the final grade is based on the previously mentioned write-up on the 5 E's of the constructivist learning cycle (10%), Web assignments (10%), portfolio (15%), and attendance (5%). A student automatically fails the course after five absences. All core critical thinking skills, except for dispositions, are assessed throughout the semester.

Thus far, this case study has concentrated on the faculty attitudes toward the mandates of the AAT degree and how their courses support these mandates. It is also important to know the way that students perceive constructive learning activities and the critical thinking that is necessitated by constructive or discovery-based learning.

Students' Perceptions of Constructive Teaching Activities

The students who attended the classes that I observed were asked to voluntarily fill out a student questionnaire studying aspects of critical thinking and student behavior (see Appendix M). The students also had to sign a consent form that was given to me by Beltway Community College's Institutional Review Board. Twenty-four students filled out the questionnaire (11 earth and space science students and 13 physical science students). The students were asked if the science course they were enrolled in helped them improve their abilities in different aspects of critical thinking: interpreting written information, analyzing numerical data, explaining scientific information to others, and evaluating strengths and weaknesses of information or arguments. For each question a student answered affirmatively, he or she was asked to name a specific course assignment, such as one particular essay, or an entire classification of assignments, such as laboratory reports, that helped in the improvement of critical thinking skills. The student was then asked to elaborate on how that course assignment was helpful. Students were also asked to explain what their instructor did in terms of teaching that helped them to learn. The last question of the survey asked if students preferred working in groups as opposed to working individually. The students were also asked to explain their responses to this question. The results of the questionnaire are shown in Table 10.

Table 10
Beltway Students' Perceptions of Critical Thinking

	Earth and Space Science (11 Students)				Physical Science (13 students)			
Core Critical Thinking Skill	Yes		No		Yes		No	
	N	%	N	%	N	%	N	%
Interpret	10	91	1	9	10	77	3	23
Analyze	5	45	6	55	2	15	11	85
Explain	9	82	2	18	12	92	1	8
Evaluate	7	64	4	36	4	31	9	69
Totals (N) Percentages (%)	31	70	13	30	28	54	24	46

Perceived Improvements in Critical Thinking

Of the ninety-six possible yes or no responses to the core critical thinking skills questions, 61% (59 responses) indicated that students perceived aspects of critical thinking taking place, while only 39% (37 responses) showed that students were not aware that aspects of critical thinking were taking place. This relatively high percentage of students who reported gains in critical thinking skills may in large part be due to the inquiry-based pedagogy and authentic assessments used by the instructors of these courses. According to the Joint Task Force on Student Learning (1998), learning involves the ability of students to be aware of their own ways of knowing and to understand that knowledge is acquired. Students must actively think about how to acquire their own knowledge in discovery-based learning, and perhaps this made the students more aware of their learning.

In general, the earth and space science students recorded more positive responses than did the physical science students (70% as opposed to 54%). The difference in percentages of positive responses may be due to two demographic factors. The earth and space science students were older than the physical science students. About 90% of the former group of students was at least twenty-four years of age but only 38% of the latter group was older than twenty-three years of age. The earth and space science students also had more experience in science courses, with 73% responding that they had taken at least two college-level science courses prior to their current course, but only 38% of the physical science students reported a similar amount of experience in science courses. Perhaps the maturity and academic experience of the earth and space science students enabled them to be more aware of their learning.

Students from both courses were similar in the fact that the overwhelming majority of them (85%) perceived gains in interpretive (91% of earth and space science students, 77% of physical science students) and explanative skills (82% of earth and space science students, 92% of physical science students). It is plausible that the perceived gains in these two areas of critical thinking may be related to the inquiry-based pedagogy used in the two science courses. Students in both courses were routinely required to verbalize predictions, collect and interpret data, compare predictions to data and results of experiments, and then explain results and discrepancies between results and predictions. Since the students used these two skills so often, they would have ample opportunity to note improvements.

Only in the earth and space science course was there a majority of perceived gains (64%) for evaluation skills; just less than one-third (31%) of the physical science students perceived gains here. I did not find anything in the data that could account for the marked difference between the perceived gains reported by the two groups of students, or why the percentage of physical science students noting gains in evaluation skills was so low. Both courses only had a minority of students (45% of earth and space science students, 15% of the physical science students) who perceived gains in their ability to analyze numerical data.

The relatively low perceived improvements in numerical analysis that occurred in both the earth and space science course and in the physical science course can be attributed to the lack of emphasis the two instructors placed on this skill. The earth and space science instructor strongly focused on process skills because she thought the students needed to become comfortable with these skills in order to be effective science teachers. As mentioned earlier, when this instructor was discussing the design of the course, she stated, "There's different kinds of operations that they do: sometimes they're graphing, sometimes they are collecting data. And they are designing experiments; always observing. Not a lot of number crunching because there isn't a lot to do." The physical science instructor also did not place much emphasis in numerical analysis in the design of his course, he stated,

> I've designed the course in such a way that I think that it's relaxing and allows the people to really get into the fun part of science as opposed to memorizing tremendous numbers of formulas and plug and chug, as I always call it. I'm trying to get really an understanding of the concepts more than the way a lot of science courses have been taught before this.

Since the two instructors purposefully shied away from numerical analysis, the low numbers of students perceiving gains in this skill should be expected, and not considered as a shortcoming.

Students from both science courses noted a mixture of instructivist and constructivist learning experiences where they perceived critical thinking to be taking place. It was difficult to pin down exact instructivist learning experiences due to the generalized comments from the students, but I was able to categorize 40 of the total 59 positive responses that were related to constructivist learning experiences. In reality, since both courses strongly emphasized inquiry based learning, most of the student comments should have specifically mentioned laboratory work, but this was not the case. Twenty of the 40 positive comments overtly referred to laboratory work, while 9 comments alluded to laboratory based work, such as the use of models and graphs, as being important in their perceived gains in critical thinking skills. Both instructors gave the students Internet assignments, and 11 student comments (28 % of categorized responses) indicated that students perceived these assignments to be beneficial in improving critical thinking skills.

Perceived Helpfulness of Teaching Techniques

The majority of the students reported positive learning experiences. All of the students cited examples of teaching techniques or instructor attributes that helped them learn. Six earth and space science students commented on their instructor's attributes that were related to her constructivist teaching approach. One such comment follows: "Our instructor allows us to answer our own questions – work it out – until it is evident that we are either on track or way off base." Another student wrote, "The hands on activities are very helpful, especially the fact that we do little or no discussion before hand. It helps that she walks the class and is always available to explain."

The physical science students mirrored the comments of the earth and space science students, with seven of them mentioning the same constructivist attributes of the instructor. For example, one student commented: "Constructivist teaching – he allows for his students to take part and do the experiments, allowing us to see the outcomes, versus him telling us the outcomes." Another student stated that the instructor allowed the class to perform the labs first, giving them the opportunity to form "our own revelations." Several students mentioned that the physical science instructor made sure that they understood the subject matter, often checking on them and working with them one-on-one.

An overwhelming number of students, twenty-two of the twenty-four, preferred working in groups. The most common reasons why students preferred working in groups were that group work enabled them to communicate with each other, to compare and contrast ideas, and to obtain help from each other. These comments also reflect the fact that these students value the opinions of their peers, and are comfortable learning with them.

I was only able to observe two class periods for each instructor, but I believe the behaviors I observed to be representative of what typically occurred in these classes throughout the semester because the students seemed to be very familiar and comfortable with the structure of the classes. Both courses were taught using discovery-based learning, and students in both courses demonstrated the same level of interest. All of the students, except for one who was suffering with a headache, were actively engaged in the learning process and participating in group experimentation and discussions. The earth and space science instructor said that her students were very afraid of math and science when they first entered the course, but had good attitudes and were willing to do inquiry-based laboratory exercises. When I asked the physical science instructor about his students' attitudes toward inquiry-based learning, his response was very similar to that of the earth and space science instructor, and he said,

> I think the average student is afraid of science, that they don't like science…. So the hardest misconception is this course is going to be very dry, very rigorous …and usually after about the third or fourth session they finally accept the fact that, "I'm having fun in this class." And then you have no problems…. I think that I haven't found one student that has not appreciated or wanted this style of teaching above any other.

Potential Factors Affecting Implementation of Change

The students' attitudes toward critical thinking and constructivist learning may have an effect on how open or resistant they are toward student-centered learning

(Bonwell & Eison, 1991; Hansen & Stephens, 2000). This in turn could influence their instructors as they plan course activities. According to the literature, there are several other factors that may come into play as the science faculty implement changes in their courses in response to the AAT degree mandates. Stark and Lattuca (1997) identified three (sometimes overlapping) spheres of influence on college curriculum: external, organizational, and internal. These sets of influences can also affect faculty as they try to implement academic change, and will be discussed in detail in the following sections.

External Factors

Stark and Lattuca (1997) defined external influences on college curriculum to be beyond the control of the college. Some examples of external influences given by Stark and Lattuca include society as a whole, accrediting agencies, publications, concerns of employers, and the media (1997). Local demands for teacher training and certification programs and state-wide difficulties encountered by education majors trying to transfer to four-year schools are the major external driving forces that initiated the ultimate development of the AAT degree at Beltway Community College. All three faculty that I interviewed were very active (for many years) in summer institutes designed to improve the science skills and certification levels of local public school teachers. Much of the curriculum and pedagogy of the earth and space science and physical science courses were derived from these institutes, so these two AAT courses were fairly well aligned with the degree mandates even before the degree was initiated.

Education majors at Beltway, as well as those from other Maryland community colleges, faced barriers that made articulation to four-year schools very difficult. The four-year schools often would not accept pre-professional courses taken at community colleges, and each four-year school had its own peculiar set of requirements. Therefore, transfer students were frequently forced to repeat courses or take other courses that delayed entry into junior level courses. This misalignment cost the students precious time and money, and, according to the director of education, made recruitment of education majors difficult for many community colleges. The AAT degree was designed to make the transfer process from a community college to a four-year school a smoother, more seamless transition, therefore was a desirable asset for Beltway Community College.

Organizational Factors

In Stark and Lattuca's model, organizational factors such as the college mission, financial stability, resource availability, and opportunities for faculty development may be either supportive or non-supportive influences on curriculum planning and change (1997). Organizational factors affecting the AAT science faculty at Beltway Community College include administrative support for the necessary courses and the faculty who teach these courses, administrative awareness of the intent of the AAT degree, resource availability, academic inertia, and opportunities for faculty development.

The chairman of the chemistry department is an advocate of inquiry-based learning and, according to the physical science instructor, feels that community college students need to experience this pedagogy because it would probably cause the students to want to take other science courses within the college. But it is interesting to note that when the two inquiry-based science courses were being developed, this chairman was not supportive. The director of teacher education related this story:

> He'll be the first one to tell you that he thought [inquiry-based learning] was a bunch of hooey … he thought it was treating [the students] like babies, and watering down [course material] … and not being able to teach as much content as you need to teach, and blah, blah, blah. All the usual suspects…. He became a convert. We did some things in his pet course … we were slowly changing some of the activities [in the course] to more inquiry stuff. And he got to like it, and all of the sudden he was crazy; he was a convert. He really became, you know when someone quits smoking is crazy about people who smoke, well, that's what he was. He went around telling everybody they shouldn't lecture any more…. He really became quite an advocate…. Not everybody in the department did, though.

The earth and space science instructor added to this anecdote:

> [The department chair] really pooh-poohed the whole thing and then he started getting into it, started to realize that this was really how he learned and it was really the way to go…. Being our department chairman, that makes it a lot easier to carry these things through.

I did not get any information as to whether or not the department chairman was aware of the content and pedagogy requirements of the AAT degree, but it appeared that his enthusiasm of and support for inquiry-based learning was certainly appreciated by the three faculty that I interviewed.

The director of teacher education, since she helped formulate the AAT degree, is very aware of the intent and purpose of the AAT degree as well as of what outcomes are expected from students graduating with this degree. She is very committed to the success of the degree and is interested in helping other community colleges meet the mandates of the degree. In order to educate community college faculty about the content and pedagogy requirements of the AAT degree, she successfully applied to the National Science Foundation (NSF) for funding to start an initiative called Maryland Articulation Partnership for Teachers (MAPT). This grant enabled her to run a series of workshops for community college math and science instructors where they could see models of constructivist and inquiry-based teaching techniques, and discuss course content.

The director of teacher education strongly supports the efforts of the instructors who teach the AAT science courses, but there is also other administrative support available. The instructor of the earth and space science course was given a total of five release hours to develop her course, but the director of teacher education did not get any release time back when, as a teaching faculty member, she developed the physical science course.   When asked about the availability of materials and equipment necessary to run the inquiry-based courses, the director of teacher education replied,

> If it was something we wanted … the science department was quite good in helping us buy supplies and things. But we were also starting to get grants. We had some summer institute grants where we had teachers come here every summer to do hands-on activities, so we bought a lot of supplies for that, which we were also able to use for our courses. So we had eighteen years of summer institutes and we bought a lot of supplies over the years through grant money, and money from the department. We did not have any problems.

The two science instructors also agreed that support for the AAT courses was good. The physical science instructor said this about the support he has received:

> This college is wonderful. They pretty much allow you freedom on what ever you want as long as it's good science and [the director of teacher education] has been very good in getting the money to buy the equipment that I need. I was mostly hauling stuff from my high school here. She's been allowing me to buy things. As far as the secretaries, everyone, they are just so cooperative as far as typing. So they really support you in any way you want; in fact, they encourage teachers to be innovative, to be creative, to develop programs, develop courses, and it's a wonderful environment to work in for an educator.

Even though the director of teacher education was intimately involved in the creation of the AAT degree, and there is strong administrative support for the AAT science courses, this was still not enough to overcome the biology department's resistance to change. The Biology 101 course at Beltway Community College is a very popular course taken by many students. Numerous sections of this course are taught each semester (about 35 sections) and the biologists did not want to change the separate lecture-laboratory format of the course. The director of teacher education stated that the biology classrooms and laboratories are not conducive for inquiry-based learning. It is unclear if the biology faculty had the opportunity to design an appropriate room when the science building was constructed or not. The earth and space science instructor said that they did not have a lot of biologists on staff who were constructivists, and that they tried to encourage the AAT students to take a particular instructor who was more friendly toward constructivism. She also discussed general resistance to change,

> I'm not really in that situation where [change to inquiry-based teaching] was thrust upon me and I had to make the change. I think it would be hard for people.

> We tried very hard with other colleagues at this institution to get them to switch and there is tremendous resistance. And … I have some people who just basically said with students, “It doesn’t matter. We want to give them something in the easiest way just to get them to memorize something and do the test and get out of here.” I think this is giving [the students] a false sense of what they know. But for the faculty, they feel that’s a politically wise thing to do, and I’ll probably get into trouble for saying that. But, I think that’s what they think; but I don’t think it benefits [the students]. Of course, this [inquiry-based] teaching and this [authentic] assessment doesn’t (sic) give the kids the highest grades either.

The physical science instructor also noted problems with getting teachers to use constructivism and inquiry-based learning, he explained:

> The hardest thing about this course is convincing teachers to teach it…. We’ve had communities of teachers coming from all over and talked about constructivism and you could see a reluctance in some people, that it’s a new paradigm for them. They kind of understand it, but they really aren’t sure this is the way they want to do it. And that might be the biggest hurdle that we have to get over. There are some people who just believe that this way of [teaching] … isn’t the right way to [teach]: “I need to tell you first everything and then you need to then go in the lab and prove that everything I told you is correct.’’ So, it’s sort of like, “See how smart I am, I told you it was right.” We’ve got to get away from that. In fact, some teachers will complain that [constructivism] kind of slows down the course, and that kind of bothers me, because maybe you are going too fast.

The last organizational factor to be considered is the opportunity for faculty development. The MAPT grant developed by the director of teacher education served as a formal faculty development opportunity for any community college instructor from Maryland and as an informal opportunity for the earth and space science instructor. When asked about availability of faculty development opportunities, she explained,

> Mainly the experiences have been through the MAPT grant .… In that grant I serve as a mentor to other people as they needed it to try to get these courses in place. So for me I guess the biggest development opportunities have been talking with other people and, not formal, not formal times, but they have been interacting with colleagues and looking at what is going on at other institutions, and watching courses develop, and what types of materials are coming around. That's been very instructive.

This instructor has also presented the MAPT program at several regional and national meetings, and was able to gain informal enrichment from discussions with peers. She did not mention any programs or workshops given by Beltway Community College that she attended or found useful to her.

But the physical science instructor stated that the college did have very good professional development opportunities that he often could not take advantage of because of his public school commitments. He did confess, "Sometimes I play hooky from my school to come [to Beltway] because they have so many neat things going on." The workshops he described dealt with technology applications; he did not mention any in-house professional development that focused on the AAT degree.

It is interesting to compare the external and organizational factors, and the pivotal role played by the director of teacher education. The role that the director of teacher education played in all of the external factors completely overlapped and merged into the role she played in the organizational factors. The MAPT grant that she initiated (an organizational factor for Beltway) became an external factor for other schools. All three faculty were very involved with the external factor of teacher training and certification programs. They have invested years of time and effort in improving the science education of teachers. Since their commitment to, and belief in the teacher institutes and certification programs were so deeply rooted, this external factor could also be described as one of the internal factors that affected change at Beltway Community College.

Internal Factors

According to Stark and Latucca (1997), internal factors that exert influence on college curricula include such factors as faculty backgrounds, disciplines, educational beliefs, and student characteristics and goals. Relevant to this study, I have discerned nine internal factors (and their interactions) that could affect faculty as they transition into the AAT science courses; the relevant factors are summarized in the Concept Map (see Figure 1 on page 31). These factors can be divided into three interrelated groups. The first group includes attitudes toward the manner of the request for change, the awareness of the intent and purpose of the AAT degree, participation in the change process, and belief in the change. Prior use of constructivist pedagogy, academic and professional background, and teaching philosophy are the components of the second group, and the last group brings together the student's attitudes toward learning and the faculty's attitudes toward students.

Attitudes toward request, awareness, participation, and belief in change. It appears that the AAT degree at Beltway Community College came about as a natural progression from all the work that the three interviewed faculty did with public school science teachers. As stated before, these three faculty have worked closely together for many, many years, and they have evolved to have similar attitudes and ideas about how best to teach science. The interviews and classroom observations clearly indicated that the two teaching faculty were very positive about the impact of their courses, and because all three faculty had such good personal and working relations, I did not delve deeply into their attitudes toward how they were approached to teach the AAT science courses. I inferred their attitudes were positive because the instructors were so heavily involved in the education of science teachers. The earth and space science instructor actually went to the director of teacher education and offered to develop that course for the AAT program. She may not have done that if she did not believe in benefits that the earth and space science course would offer the education majors.

The director of teacher education initially developed and taught the physical science course, modifying it as she went along. She wrote the activities book for the course. These activities came from materials that she and the current physical science instructor used in their summer institutes. According to the physical science instructor, as the director's administrative duties increased and she assumed more responsibilities, she requested that he teach the physical science course. Since he was familiar with the activities book, and had team-taught with the director, he was able to seamlessly merge into the physical science course, and continued her philosophy of teaching.

As stated earlier in this study, all the participants were aware of the content and pedagogy requirements of the AAT degree. They all, in one form or another, participated in the development of the degree. They completely designed and developed the science courses associated with the degree at Beltway Community College. The efforts put forth by the three participants are a good indication that they thoroughly believed in the AAT degree science courses and in all of the changes that they had gone through over the years.

Prior use of constructivism, faculty background, teaching philosophy. The director of teacher education and the two science faculty that I interviewed were all very well versed in constructivism and inquiry-based learning. They had been using constructivist-teaching techniques in the summer institutes for many years before the AAT degree was proposed. They all had been exposed to constructivism as students. In fact, constructivism appears to be an integral part of their backgrounds. I have limited information on the background of the director of teacher education. She has a PhD in science education from the University of Maryland and stated, "When I went back to get my PhD, [constructivism] was just coming to the fore. So I was fortunate in being in graduate school when a lot of this was coming out. So I knew the theory…"

The earth and space science instructor also has a PhD in science education from the University of Maryland. She got this degree before the director of teacher education obtained hers. But the earth and space science instructor had prior exposure to constructivism as a student:

> I'm really a product of the curriculum reform of the '60's, so I am old enough to be post-sputnik…. I was one of those first cadres of students that were getting

> [new science curriculums, e.g. Chemstudy, PSSC Physics] in high school, so we were really imbued with science. And actually science that was inquiry-based at that time … where you have to do a lot of experimentation and draw conclusions from the experimentation. Somebody didn't tell you how it was going to behave.

This instructor also cited all of the work that she and her colleagues had done in the summer institutes as part of her background in constructivism and inquiry-based learning.

The physical science instructor's background was well grounded in constructivism. He was introduced to constructivism, although it wasn't called that at the time, when he was a student in a boarding school. He recalled that his physics and chemistry teacher conducted very activity-based classes. This left a lasting impression on the physical science instructor, who recalls studying the teacher's methods. There are other educators that greatly influenced the physical science instructor. His high school mentoring teacher was voted the outstanding biology teacher in America. He also worked with a Swedish professor at the University of Maryland who was honored as one of the top twelve educators that ever lived. The physical science instructor felt very fortunate to be working with the director of teacher education and the earth and space science instructor because they were strong constructivists. Constructivism is one of the main foundations of the participants' educational philosophies.

The earth and space science instructor describes her teaching philosophy as follows:

> Well, definitely I think that learning depends on the students and their own motivations to learn. And so part of my role is to get them to be motivated to do

> this. They need to be able to take the information that I give them and put it somewhere so that they can access it and use it reasonably in the future. And I guess you would say that's a constructivist view. I think they need to take it and make it important to them is some way, shape, or form…. So I am really a constructivist at heart. I think the way to do that is through inquiry, but I don't think that just open inquiry is a very efficient way of approaching it because these students don't know what it is they need to know. That part of my responsibility is really to engineer the curriculum and activities that will guide them to what I think is an important concept for them to know.

When asked if the teaching of the AAT science course had changed her philosophy any, this instructor replied that she actually brought her philosophy to the course. Her constructivism was well entrenched before the beginnings of the AAT degree.

The physical science instructor's thoughts on his teaching philosophy mirrored those of the earth and space science instructor. The physical science instructor had this to say about his teaching philosophy:

> Well, I'm very hands-on, and I really, really believe, I've always believed in the constructivist approach. I've never used a textbook in my life because I felt that … it was reminding me too much of the way I was [often] taught. So I've always been hands-on… I felt that the reason why I enjoy teaching science is because of the activities…. I like doing multiple labs where kids do a lot of different labs to show a concept. And then we bring it all together with the explanation…. And that's always been my philosophy, so when they came up with the constructivist

[and inquiry] approach to teaching, to me, it was like they stole my ideas. That was, to me, the only way I thought science should ever be taught.

Students' attitudes toward learning and the faculty's attitudes toward students. The students in the two AAT science courses were a fairly typical mix of community college students. They ranged in age from 18 to 50 years of age. All 11 students who completed the survey in the earth and space science course were females. The physical science course was split fairly evenly between the genders, with 6 males and 7 females. The majority of the students, 79%, were going to school full time. Five of the 24 students were enrolled in their first college-level science course. I do not have any information as to whether or not the students had any prior exposure to constructivist or inquiry-based learning, unless they were enrolled in their second AAT science course. If they had previously taken either the earth and space science or the physical science course at Beltway Community College, then I know they had been exposed to inquiry-based learning, but I do not have any direct data on this. However, it appeared that the students in both classes were comfortable with student centered learning, as evidenced by their behavior in class and from comments obtained from the faculty interviews, as well as responses students offered in the student questionnaires.

I observed two class meetings for each of the AAT science courses. There was no discernable difference between the behaviors of the earth and space science students and the physical science students. The students worked in groups and appeared to be engaged in the guided inquiry activities. Only one student did not fully participate; she was ill with a bad headache. The students were animated and I did not see any reluctance to participate in the activities. I could hear the students discussing and asking each other questions. Several students engaged their instructors in dialog. One physical science student in particular sought out a more in-depth explanation of magnets than was given in the handout. All of these observed behaviors lead me to the conclusion that the students, in general, had good attitudes toward and were receptive to inquiry-based learning. Comments taken from the faculty interviews mainly, but not entirely, support this conclusion.

The earth and space science instructor related her opinion of student attitudes toward learning:

> Most of [the students] are science and math phobic when they come in here. But they are willing to do what ever you tell them to do. They are very obedient in that sense; they will sit down and do it for the most part…. They're not our strongest students academically but then again, there are exceptions. If they are kids in the AAT program they are very strong. If they are people that are coming into this class because they just need certification in science, … they tend to be extremely weak and very belligerent. So the students from the AAT program are much more fun to work with….

This instructor noted that most of her students were anxious, especially so about exams, and compared elementary education majors to early childhood majors by stating, "If you think the elementary teachers are anxious about math and science, early childhood are anal. They are very anxious about it … and don't do as well." But she also stated that it was her impression that the students liked the hands-on learning, although they would not always admit that, and that the students appeared to enjoy working in groups. The physical science instructor was pleased with his students because he thought they were involved in the learning process and that they appreciated the inquiry-based learning.

When asked about his students' attitudes toward science, he stated:

> I think the average student is afraid of science, that they don't like science…. So the hardest misconception is [the physical science] course is going to very dry, very rigorous, you are going to be up all night pounding your head, trying to understand the concepts and usually about after the third or fourth session [the students] finally accept the fact that, "I'm having fun in this class." And then you have no problems.

Although I did not directly ask students about their attitudes toward learning, I can infer from their responses in the student questionnaire that their attitudes were mostly positive and that they valued learning. For example, an earth and space science student, when asked about improvements in ability to explain scientific information to others, wrote, "The assignment on plate tectonics helped me to explain to my co-workers why volcanic activity must occur in specific parts of the world." A physical science student explained, "I am now able to view information differently and I am able to decide different ways of showing data for presentations." Another physical science student added, "When explaining scientific information to others I am aware of what I am saying, why I am saying it, and the value of the question, as well as the answer." These three comments illustrate that what the students have learned is important to them. An appreciation of learning can be taken as an indirect indication of a positive attitude toward learning. Not only are the students' attitudes toward learning important to the learning process, the attitudes that instructors have toward students and learning can have a direct effect on the learning process.

The earth and space science instructor appeared to have a positive attitude toward her students even though she characterized some of her past students as being belligerent. She was very aware of the diverse educational backgrounds of her students and used inquiry-based learning as a method of giving students with poor backgrounds in science an equal opportunity to learn:

> We have kids who come in with very diverse backgrounds and experientially they just don't have the same, they are not at the same level. So if I start to talk to kids and say, well do you know, think about this situation, I've got them looking at me like they don't understand it. So one of my reasons for doing [activity- or inquiry-based learning] is that it also sits everybody down and they all have the same experience, they all do the same activity, they all observe, whether they see it the same way or not, they all observe the same basic materials and they do the same activity so that we can talk intelligently about it and they've got the experience. We don't have to rely on former experience or what they've learned before or what they take out of my lecture.

She also included a few "therapeutic labs" that the students could enjoy while learning college-level material. She explained her rational for this:

> This is going to sound silly, but some of the things, I have the kids cut things out, they paste things, they color things, because for this particular population, and probably any student would like doing this; they just have fun doing it…. But [the

fun exercise] illustrates a concept in either earth or space science, and the kids sometimes really enjoy it, so this is a therapeutic lab.

This instructor summarized her attitude toward her students and the AAT degree: "It's been a wonderful experience working in this program and it's really a lot of fun working with the kids. Sometimes it's very frustrating working with teachers because they get whiney, so classes will be very difficult."

The physical science instructor did not overtly express his attitudes toward students during the interview, but from his behaviors in the classes I observed and from comments made during the interview, it is clear that he enjoys his students and has a good attitude toward them. He was always available to the students during the class, and he always walked around the classroom, checking on and helping students. He was very aware of how many of his students that graduated from local high schools were hindered by the low standard of student performance expected in these high schools. He strived to be a positive influence on his students.

When asked if his students influenced the way he taught, he responded by first giving me a synopsis of the radical change in demographics of the local public schools and high school students. Thirty years ago, the high school he taught at was rated the best school in Maryland. Many of his high school students came from households whose parents were highly educated and worked in various fields of science. These students were very talented and several of them achieved prominence in science related fields. One of these former students was actually nominated for a Nobel Prize. The physical science instructor said that teaching these students was easy and fun, but that they were capable of teaching themselves and would have learned without him. At the time of the interview, however, this same high school was ranked as one of the lowest in the state. The physical science instructor finished telling me how his students influenced him, and related,

> What I think has done a change in my life is that I really think that I made [more of an] impact on some of the students I have now, because maybe it was a special teacher that turned them around. So you see a child, maybe that he is kind of poverty stricken, he's apathetic, non-motivated; you turn him on to something, and all of a sudden you find out he's at George Washington [University] majoring in engineering!

This excitement of being able to help students achieve their goals is indicative of his positive attitudes toward students.

Summary

At the time of the site visit at Beltway Community College, two of the three science courses that supported the Associate of Arts in Teaching degree (elementary option) were fully inquiry-based, and could be considered to be model courses. The biology course taken by AAT majors had not yet adopted the integrated lecture-laboratory format and could not be considered a model course. However, this may be changing. The latest Beltway Community College course schedule lists one biology section as being integrated and recommended for AAT students.

There is strong administrative support for the faculty who teach the earth and space science and the physical science courses that support the AAT degree. The director of teacher education and the other two faculty seem to have a good rapport with the public school system and have made a large investment in teacher training and certification. The creation of the two AAT science courses are a natural outgrowth of this investment.

External and organizational factors affecting college curricula described by Stark and Lattuca (1997) were very much intertwined and internalized by the three faculty that I interviewed. These faculty shared a strong belief in inquiry-based learning and worked well together. Their collegiality reinforced their beliefs in constructivism, and constructivism seemed to reinforce their collegiality. These reinforcements produced a positive feedback loop for the faculty. Although Beltway Community College is fortunate to have the three science faculty who are involved with the AAT degree, there is some concern about the future of the AAT science courses. All three of the faculty that I interviewed have been very active in teacher education for many years, and it has become second nature to them. But although their years of experience certainly are a positive factor, their longevity can also be considered a negative factor. These faculty are nearing retirement, and there did not appear to be any young, constructivist faculty ready to step in and continue the inquiry-based courses. The AAT degree could face serious problems if all three faculty retire within a few years of each other.

Chapter Eight: Case Study of Bayview Community College

This case study was approached differently from the other three studies due to the status of the science courses that support the Associates of Art in Teaching degree at Bayview Community College. The two science courses that support the degree were designed about five years before the inception of the AAT degree and were not changed in response to the degree. Instead of being divided into the 7 major sections used in the other studies (see p. 64), I forwent some sections and created a new section, leaving 5 major sections in this case study (see Table 11).

The discussions of individual changes to course content and pedagogy, and changes in assessment techniques were eliminated. These changes were made so long ago that none of the current instructors of the relevant science courses were even teaching at Bayview. These sections were replaced by a discussion of the reasoning behind the development of the physical science and environmental science courses that currently are required as part of the AAT degree, and a synopsis of the present states of these courses. Since the current instructors of these two courses did not make any changes in response to the AAT degree, potential factors affecting faculty going through a change process were not relevant, therefore not included in this study.

The first section of this modified study includes all of the necessary background information and describes the institutional context, history of the Associates of Arts in Teaching degree at Bayview Community College, and the backgrounds of the faculty interviewed. In the next section, the discussion centers on the development of the physical science and environmental science courses, and on the current states of these courses. The third section focuses on the individual faculty's awareness and knowledge of, and attitudes toward the AAT degree requirements. I believe that once the reader has read this section, and compared it to the corresponding sections of the other case studies, the reasons for modifying this case study will become more apparent. Since it is always interesting to learn about students' perceptions of teaching activities, and to add depth to the study, this section remains in the case study. The fifth and final section summarizes the key findings in this case study.

Table 11
Case Study of Bayview Community College

Case Study of Bayview Community College
Background Information
Institutional context
History of the AAT degree
Faculty interviewed
Science Courses that Support the AAT Degree
Development of the science courses
Present state of the science courses
Awareness of and Attitudes Toward the AAT Degree Requirements
Awareness and knowledge of AAT degree requirements
Attitudes toward AAT degree requirements
Students' Perceptions of Constructivist Teaching Activities
Perceived improvements in critical thinking
Perceived helpfulness of teaching techniques
Summary

Background Information

Institutional Context

Bayview Community College's main campus is situated about halfway between two sprawling metropolitan areas, close to the state capital and the Chesapeake Bay. It has three major branch campuses and offers courses at a total of seventeen locations throughout its region. Bayview boasts a fall enrollment of 14,290 credit students, 33% of whom are enrolled as full-time students. Even though the main campus is situated very near a heavily traveled commuter artery, it is far enough from the highway so that it is not affected by the bustle and noise of the commuter rush. In fact, the campus is quiet and sheltered from the highway by houses and trees.

The well-kept buildings on the main campus are clustered on a hillock and several of the buildings have entrances at different levels. The science building is very well appointed, including several laptops in each physics laboratory (supported by laser printers), and smart, wireless classrooms. There appears to be more concrete and steps than green space, but the grounds are well maintained and very attractive. Although I was told that the campus had been spruced up in anticipation of a Middle States accreditation visit, I got the impression that the campus was always kept neat, providing the students a pleasant walk between classes. A boardwalk that meanders through a wooded area connects the main part of the campus to a new health care complex that was under construction at the time of my site visit. I also had the opportunity to gather data on one of the major branch campuses, located beside a very large shopping mall and movie complex. This campus consists of a new, multi-storied building that is equipped with smart classrooms and laptops supported by laser printers in the science laboratories.

The college personnel strive to create a positive climate, encouraging the college's and the students' success. Bollman and Deal (1997) state that good organizations celebrate their successes. Bayview formally celebrated its re-accreditation by Middle States by hosting a party for all of the staff involved in the accreditation process. The staff was treated to refreshments and live music as a reward for and an observance of their contributions and accomplishments.

Students are encouraged to do their best, both physically and mentally. The stalls of the women's bathrooms had large posters that encouraged healthy habits such as not smoking. Mousepads advertised the college-wide competencies for student learning. The Science department distributed bookmarks listing 18 tips for science students, such as, "Take Notes. Rework your notes as soon as possible after class," and "Take good care of yourself, eat right & exercise." "Students First" was written in bold print below the tips, indicating the college's commitment to student success. There was a tutoring center in the science building (staffed by many of the science faculty) where students could get assistance in any field of science offered at the college. The center was open thirty-four hours per week, with different fields of science featured at different times. Bayview also advertises its collegiate spirit of community, similar to that of Oakmont Community College:

Bayview Community College Spirit of Community

> Bayview Community College is built on our commitment to excellence, engagement in the learning process, and mutual respect and courtesy. As a member of the Bayview Community College Community I will:

- Respect the rights and properties of all members of the campus community
- Uphold personal and academic integrity
- Practice honesty in communication
- Listen to others' viewpoints
- Recognize the strength of diversity

- Oppose bigotry
- Work with others to uphold these standards

Even the college newspaper featured an article on courtesy and becoming aware of the presence of other people.

History of the AAT Degree at Bayview

Maryland's Associate of Arts in Teaching degree (elementary option) follows the current conceptualization of teacher preparation by stating outcomes for elementary teacher candidates that should be achieved within the first sixty credit hours of a Bachelor's degree in education. Using guidelines found in the *Maryland Outcomes for Teacher Preparation – The First Sixty Hours, Elementary/Middle School* (TEAC, 2001) as a basis, Bayview Community College, as did other community colleges, organized its own program of study for elementary teacher candidates that met the designated outcomes.

According to the chair of the physics department, Bayview Community College instituted its AAT about three or four years prior to my site visit. The current director of education has only been on board for the past two years, and I got the impression that she was not familiar with Bayview's internal process that culminated in the AAT degree. She stated that, although she was not part of the original planning of the AAT degree, she was aware of it, and related what she knew of the statewide process:

> The elementary AAT was formed a few years back as a statewide initiative. When I say statewide, groups of representatives from two-year colleges and four-year colleges came together and created the AAT…. Between 65% and 68% of the teachers in Maryland start at a community college. They may not have gotten

> an associate's degree, but they've taken course work here before going on to the four-year schools. So the community colleges have a pretty good impact on teacher education in our state. So it was time that they formalized things and made a degree that would be an automatically transferable degree; that's what the AAT is. So the four-year colleges, public and private, in the state of Maryland accept the degree intact. They don't credit count, you know, look at course by course or any thing like that; its intact. And the other unique thing about the AAT is that it is outcomes based.

There are two science courses that support the AAT degree: Physics 100 – General Physical Science, and Biology 107 - Environmental Science. These two courses are open to the general student population and were well-established before the advent of the AAT degree. The physical science course has a laboratory component that is separate from the lecture, while the environmental science course has integrated the lecture and the laboratory, and does not distinguish between the two. Both of these courses are classified as four-credit laboratory science courses. When asked to comment about the state requiring 12 hours of science in order to become certified to teach in elementary schools, and Bayview only requiring eight hours of science in order to graduate with an AAT degree, the director of teacher education stated,

> Eventually [the students] will need 12 hours in the four-year [colleges], but here the way it was designed before I came, we thought all the outcomes were met in the two courses, the environmental science class and the physical science class, in just those two, which are 8 credit hours…. Even though on paper we know we do meet all of the outcomes, we don't want our students going to the four-years

> having to make up a science class that many of the other students coming from the community colleges have already done. Because the four-years do want them to have three sciences, even though we do meet the outcomes in two. So we will probably add that additional science.

She said that the additional science would probably include some astronomy, although she was somewhat vague about whether this inclusion of astronomy would be for the new AAT early childhood degree being developed at Bayview or for the current elementary education AAT option.

Faculty Interviewed

I interviewed the director of teacher education, the chair of the physics department, a representative sample of three of the physical science instructors, the chair of the biology department, and two environmental science instructors (see Interview Protocol for Director of Teacher Education and Interview Protocol for Science Faculty in Appendixes G and H, respectively). The director of teacher education is a former secondary teacher of English and a media specialist. She was asked to head a joint project between the public schools and Bayview Community College that focused on technology training for teachers. This project evolved into a full time directorship of the college's newly created Teach Institute, a combination of teacher professional development, childcare training, and traditional education courses.

The chair of the physics department earned a bachelor's degree in chemical engineering from Notre Dame and worked in industry for two years while teaching part-time in the evenings. He went on to obtain a Master's degree in physics from West Virginia University and a PhD in science education from College Park, University of

Maryland. He has been at Bayview since 1989. One of the physical science instructors also has an undergraduate background in chemistry, obtaining degrees in chemistry and biochemistry at Michigan. She finalized her education at Purdue University doing qualitative research in education for her PhD in chemistry education, and then took time away from academia in order to start a family. She has been at Bayview for the past two years, teaching various chemistry courses and physical science. Her faculty position at Bayview is actually her first professional teaching position, although she has about 15 years of teaching during her undergraduate and graduate education.

The second physical science instructor that I interviewed received her Master's degree in geochemistry and mineralogy at Penn State University and has many courses beyond the master's degree. She has between 15 – 20 years of teaching experience spanning from the public middle school level up to the collegiate level, teaching a wide variety of courses: middle school earth science, physical science, and computers; high school marine science, environmental science, and conceptual physics; and college level physical science, physical geology, oceanography, statistical methods, and computers. She also served as a computer consultant and did workshops for faculty and graduate students during her teaching career. Although she has many years of experience, she has only been at Bayview for 2 ½ semesters, the first semester on an adjunct basis.

The physical science instructor who was currently teaching at the branch campus that I visited was the only physical science faculty that I interviewed who did not have a formal background in science education or experience in teaching in public schools. His BS and MS degrees in physics were obtained in New Zealand. A PhD in astronomy from Florida led to several positions in industry that included research at NASA in plate tectonic formation. He has also conducted research for other organizations. In total, he has been involved with collecting data from three different space-based telescopes. He started teaching part-time in 1975 and became a full-time instructor in 1996, with over six years of experience at Bayview.

The chair of the biology department is the most experienced of all the faculty members that I interviewed, having been a faculty member at Bayview Community College for the last 27 years. A bachelor's degree in biology conferred at Salisbury State College was followed with a master's degree in plant physiology from Louisiana State University and a PhD in aquatic plant biology from the University of Maryland at College Park. In addition to being the chair of the biology department, this participant is also a full professor of biology and the director of the college's environmental center, which conducts aquatic research on problems of the Chesapeake Bay and the Atlantic coast.

The first environmental science instructor that I encountered, who taught a day section of the course, earned a master's degree from George Washington University. His PhD studies were in marine biology undertaken at Boston University at Woodshole. He related events leading up to his current faculty position:

> And then after I had my doctorate in Woodshole, which is where we did the research … I came down and was doing a post-doc with the Smithsonian working with blue crabs. And anyway, I started doing part-time teaching here while I was doing that, and I liked it. With research being what research is, funding was running out and there was an opening here, so I came here.

His full-time professorship began in 1998.

The other environmental science instructor that I interviewed taught an evening section of the course. She took a more circuitous route in completing her education. She started post secondary school at a community college and dropped out because she could not figure out what she wanted from her education. She waited until she was in her thirties to continue her education and received a bachelor's degree in biology from Framington State College. Her current PhD research is on vegetation growth on a constructed wetland for wastewater treatment. This instructor did have previous experience in education, being the education and curriculum director for a nature park. She presented workshops, field trips, and other programs for the K-12 public school system. She has taught at the collegiate level for three years.

Science Courses that Support the AAT Degree

Development of the Science Courses

Since both the physical science and environmental science courses were very well developed before the advent of the AAT degree, and determined to meet AAT requirements, there were not any changes made in either course as a direct result of the AAT degree mandates. Both courses follow common syllabi, and were designed by their respective department chairs. The current instructors teaching these courses are not making any changes in response to the AAT degree. The only definite change I could perceive, and this may have been done before the advent of the degree, was in the scheduling of the environmental science course at times convenient for the elementary education majors.

Although the science courses were designed before the advent of the AAT degree, and the director of teacher education is confident that the two courses meet the mandates of the degree, it is yet instructive to describe the process and reasoning that was used for the design of these courses.

The director of the physics department described the planning process that culminated in the physical science course:

> It came from my association with Maryland Collaborative for Teacher Preparation [MCPT]. I was a graduate student over at College Park. There are two things. [The first] one is when I first started teaching in '89, at [Bayview], I was given the general physical science course, one daytime and one evening section. It was sort of tossed in my direction. The first three weeks of teaching it out of the textbook and using the mathematics, [I could see that] it wasn't working. So I came back in about three weeks into it and said we're just [going to do] a different course, the new and revised. And I started doing group work, and looking for different ways to get the students involved. And to that course I just played with changing and adding content, moving content around. [The second began] in '93 when I was involved with the Collaborative. The MCTP folks, they were looking for courses that altered the way the higher ed faculty taught, that modeled it for elementary and middle school teachers. I attended a lot of workshops, talked to a lot of other faculty across the state of Maryland in terms of the education faculty that were teaching in the content courses. Some were doing journals, some were doing portfolios, some were doing authentic assessments, some were doing performance assessments; nobody actually had everything in one course. Some were doing microcomputer-based labs. So I just took all of that, threw it in one course. And, it is actually the journals that really determined the content of the

course. I did journals everyday in class. And what the students wrote about was basically one thing that made sense to them, one thing that didn't make sense to them, and how the course is going… As students started writing about their concepts, and my noticing where they were having difficulties, I would then try to alter the course and meet those [difficulties]. What I found, they got one concept down, [for example], the universal law of gravitation, then three more would spring up because they would then misinterpret its application…. So it was basically just stepped on top of each other through the journals and then it ended up being the general physical science course.

I asked the chair if there were any science courses strictly for education majors, and he replied,

No, and that was purposeful. When I was developing the course and thinking about working with teachers, what I just found in the general atmosphere out there is that most folks, most science people did not respect science courses for teachers. They always considered them lesser courses. So I was very intent on not making a physical science course for teachers. I was going to work with them, the course that I had. All of the same methods were going to go for everybody.

In the course of the interview, I determined that the department chair maintains a benignly tight grip on the physical science course. This came to light when I asked him if the physical science course was still changing, he replied,

We are still changing them mainly because the faculty need to have ownership of the courses [even though] they are pretty well established. We know what the curriculum is, but there is room for flexibility. I'm almost done with lab and edited lecture tapes that I can hand off to part time and new faculty and say, "Here's the course." All of the demonstrations are done, why we do them, what student responses will be, and how we go about trying to address those. So it's pretty much a course that I can give somebody the skeleton. But they put their own meat on some of the bones that are there. The most important things for the tapes are for relaying the information. It's really not so much the content as it is the pedagogy, so that they're teaching in a certain manner and they have to hit the content, but they've got some room in terms of what examples they provide and things like that. But we all sort of do some core demos. It's pretty much where we want it. But where we want it is, we want folks constantly working on it.

This department chair also handpicks the faculty that he wants for the physical science courses. I asked him if all of the faculty teaching the physical science course were interested in the constructivist or inquiry based pedagogy, and he replied,

> Not necessarily. Most of the folks that I bring on board are traditionalists, but they have inclinations. So once they get into the course, most of them enjoy it and they take to it, with some training or some modeling, or some guidance. So most of the folks who have taught in the past and are teaching it are on board in various degrees. There are some folks I would never let teach the course because their inclinations just aren't there. So yeah, pedagogically there is some range but [about] 50% of the lean is toward some type of constructivist active learning.

The chair of the physics department also shed some light on the development the environmental science course and how it corresponded to his own work:

> The environmental science course, there's a cooperation [with the chair of the biology department]. He wanted to do a problem oriented course, not math problems, but integrated problems like social issues, environmental science, rain drainage, storm drainage, landfills and things like that. So I worked with him a little bit on a couple aspects of his course. So his got developed independently, but I had a little bit of input in terms of crossover with the MCTP folks. So it's actually in my graduate work and association with the NSF project.

The chair of the biology department did not mention any collaboration on the environmental science course with the chair of the physics department and described his role in, and the rationale for, the design of the environmental science course:

> I planned it, I developed it, I wrote it up. I'm the author…. We found students were having a strong disconnect with the traditional lecture-lab format. At its simplest level, they were worrying about, well, is this something I need to know for the lecture test as opposed, is this something I need to know for the lab test. And they were very focused on that many times. You can't ask this question because you taught that to us in the lecture as opposed to the lab. So you have students stewing about, well should I do this thing because it is part of the lecture and this is the lab part, and it's almost as if they would distinguish between two separate and distinct courses. And then when you look at the course specific details, sometimes there might be a topic that is better served by a laboratory exercise, as opposed to doing something in lecture. The old lecture-lab format typically met in two places, so it was like here's the lecture room where we lecture, and here's the lab room where we lab. And that helped reinforce

> students' ideas that instead of being two complementary pieces to the discipline, they were separate and distinct. So that pathway that we used was to develop an integrated form… lecture and lab is typically held in the same room. Depending on the subject and the topic, if you need a little more lecture, you've got it; if you need a little more lab time, you've got it. Basically you do what's necessary to best convey the material. You don't have this artificial construct of here's the lecture, here's the lab. Completely takes it off the board for the students. The consequence in the courses that we've done that, and it's been a number of them, the retention rates have been much higher with the students, probably around 20%…. It was pretty amazing how students would focus more on the format than on the message. And not make the connect in it, and in some cases, the students would almost do a turn-off: Well, I can't use that here because I learned that in lecture, I didn't learn it in the lab and this is a lab quiz, so I can't do that thing. It sounds silly; it was especially true for actually some good students who liked to follow rules.

The chair of the biology department ceded the continual development of the environmental science course to the daytime instructor who was active in research on the blue crab. This instructor stated that the course had evolved into a somewhat different course, with more subject matter and the addition of three or four more laboratory exercises. Although the department chair did not appear to be heavily involved in the day to day running of the environmental science course, he still maintained a very strong personal interest and presence in the class, as evidenced by the following quote by the evening environmental science instructor, "… the department head is an environmental scientist, and he is very interested [in the course content]. I did leave out the fish lab one semester and he was totally offended, so I put it back in." Although this instructor deferred to the preferences of the department chair, she did not indicate that she was forced to include the fish lab or that she was intimidated or pressured by the department chair.

Present State of the Science Courses

It is clear that the physical science and environmental science courses were developed with diverse goals in mind. Classroom observation and document analysis confirmed two completely different course structures, which are described in the following sections.

Physical science. As previously noted, the physical science course had separate laboratory and lecture sessions that met in two different rooms. The instructors in this course followed a common syllabus, or "Course Policy," and other procedural documents. The instructors on the main campus used these general documents, but I was not given any personalized syllabus from either of these instructors. The instructor who taught at the branch campus did give me his personalized syllabus, and appeared to use a less rigorous approach to following the "Course Policy." The description of the "Course Policy" and other documents will help describe the pedagogy of the courses.

The common documents used on the main campus were very formal in nature and somewhat intimidating in their length (almost 50 pages) and level of detail. In general, these documents appear to "talk at the students" rather than "with the student." The welcoming statement of the "Course Policy" states:

> Welcome to General Physical Science!! I think you'll find this course to be quite interesting. If you are willing to do the work asked of you, and truly want to achieve an understanding of the material, then you will do well. **The goal of this course is not for you to meet minimum standards, but for you to pursue and demonstrate maximum understanding** (bold accent in text)**.**

There is no mention of the instructor's role in the learning process until later in the document. One example of this role can be found in the opening statement of the "Journal" section of the "Course Policy":

> Journals will be a vital part of your education this semester. Please take your assignments seriously and do your best to express yourself clearly, honestly, and openly. I will do my best to understand what you have written, pay attention to it, and respect it.

The "Course Outcome Summary" consists of seven pages of descriptions of outcomes. Three core abilities were listed: communication; scientific, mathematical, and technological; and critical thinking and problem solving. These core abilities are taken from a campus-wide list of core abilities. The physical science course was broken into ten units, each with its own set of competencies. Under each unit heading is a list of knowledge and skills leading to mastery of the topic. I analyzed the lists and found several key words, some of which appeared in more than one unit: characterize, recognize, describe, recall, articulate, analyze, interpret, develop, assess, predict, explain, sketch, visualize, define, infer, rank, decode symbols, identify, sort, state, compare, and contrast. These words indicate that all levels of Bloom's Taxonomy (Bloom, 1956) are addressed in the physical science course. This list of key words also fit into the description of the six core critical thinking skills identified by Facione (1990). These core critical thinking skills include analysis skills, evaluation skills, explanation, inference skills, interpretation skills, and self-regulation. Although the core critical thinking skill of disposition (Jones, 1995) did not appear anywhere on the syllabus, the tenth unit of the syllabus (titled Epistemology), which focuses on the sixth core critical thinking skill of self-regulation, may possibly set the stage for the thinking skill of disposition:

1. Recognize that awareness of one's own learning process can improve learning.

Knowledge and skills leading to mastery of this competency:

a. Accept that current understanding or long-held beliefs may be inconsistent with experiment – and experiment is preferable.

b. Recognize the need to alter beliefs.

On-campus classroom observations revealed a mixture of instructivist and constructivist pedagogies. The pedagogy in the lecture periods for the two main campus instructors was formal, mostly instructivist-based, and very conceptual in nature. Students were mainly the receivers of knowledge in the lectures that I observed. The instructors generally lectured for the entire period and always answered questions posed by students.

The first instructor's lecture was interactive through the use of personal responders, and therefore could be considered slightly constructivist. She would ask a multiple choice question (displayed on power point) and the students would reply through their responders. The instructor would then display the tallied results on power point.

She would ask conceptual questions, give the students time to record answers, and then display the ideas given by chosen students. This instructor also used several demonstrations in order to give the students a fuller explanation of the topic at hand. The students appeared to be very familiar with this interactive lecture format, so I believe that this lecture format was used extensively throughout the semester.

The second instructor was more formal in her lectures. Her lectures were very structured, clear, and logical. The students were passive listeners, except for the few who asked questions. Although this instructor did not present any demonstrations during the observed periods, her lectures were interspersed with several real-life examples and comparisons in order to help the students visualize difficult concepts. For example, when she was discussing the structure of the atom, she helped the students understand that the atom is mostly empty space by stating that all of the atomic nuclei of the materials comprising the Washington Monument would fit into a pencil eraser. In one of the class periods that I observed, 30 of the 50 minutes were spent on the results of the mid-term exam and explanations of correct answers. The instructor used the remaining amount of time telling the students how to calculate their grades.

In contrast to the lecture formats of the instructors, the laboratory format was clearly (guided) inquiry-based. Groups of students were actively engaged in the learning process. In the laboratories that I observed, the students were initially given instructions and some guidance before beginning their experiments, but this "pre-lecture" used a minimum of the laboratory period. Then, each group of students worked with temperature probes that were interfaced to a computer. Given certain amounts of hot and cold water, the students were asked to predict the final temperature of the solution when the hot and cold waters were poured into one container. The students recorded their predictions and explained their reasoning. They then tested their predictions by mixing the waters and graphing the change in temperatures of the waters. Finally, the students interpreted their graphs and determined if their prediction matched the results of the experiment. One member of each group reported the results to the instructor and received feedback from the instructor.

This type of inquiry-based learning, starting with predictions and ending with analysis and reporting results was standard procedure in this laboratory. Computers interfaced with data probes were used extensively. I noted that the students appeared to be very familiar and comfortable with this type of learning, and worked with very little intervention from the instructors. But the instructors were always very willing to answer any questions and help when needed.

The branch campus instructor used the same general course documents used by the on-campus instructors, but he also gave students a personalized syllabus. His tone was much more congenial. He talked with the students, not at them. The wording also indicated that the class would be taught from a constructivist point of view as shown from excerpts taken from the "Course Philosophy" and "Class Structure" segments of his syllabus:

> My aim in this course is to develop your **conceptual** (accent in text) understanding of the physical world around you. It is not just a matter of achieving a "good grade." If you understand the concepts, the grade will come naturally. I want you to be able to observe the world around you and to attempt explanations for things you did not think you understand…. In the process of

achieving this conceptual understanding, I will make this class ***FUN*** (accent in text) and a positive interactive learning environment… For my part, I will do "whatever it takes" to help you achieve the goals of this course. I will respect your views, constraints and abilities, and expect the same from you. Remember: I am here to help you understand and learn, not to "dictate" to you…. In general, each lecture period will consist of one or more (often three or four) demonstrations or hands-on activities…. Expect to actively participate in the before and after discussions – no "wall flowers" will be allowed.

The lecture that I observed confirmed the "laid-back" attitude of this instructor and the greater involvement of the students. After taking care of procedural matters and giving a quiz, the instructor presented a demonstration and discussed the effects caused by a vacuum. Class discussions emerged from responses to queries posed by the instructor. Students freely asked questions throughout the class period. The students were comfortable and attentive, and reacted to their instructor's playful sense of humor. Since the students were active and involved in class discussions, this instructor's lecture could be considered somewhat constructivist, but not inquiry-based. The laboratory at the branch campus was identical to the one done on the main campus, with the students following the same inquiry-based exercise where they again tested their own predictions.

Student assessment criteria reinforced the philosophical difference between the lecture and the laboratory. A document analysis performed on course policy documents, several quizzes, homework assignments, midterm exams, and laboratory report formats revealed a much greater emphasis in critical thinking and higher order thinking skills in the laboratory student assessment than in the lecture student assessment. The overall course grade is determined by a "Flexible Grading Policy." This policy allows a student to customize 10% the final score by allocating different weights to the assessment criteria (see Table 12).

Table 12
Student Assessment in Bayview's Physical Science Course

Assignment	% of Final Grade	
Class Attendance and Participation	5%	(5% maximum)
Quizzes	5%	(10% maximum)
Homework and Journals	10%	(15% maximum)
Portfolio	15%	(20% maximum)
Midterm Exam	15%	(20% maximum)
Final Exam	20%	(25% maximum)
Lab Grade	20%	(25% maximum)
Student's Customized Policy	10%	

Even though the laboratory portion of the final grade accounts for only 20% of the final grade, this component is really much more important to the final grade because the student must complete and pass the laboratory in order to pass the course.

Take home quizzes were given periodically throughout the semester. The students were allowed to redo the quiz and earn up to half of the points missed on the original quiz. I collected sample quizzes from 4 physical science faculty: the three interviewed faculty and one other on-campus instructor. These quizzes were sometimes identical, but at the least, very similar and tested for the lower order thinking skills of knowledge and comprehension. The midterm exam that I examined also tested for the lower order thinking skills, but did require students to explain why they chose particular answers. Even though the students were asked for explanations, most of the explanations could be completed if the students knew the proper definitions.

Journal assignments were due every week. Students were assigned or allowed to choose from a set of topics and wrote a paragraph about each topic. The topics required the students to use higher order thinking skills described by Bloom (1956) and the core critical thinking skills of presentation of arguments and self-regulation or reflection (Jones, 1995). For example, two possible topics required the students to discuss one concept from the course that made sense and one concept that did not make sense. One topic in particular gave the students the opportunity to reflect upon their learning and discuss how a concept that the student now understands is different from the student's preconceived ideas of the concept. The students are reminded in the "Course Policy" that the instructor is "looking for some personal interpretation of concepts, not simply a description of what happened in class or a restatement of definitions."

The portfolio assignments required the use of the higher order thinking skills of analysis, synthesis and evaluation, and at least the core critical thinking skills of inference (Facione, 1990) and reflection (Jones, 1995). Two sample topics from a list of 18 are as follows,

> (6) Identify one topic or concept and trace the development of your understanding of that topic throughout the semester. How many times have you noticed its relevance and in what ways?
>
> (16) Pick a science related topic that directly affects society (rain forest, ozone hole, global warming, etc.) and make connections to this class.

Although the journals and portfolio assignments involved a great deal of critical thinking on the part of the student, the value of critical thinking was diminished by the way these assignments were scored. At least one quarter of the grade on the Journal assignments depended upon neatness and how well students met minimum requirements. This downgrading of the emphasis critical thinking or constructivist learning was even more pronounced in the assessment of the portfolio, as evidenced by the list of assessment criteria. Seventy five percent of the portfolio grade depended on minimum requirements such as the inclusion of a table of contents, whether or not the portfolio was word-processed, the minimum amount of content, and if the included item was appropriate. Only 25% of the assessment was based on higher order skills: sufficient and correct scientific information, creativity, effort, and obvious connection to personal learning.

When all of the above factors are considered as a whole, the assessment of the lecture-based portion of the course was more consistent to an instructivist approach to learning. But the laboratory assessments were much more constructivist and inquiry based. Students were given practical exams that were taken in the same context as the learning experience. For example, if the students worked in groups using a motion detector, then they were tested with their groups, using the same motion detector. The students were given a group grade and were scored on their own individual work. The most interesting, and most inquiry based, assessment involved an open laboratory where the students designed and conducted an experiment on topics of their own interest. The list of minimum requirements on the major written summary report included items such as interpretations of graphs, discussion and application of physical laws, and a self-assessment. These requirements did require the students to employ critical thinking and the higher order cognitive skills of Bloom's Taxonomy (1956).

In summary, the physical science course was very conceptual in nature, with a mixture of instructivist and constructivist pedagogies. The lecture portion of the course was presented more in the instructivist mode. Student assessment in the lecture portion appeared to be more instructivist in nature due to the grading criteria putting less emphasis on the value of constructivist activities. The laboratory portion of the course focused on inquiry-based learning and was therefore clearly constructivist, both in terms of presentation and assessment. As a whole, the pedagogy in the physical science course included all five steps of the constructivist learning cycle, or the 5 E's (Bybee, 1993): engagement, exploration, explanation, and elaboration (assessment).

Environmental science. The environmental science course differed from the physical science course in class structure, pedagogy, syllabi, and assessment. Lecture and laboratory were fully integrated in the environmental science course, and the students always met in the laboratory. This arrangement allowed instructors more freedom to schedule constructivist activities such as problem- and inquiry-based learning. The instructors were also not constrained by 50-minute periods, as were the physical science lecture instructors.

From what I observed in my brief on-site visit, environmental science instructors appeared to have more freedom in content delivery and student assessment than the physical science instructors, as evidenced by classroom observation and document analysis.

The instructor who taught the day section spent over half of the two observed periods on constructivist activities. He began each period by having students give short presentations of newspaper articles on current events in ecology. He would add highlights and more in-depth analysis of the topic after each presentation. I considered this to be a constructivist activity because the students had to gather their own knowledge and synthesize it with what they had learned in class. In one class section, this instructor lectured about 50% of the time. The rest of the two observed periods were spent on problem- and inquiry- based activities that focused on different ecosystems, wetlands and the Chesapeake Bay. The students were attentive and actively engaged in their experiments. I inferred from their behavior and ability to work independently of the instructor that they were very familiar with this type of learning and encountered it often in the course.

The instructor who taught the night section of the course spent less time on constructivist activities than the other instructor, but this was partly due to reviewing for an exam and administering the exam. Each of these activities consumed over half of each period, respectively. The review consisted of a series of videos on sustainable agriculture. The rest of the periods were spent on problem-based learning, with the students continuing work on the same wetland ecosystem experiment that the day section students were doing and working on a different problem related to agriculture. The students were given a "problem" on how to manage a 40-acre farm specializing in chickens and soybeans. Students had to determine factors such as pH, chicken manure, water filtration, and other factors that could affect the soybean crop. Just as the students in the day section, the evening students were also very comfortable and familiar with the learning opportunities presented by the instructor.

Both of the instructors used the same laboratory manual that they were in the process of developing. It was written with a very casual style, with the authors often calling animals “critters.” The manual contained constructivist-learning activities such as problem- and inquiry-based exercises based on local environmental concerns, and the students were required to use the core critical thinking skills of interpretation, analysis, inference, evaluation, and explanation (Facione, 1990) as they worked through the given problems. However, the students were not often asked to make hypotheses, but were given scenarios to work with. For example, students were to design a house that would take full use of solar energy. This design included such things as windows and window placement, landscaping, and house orientation. Some of the laboratory exercises involved data collection over a several week period. The one that interested me the most was the fish lab (the favorite of the department chair that was excluded once by the evening instructor) that was done by both instructors. The day students were working on this at the time of my site visit. This lab began with a framing of the problem about losing the benefits of submerged grasslands in the bay: “Imagine the scenario if I, as an expert witness (scary thought), am called upon to testify as to the beneficial nature of submerged grasses.” The expert witness is badgered by an attorney, whose client wants to build a marina that would destroy the sensitive grassland (of course, the lawyer misconstrues the expert’s statements and wins the argument). This scenario led to the need for more knowledge about the ways aquatic and underwater plants interact and what the students needed to do:

Devise an experimental system that will provide definitive unbiased information necessary to answer the following questions:

1. Do some fish prefer a habitat supporting grasses?

2. If a preference is demonstrated, what is it about the grass habitat that is attractive? Is it the mere presence of structure to hide in?

3. Can minnows distinguish between different types of structure?

4. Do minnows exhibit a preference for a particular type or species of underwater grass?

The students were given a "budget" and instructions to design an experiment to answer the questions. The instructor was to review the experimental designs and help the students modify them so that the designs were compatible with available equipment and supplies.

The problem-based laboratories included four steps of the five step constructivist learning cycle, or the Five E's (Bybee, 1993): engagement, exploration, explanation, and elaboration. The fifth "E," evaluation (assessment) was not obviously present. Some assignments, such as the exercises involving long term data collection current event articles, might enable the students to improve their skills of self-regulation and dispositions (Jones, 1995), but the students were never asked to specifically reflect upon these two core critical thinking skills, either in lab or lecture. Even though the students should have been aware of their learning, I did not see any evidence of purposeful evaluation of the learning process.

Further document analysis revealed a distinct difference in the syllabi used in the physical science course and the environmental science course (see Table 13). The environmental science syllabi were much more streamlined than that of the physical science course and, in contrast with the physical science syllabus, gave students a minimal amount of information. Although the three biologists involved with the environmental science course stressed that they used the same syllabus and generally covered the same course content, class observations and document analysis revealed that, unlike the on-campus instructors in the physical science course, the two instructors teaching the environmental science course did use somewhat different syllabi, different teaching styles and very different grading criteria. Neither environmental science syllabus listed explicit goals or objectives, so I could not determine from the syllabi alone what core critical thinking skills were being stressed or exactly what type of pedagogy was featured. However, both syllabi hinted that constructivist learning would take place from the types of student assessments employed by the instructors. But the main difference in the student assessments between the two environmental science instructors was in the level of abstraction of exam questions. This difference tended to even out the amount of the final course grade based on constructivist activities and higher order thinking skills. As shown in his sample exam that I analyzed, the day environmental science instructor definitely assessed all core critical thinking skills in about 30% of his exam questions, except for self-regulation and dispositions (Jones, 1995). For example, one question gave the background of two endangered species, the Delhi Sands flower-loving fly and the scavenger California condor. The students were instructed to draw upon ecological concepts discussed in class and argue for the protection of the fly and against the protection and recovery efforts to save the condor.

Table 13
Student Assessment in Bayview's Environmental Science Course

Assignment Type	Instructor of day section % of Final Grade	Instructor of evening section% of Final Grade
Exams	27	30
Final	20	10
Quizzes	13	Not required
Current Events	7	Not required
Class Discussions	Not assessed	Not assessed
Laboratory Reports	13	35
Research Presentations/ Service Learning	13	10
Field Trip	7	Not assessed, but required
Journal	Not required	10
Attendance	Not assessed directly	5

The evening instructor's exam I analyzed mainly assessed the student's knowledge or other lower thinking skills as identified by Bloom (1956). This sample exam predominantly consisted of multiple-choice questions (69%), with a lesser amount of true-false questions (11%). Students could receive bonus points if they corrected false answers. The remaining 20% of the exam required the students to answer 4 of 8 short answer questions. Two of these questions listed below.

5. How would you go about implementing IPM (Integrated Pest Management) in your yard? Include the term "economic threshold."

Although the clever student could answer this question fairly easily because one of the multiple-choice questions listed examples of pest management, the student would have to use evaluation and explanation skills in order to fully answer this question.

7. List the pro's and con's of genetic engineering of plants.

This question simply asked the student to recall knowledge.

In summary, even though the physical science course and the environmental science course were very conceptual in nature, they were structured differently. The physical science course had separate lecture and laboratory sessions, which met in two different rooms. The laboratory had a heavy emphasis on inquiry-based learning. The environmental science course employed an integrated lecture-laboratory format and always met in the same room. This course featured problem-based learning. The environmental science instructors had a little more freedom and leeway in how they approached their classes than the physical science instructors. Students in both classes were assessed on higher order and critical thinking skills, but only the physical science students were specifically asked to reflect upon their learning.

Awareness and Knowledge of and Attitudes Toward the AAT Degree Requirements

Awareness and Knowledge of AAT Degree Requirements

Before I could determine faculty attitudes toward the AAT degree and its requirements, it was necessary to understand faculty awareness and knowledge of the AAT degree requirements. As expected, the director of teacher education was very aware of the purpose of the degree, but was not as fully aware of the requirements of the AAT degree. She knew that one of the overall intentions of the degree was to improve the transfer process for community college education majors moving on to 4-year schools. She offered some thoughts on the seamless transferability of the degree:

> So the seamless part is very important, of course, to our students, but the other reason is that as a state, and of course nationally, we know we have a teacher shortage…. So it was the state's way of approaching it and saying, we're going to try to make it less difficult for students to enter the field…. We want to take away a few of the hoops that we made [community college] students go through by having a seamless transfer.

The director of teacher education knew about the specific course content and science outcomes listed in TEAC's *The First Sixty Hours* document and felt that the two science courses were meeting those outcomes. When asked if there were any specific pedagogy requirements for the science courses, she first talked about pedagogy in the entire curriculum in general before she focused on pedagogy in the science courses. She said that even though they certainly discuss pedagogy in their education courses at Bayview, most of the pedagogy is presented in the upper division courses given at the four-year colleges. Honing in on the science courses, she related,

> I think the important thing in the science classes is that they are modeling a variety of teaching strategies and they are doing group work, and they are doing collaborative learning, and peer work and peer review, and a lot of more constructivist type things that maybe they weren't doing ten years ago.

When asked if the constructionist activities were mandates of the AAT degree, she incorrectly stated that they were not, but were just models of good teaching practices. I noted that the term inquiry or inquiry-based learning, stressed in the *Outcomes*, was never mentioned in her description of the pedagogy requirements. In fact, inquiry was never mentioned at all in the entire interview.

The chair of the physics department seemed to be very knowledgeable about the rationale for, and requirements of, the AAT degree, as evidenced in the following quote:

> It's basically to try to get a seamless transfer between the two-year schools and the four-year schools. So when you are AAT, elementary education AAT then a student can transfer into the junior year and not lose credits. It's basically to get more folks into the pipeline…. In terms of content, there is a whole list of outcomes that we are aware of; I won't be able to list all of them off. It's basically all the physical sciences and biological sciences, earth, space, geology. It's a wide range. And then the biology, it's life and some environmental. So content wise it's pretty much everything that you can think of in some degree or another. For the pedagogy, it's modeling the type of instruction that these teachers would be asked to use…. It could be called constructivist, if folks like that language or not, some are turned off by it. It's more active learning, it's inquiry, but it needs to be directed. Maybe the best way to say it is it's not straight lecture. Folks need to be engaged in terms of some type of active learning.

Although the department chair had a good understanding of the AAT degree, none of the three physical science instructors that I interviewed were very familiar with this degree. The first physical science instructor that I interviewed was not aware of the AAT degree or any of its specific requirements. I asked her if any of her physical science students were education majors, and she replied, "In the physical science, I know that [education majors] are one our primary target audiences…. And I know that many of our physical science majors are planning on being primarily, I think, elementary ed majors."

When I asked the second physical science instructor about the AAT degree, she replied, "I don't know anything about it. The only thing I know is that a large part of our population are education majors and when I ask them elementary or secondary, the majority of them are elementary." She was also unfamiliar with inquiry-based pedagogy, confusing it with the Socratic method of teaching by questioning. She explained how often she used the inquiry technique in her lecture:

> In an introductory lecture to a topic, probably not much; it's more of content, and see where they are. After we've had some content then it's go around the room and tell me, what do you think about this, what do you think will happen, do you agree with the person that just said that, and what are you thinking…. I use a lot of questioning, inquiry based at that point but not at the start, I give them some background first and then we do a lot of that. I will start with real straightforward questions that anybody would probably have an answer to and then as we progress through the topic then they will get more specific.

The physical science instructor who taught at the branch campus seemed to be a little more knowledgeable of the AAT degree than his main campus counterparts, and related his understanding of the degree and its requirements in the following interview excerpts:

> I know it exists, but apart from that I don't know too much more about the details or anything like that. I know the course is sort of structured towards [the elementary education major], for I've seen some of the previous class notes and things like that. It's mentioned in there, but that's about it, all I know about it….

> I couldn't give you specifics, I know that it's structured around whatever those requirements are because, as I was saying, some of the old class notes and things like that, I know there's records as to various requirements for that but I haven't really taken much notice about them, and as to how the course actually addresses those issues.

The chair of the biology department was very opinionated and tended to give expansive answers that really did not always answer my questions. But his responses were very telling (and more appropriately displayed in a later section of this study), so I was able to glean the information that I wanted from his comments. When I asked him what he knew about the AAT degree and its requirements, he was more interested in explaining the reasoning behind the creation of the environmental science course that the elementary education majors are required to take. He did not mention anything about the creation of the AAT degree, or any specific purposes of the degree, such as its seamless transferability. In fact, he did not use the term AAT degree even once although I mentioned it several times in my queries. I got the impression that he really did not know much about the tenets of the degree. But he believed that the purpose of the degree was to "train teachers for the future so they're prepared to do better than they have done in the past."

As far as the content and pedagogy requirements of the degree are concerned, he appeared to be totally unaware of *The First Sixty Hours* document and stressed that the content was defined in the documents approved by the college and Maryland's Higher Education Commission. He alluded to the fact that the college consults teachers in the public school system as to their curriculum and what they were trying to accomplish. He said that there should be many styles of teaching but was adamant that the course content drives the methods of delivery: "So the emphasis is on the course content. You demonstrate that the course content is delivered in multiple ways." The environmental science instructors were very similar to the physical science instructors in the lack of knowledge about the AAT degree. The first environmental science instructor that I interviewed admitted that he knew nothing about the AAT degree and stated,

> I should, I don't, I know that's true. I know that I get many students who are planning on becoming teachers. I actually don't know the details [of the AAT degree] and because I've never looked it up in the catalog, I don't know exactly. I know they have to take [my environmental science course]. I don't know what else they have to take.

I asked if anyone had ever discussed requirements for the AAT degree, and he replied, "No, and actually that is probably not a bad idea, but no one has ever done that, saying this is what we'd like our students to get out of your course."

The second environmental science instructor gave the following account of how she learned about the AAT degree:

> From my students. I was teaching environmental science and I always ask students what they are taking the class for, and a lot of them would say it's part of my degree, it's part of my degree, and when I asked them what it was for, it was the AAT. And then I did teach a whole class of AAT students last summer. [The public school system] had teaching assistants that had to get their AAT by, is it 2005, for No Child Left Behind, so the county schools had a whole cohort that was going to go through and do their AAT. Environmental science was the first

> course they took. So I really became more familiar with their requirements when I had that class last summer.

This instructor continued when I asked her if she had any formal knowledge of the degree requirements:

> Not really, I've been meaning to. I was going to go to a workshop on Praxis but I was too busy. I haven't really done much. I did look at what the requirements were for the degree and just looked in the college catalog, just spoke with teachers…. I've got some teachers I've spoken with about what they have to do and what is expected of them, but nothing really formal.

She also stated that she knew the physical science course and environmental science courses were required, and wondered why Biology 101 was not included as a requirement.

In summary, there was a mixed awareness of the AAT degree itself, and of the content and pedagogy requirements of the degree. The chairman of the physics department seemed to be the most knowledgeable about the degree, although the director of education was also very familiar with the degree. It is interesting to note that none of the faculty who were actually teaching the science courses that support the AAT degree were ever directly informed of the degree and had little knowledge of it. This may in part be due to the two science courses being well established, long-standing courses before the AAT degree was even conceptualized.

Attitudes Toward AAT Degree Requirements

Just as the level of awareness of the AAT degree varied, one might expect the attitudes toward the degree to vary as well. The director of teacher education and the chair of the physics department were very aware of the degree requirements and offered definite attitudes toward the degree requirements. The chair of the biology department was not aware of the AAT degree requirements, but had definite opinions about how science courses should be conducted. Since the six teaching faculty that I interviewed were not very cognizant of the degree, or its content and pedagogy requirements, I am going to infer that their attitudes toward constructivism and inquiry-based learning reflect their attitudes toward the degree requirements. I believe this is justifiable since the three other case studies showed that faculty who had strongly positive attitudes toward these types of pedagogies also had positives attitudes toward the AAT degree requirements. Information on what an instructor would do if he or she were to design a course for elementary education majors also sheds light on attitudes toward the AAT degree requirements.

The director of teacher education was very enthusiastic about the AAT degree, with only a few minor concerns. When asked whether or not the AAT degree would improve the education of the elementary education major, she replied,

> They will be very well rounded students in science, in math, in the social sciences, in psychology, and in education courses. They will have a health course and they will have a fine arts course that covers all the fine arts. They will be very well rounded, very appropriate for what you would want a future elementary teacher to have. So I think it's fabulous. On the other hand… we have a lot of people who took one or two courses 5 or 6 years ago, maybe a course ten years ago, they are coming here to us with a dozen random credits…. They are 30 years old, they've been volunteering in their kid's schools and they want to be teachers.

> Fabulous, we want them. But you know what, those 12 credits you took don't fit. So that's the hard part… I feel bad when I have these students who come in, who just don't have the right variety of credits that they have accumulated along the way or whatever. There is the opportunity for those students, however, to not get the AAT. We've kept our AA degree in teaching alive. It's more like a general ed degree….
>
> I think that overall the AAT is really a good step in the right direction to create teachers that have very strong foundations. Because, I think, before [the AAT degree] it was really easy to get your gen ed requirements and then take what you liked and not [have taken physical science]. I've seen [the chair of the physics department] teach this class and I think it's fascinating, but if I had just read the description back when I was 19 in college, I wouldn't have taken the class. And that's what we don't want to happen…. they need this variety, don't just take what you like…. You are going to be teaching that variety, so you need it. So I think it is excellent.

She gave a specific example of how the physical science course (as taught by the chair of the physics department) was received by current teachers returning to improve their education or to attain re-certification:

> So we had this Eisenhower grant that we were able to bring current teachers in to take our physical science class, which is what is in our AAT now. So future teachers are getting it as part of their AAT, but the former teachers and current teachers… don't have that background and that basic understanding of physical science…. The responses were just wonderful. So I know when [the department

> chair] works with the AAT students, and all of his instructors as well, that [the returning teachers] are getting [that basic understanding]…. When you look at the teachers that are out in the field and are teaching out there, they are saying, I wish I'd had this back in college. I wish I'd had this background for the last 15 years I've been teaching because this is going to be great for the next 15, and things like that. So those are the kinds of comments they were saying. So it was very rewarding [to know that] we are doing the right thing with these AAT students, because we know from people in the field that have just taken the course how valuable they see this class.

The physics department chair's opinion of the AAT degree centered mostly on its transferability, as evidenced by the following interview passage:

> Probably for me the most useful [outcome] for the AAT is being recognized by the four-year schools, to ease transfer, as opposed to making sweeping changes in our pedagogy or curriculum. Our [pedagogy and content were] pretty well set and matched up fairly well [with the AAT degree] at the beginning, so I don't think there is a huge change…. I think that the biggest thing is that our students leaving our school actually get [into the four-year schools], become a junior, and not lose a lot of transfer credits, and that should produce more students in the pipeline.

Although not directly stated, the department chair implied a strongly positive attitude toward the content and pedagogy mandates of the degree through his acknowledgement of how well their long-standing pedagogy and content matched with the AAT degree outcomes, and through his desire to maintain stability in the physical science course in the future. In fact, this department chair was absolutely adamant about maintaining the constructivism and guided inquiry that he had infused into the physical science class over ten years ago, and stated, “We are cognizant of the curriculum that we have, that we’ve got to make sure that it is being passed along and remains somewhat stable across semesters.” He used his authority to ensure that only hand picked instructors who were amenable to constructivism were allowed to teach the physical science course. I asked him if all of the faculty teaching the physical science course were interested in the constructivist or inquiry based pedagogy, and he replied,

> Not necessarily. Most of the folks that I bring on board are traditionalists, but they have inclinations. So once they get into the course, most of them enjoy it and they take to it, with some training or some modeling, or some guidance. So most of the folks who have taught in the past and are teaching it are on board in various degrees. There are some folks I would never let teach the course because their inclinations just aren’t there. So yeah, pedagogically there is some range but [about] 50% of the lean is toward some type of constructivist active learning

The first physical science instructor, who was not aware of the AAT degree or any of its requirements, naturally could not state any defined attitude toward the degree. But I could infer at least a positive attitude toward the physical science requirements by her answer to my question of what she would do if she were in charge of designing a physical science course for elementary education majors:

> I would do this course. From a student point of view, I think this is an excellent, excellent course. The students have been so freaked out with their experiences with science, and in one semester of teaching them science, you are not going to improve their math skills to an extent that you could ever possibly try to teach

> them a mathematical based science course. So I think this course hits it on the head. I'm really happy from a student point of view for this class, [but it's] a lot of work from the faculty point of view.

The second physical science instructor, who confused the Socratic method with inquiry-based learning, really did not know enough about the degree to have a well-formed attitude one way or the other. She did, however, exhibit some ambivalence toward the inquiry-based laboratory, and stated,

> The way the lab is structured, no matter what topic they are doing, they are asked to predict what will happen in a certain situation, and then actually carry it out and analyze what they got [as compared] to what they predicted. I haven't used that before in a lab situation. That was new to me here. Sometimes [the students] are surprised by their predictions, but I don't think that there is enough time by them, or maybe it's the lab situation, spent on actually comparing what they find experimentally and what they predicted. They pretty much go with what they find experimentally and they ignore what they predicted. They don't really go back and analyze and compare the two that much. And I know that's the purpose of it; [students should] see where the flaws are in [their] original thinking. But I don't know that the students, by the end of the three hour lab, that they are awake enough or spry enough to keep going like that.

The physical science instructor who was teaching at the branch campus also had very unclear attitudes toward the degree requirements even though he was slightly more aware of them than his counterparts on the main campus. I did not ask this instructor about inquiry-based learning because it was clear from his academic background and descriptions of how he taught that he was totally unfamiliar with educational terminology describing teaching methods. I got the impression that he would have used some constructivist pedagogy in his design of a physical science course for elementary education majors. He stressed that any course that he designed would be oriented heavily toward demonstrations, although he would ask students to make predictions before he performed the demonstrations. The use of predictions is clearly constructivist, as is his emphasis on wanting students to come up with their own answers. Even though this instructor was not formally aware of inquiry-based learning, he did seem to enjoy the format of the inquiry-based lab that I observed.

I did not directly ask the chair of the biology department about his attitude toward the AAT degree, but when I asked him to define the pedagogy requirements for the AAT science courses, he asked for a definition of pedagogy. When I offered the terms constructivist, instructivist, hands-on, inquiry based, he offered this animated reply:

> That's educational jargon I'm not overly fond of. I have some very, very particular biases. A course is defined by its academic course content, so in terms of what a course is to deliver, the primary focus is on the content. It's driven by the standards of the discipline. If it's a chemistry course, its going to be this. If it's going to be an environmental science course, it's going to be that. So the course is constructed around the contemporary requirements of the discipline, and, in as much as possible, you avoid those annoyances that detract from delivering the core course content of the contemporary discipline. My personal biases [are that] often, educators can get in the way of that process.

He did concede that an instructor must be very realistic about the audience and the available resources, especially when teaching teachers, as evidenced in statements made after his tirade about educators:

> So the emphasis is on the course content. You demonstrate that the course content is delivered in multiple ways. Sometimes, depending upon the time and the format, you have to be able to demonstrate that you can accomplish the same thing with two very, very different approaches. So, maybe your preference for doing a particular thing might be a field trip or a laboratory exercise. Now what happens if you don't have a lab or it is raining that day? You need to have a back-up plan for teaching those same things in an alternate pathway. So part and parcel of what you get in a course is a smorgasbord—here's the course content,and you convey that content by multiple vehicles.

He continued this discussion and focused on the environmental science course that elementary education majors take:

> Something that I think is pretty important that is often times overlooked, is I will use the same teaching resources literally to a group of first-graders that I will use for the governor and state senators. Because the facts are what they are, the issues are what they are. And now, will I translate them in different ways? Yes. Will the degree of detail be different? Yes. But in terms of the core message, here's the issue, here's the problem, here is what we need to solve. The message is what it is. And I found that people understand that message well and the discipline will have a good facility for translating it, irregardless of the age level. A first-grader has a lot of common sense, arguably more than a state senator.

He raised a concern about gearing a course toward education majors, and declared,

> It really concerns me when I seem to be hearing a slant, well, how is this tweaked to fit elementary ed, middle school, high school, college – it doesn't matter…. It seems like the focus is a little bit on the group as opposed to the discipline. There is a slight, but important, difference. The focus has always got to be on the discipline. How can you make that material useful to this group? Same difference, but I think it's an important one.

Although the chair of the biology department seemed to be very caustic about "educational jargon" or descriptions of different pedagogies, and sneered at terms such as constructivism and inquiry-based learning, whether he realized it or not, the environmental science course that he himself designed includes many aspects of constructivist pedagogies.

The first environmental science instructor I interviewed (who seemed somewhat apologetic for his lack of knowledge of the AAT degree) recognized, as did the chair of the biology department, that the environmental science course format somehow promoted better student involvement and interest than did the traditional lecture-lab format of his standard introductory biology course. He stated that even though he expected more from his environmental science students than he did from his biology students, the environmental science students tended to get better grades. He also thought that the way his environmental course was taught would be beneficial for the elementary education major. Since this course met the AAT requirements, I inferred that this instructor had a good attitude toward the AAT degree (at least the required environmental science course). I asked him how he would design science courses for the elementary education major, and he replied,

> Well, let's see, if you were an elementary ed major, first of all, you need to understand how science works. Actually, I think environmental science, the way we teach it anyway, is a really good course for them because we teach them how science works and we also teach them how the immediate world around them functions…. If they take [Biology] 101, they can learn the chemistry of cellular respiration and they can learn genetics, but I'm not sure how often that is going to come out in their elementary school classrooms.

Later in the interview, we discussed my own personal research and constructivist teaching techniques. I asked him if he had ever been taught by constructivist techniques, such as those used in the environmental science course, he laughed and said,

> No, actually I haven't. One of the first things I figured out is that if I came here and taught the way all my professors have ever taught me, I would be fired…. I was at one undergraduate and three graduate school places…. As long as [professors] were accurately throwing that content out, [they were doing their] job. What you learn when you get here is, you've got to be accurate about your content, but that is not the end.

He volunteered the following comments on constructivism versus instructivism,

> I think it's better [using constructivist techniques], but it's harder…. If you are going to teach through example, through inquiry, and through experiments, you've got to figure out how to do the inquiry, but you also have to figure out

how to make the inquiry convey all that content also. And it's really cool when you figure it out, but it's much harder to do.

I did not ask the second environmental science instructor about her attitude toward the AAT degree since she was not very aware of the degree, so I asked about her feelings toward the constructivist teaching paradigm. She stated that she was not sure what I meant, but when I added the term inquiry-based, she immediately responded,

> I think it's good. The kids have to learn how to do. Like right now, I'm getting the product of years of education where they just sat there and absorbed and repeated…. One of the things that worries me is sometimes with the inquiry based, I've seen times where students just aren't learning the material… they never quite figure out why they are doing it, they never come up with the answers…. A lot of times they are just kind of left on their own and they are not getting the answers. And sometimes there are answers and they are not getting the answers to where they should have them. And they are not quite understanding what they are supposed to be doing with the inquiry. I think they definitely need more guidance along the path.

This instructor continued the discussion by stating that she likes to get the students involved in the learning process. She explained why it is important for students to be able to express their own opinions,

> I try to avoid just getting up there and talking. I like to ask them how they think this works. And with environmental science, it is interesting because opinion does play a bit of a role. Sometimes the science is there, but you can argue it from two different ways…. Your personal philosophy plays its role in

> environmental science…. I like to get [the students] to at least form an opinion. A lot of the younger students… expect to memorize things and tell the teacher what the teacher wants to hear. And that's what they are going to get tested on. I try to get them to look at the science and form their own opinions on what they think is happening…. There is not always a right or wrong answer [to scientific problems], it's how you back up [your opinion]…. I think that it is important to get them to trust what they're reading and what they are thinking, and use the science to back that up.

In comparing the level of knowledge about the AAT degree among the four community colleges in this study, Bayview Community College faculty (at least the participants actually teaching the science courses in support of the AAT degree) appeared to have the least amount of formal knowledge concerning the degree. They also showed the least concern about accommodating elementary education majors, and generally followed standard course policies. I believe that this gives cogent and compelling reasons for omitting sections on factors affecting the change process.

Students' Perceptions of Constructivist Teaching Activities

The students from four of the five different instructors whose classes I observed were asked to voluntarily fill out a student questionnaire studying aspects of critical thinking and student behavior. Seventy-four students participated in this study. Forty-one physical science students from two different lecture sections, and 33 environmental science students, again, from two different lecture sections, filled out the student questionnaire. Students from one of the on-campus physical science sections did not participate due to the instructor running out of time at the end of the observation periods.

The students were asked if the science course they were enrolled in helped them improve their abilities in different aspects of critical thinking: interpreting written information, analyzing numerical data, explaining scientific information to others, and evaluating strengths and weaknesses of information or arguments. For each question a student answered affirmatively, he or she was asked to name a specific course assignment, such as one particular essay, or an entire classification of assignments, such as laboratory reports, that helped in the improvement of critical thinking skills. The student was then asked to elaborate on how that course assignment was helpful. Students were also asked to explain what their instructor did in terms of teaching that helped them to learn. The last question of the survey asked if students preferred working in groups as opposed to working individually. The students were also asked to explain their responses to this question.

Perceived Improvements in Critical Thinking

Of the 294 yes or no responses to the core critical thinking skills questions, 55% (163 responses) indicated that students perceived aspects of critical thinking taking place, while 45% (131 responses) showed that students were not aware that aspects of critical thinking were taking place (see Table 14).

Table 14
Bayview Students' Perceived Occurrences of Aspects of Critical Thinking

	Physical Science (41 students)		Environmental Sci. (33 students)		All Students (74 students)	
Core Critical Thinking Skill	Yes %	No %	Yes %	No %	Yes %	No %
Interpret	76	24	52	48	65	35
Analyze	41	59	24	76	34	66
Explain	85	15	73	27	80	20
Evaluate	43	57	42	58	42	58
Overall Percentages	62	38	48	52	55	45

When looking at the data, I immediately noticed two major differences between the physical science students and the environmental science students, and one interesting similarity. First, there is a stark difference between the perceptions of the total number of physical science students (41) versus the perceptions held by the 33 environmental science students. Sixty-two percent of the physical science students perceived aspects of critical thinking taking place, while only 48% of the environmental science students perceived that critical thinking was occurring. It is very difficult to discern reasons for such a disparity. I was not able to compare the effect of the course structure and format (inquiry-based labs versus problem-based learning), but I did notice a difference in student assessment between the physical science course and the environmental science course. In the physical science course, students were explicitly assessed on, and asked to use the critical thinking skill of reflection (Jones, 1995), whereas the environmental students were not. However, I am very reticent to state that this is the sole cause, or even a contributing factor, in the difference between the two courses. This phenomenon warrants further study.

The second striking difference between the physical science students' and the environmental science students' perceptions of the use of core critical thinking skills occurs in the comparison of individual course sections (see Table 15). Both sections of physical science course that were given the student questionnaire had the same percentage of students (62%) perceiving that critical thinking was present. In contrast, there was a marked difference between the day section and evening section of the environmental science course. A higher percentage of the students in the evening section

(52%) perceived aspects of critical thinking occurring than did their counterparts in the day section (45%).

Table 15
Bayview Students' Perceptions of Use of Core Critical Thinking Skills

	Phys Sci main (26 students)		Phys Sci branch (15 students)		Envir. Sci day (19 students)		Envir. Sci eve (14 students)	
Core Critical Thinking Skill	Yes (N)[a] %	No (N) %	Yes (N) %	No (N) %	Yes (N) %	No (N) %	Yes (N) %	No (N) %
Interpret	19 **73**	7 **27**	12 **80**	3 **20**	9 **47**	10 **53**	8 **57**	6 **43**
Analyze	12 **46**	14 **54**	5 **33**	10 **67**	4 **21**	15 **79**	4 **29**	10 **71**
Explain	22 **85**	4 **15**	13 **87**	2 **13**	14 **74**	5 **26**	10 **71**	4 **29**
Evaluate	11 **42**	15 **58**	6 **43**	8 **57**	6 **35**	11 **65**	7 **50**	7 **50**
Totals (N)	64	40	37	23	33	41	29	27
Percentages	**62**	**38**	**62**	**38**	**45**	**55**	**52**	**48**

[a] Number of student responses

The only difference between these two sections that has not been discussed, and that may be a contributing factor, is the student demography. The overwhelming majority (17 of 19) of students in the day section were young and all but one student was registered as a full-time student. Twelve of the 19 students were less than 21 years of age and 5 students fell within the 21-23 years of age bracket. Half of the 12 youngest students were registered as full-time sophomores, yet had not taken a science class before. In contrast, only 1 of the 5 evening students who were taking their first science course was registered as a freshman in the 18-20 years of age bracket, and all 5 of these students were registered on a part-time basis. This data may indicate that the evening section students were more academically mature than the day section students, and perhaps, not as afraid of science as the day section students who avoided taking science in their freshman year.

Although the physical science students and environmental science students held varying perceptions on the presence of critical thinking skills, they exhibited the same relative rankings for the frequencies of their perceptions on the presence of each of the four critical thinking skills (see Table 13). The critical thinking skill of explanation of scientific information was perceived to be by far the most used critical thinking skill by each set of students, followed by interpretation of information, evaluation of information and arguments, and, finally, the skill in analysis of numerical data. I believe that the very high ranking of explanation (80% overall) is due to the fact that the students were always explaining concepts, results, and rationales. Since both courses were very conceptual in nature and limited the amount of difficult numerical analyses, the very low ranking for analysis of numerical data (34% overall) is to be expected, and should not be construed as a shortcoming.

When looking at the entire group of student participants at Bayview, it is difficult to discern which course activities were the most influential in perceived gains that students noted in their critical thinking skills. Only 73 of the 163 responses clearly mentioned identifiable course activities that promoted critical thinking. The frequency of specifically mentioned assignments may not truly be indicative of their overall importance to the students since there was considerable difference in the types of activities stressed in the two courses, especially between the different sections of the environmental science course. As a whole, 38 (52%) of the 73 responses that I was able to categorize clearly showed the importance of the laboratory experience in helping students to perceive gains in critical thinking skills. But this number may be a little low because some students mentioned laboratory type exercises without clearly using the word laboratory in their comments. The next most frequently cited activities were the use of journals (13 comments, or 18%) and Internet assignments (10 comments, or 14%).

Perceived Helpfulness of Teaching Techniques

Although the levels of perception of the presence of critical thinking skills varied, 95% of all the student participants recalled and related some positive learning experience. These students were able to cite examples of teaching techniques or instructor attributes that helped them learn. Many students appreciated the demonstrations and hands-on work, which they said breaks up the boredom of straight lecture. An environmental science student commented, “He creates a hands-on learning class which is wonderful. We get a world view along with an understanding of our local environment.” They also appreciated visual aids such as diagrams and demonstrations. One physical science student commented on how important diagrams could be in maintaining student interest by saying, “She breaks the lecture down to our level and goes in depth. She reads our faces and elaborates even more. Draws stick people too.”

Several students in each of the 4 sections commented on the patience of their instructors and how they were willing to repeat information for students. The students were also impressed by the clarity and depth of explanations given by their instructors. One quote taken from a physical science student at the branch campus nicely sums up frequent comments about teaching techniques and instructor attributes that were very helpful and conducive to learning, although I do not think that all of the parenthetical aside applies to the entire set of students:

> "(Our instructor) interrelates different sciences to show how they coexist in nature. He takes as much time as necessary to make sure that we understand the concepts. He uses various types of experiments and class involvement rather than just lecture. (This is the hardest I have <u>ever</u> [emphasis in text] worked for a 100 level course – but it is worth it. I really understand what he is teaching.)"

Although 95% of the students had positive comments about their instructors' teaching techniques and attributes, only 65% of them stated that they preferred to work in groups. A typical reason for appreciating group work is given by a physical science student, " I like to work in groups so that when I don't understand something my teammates can help me understand. Working in groups also gives you other ways to think of things because not everyone has the same answer." An environmental science student adds, "Most of the time I like working in groups because everyone has their strengths and weaknesses. One group member's weakness could be another's strength. Groups also help me stay on track."

A few students were ambivalent about group work, citing pro's and con's on why they sometimes liked group work and sometimes did not. The rest of the students, 27%, stated that they did not like group work for various reasons, most commonly because some group members do not participate fully and contribute to the group effort. Six students specifically stated that they were independent thinkers and worked better alone. One of these students offered a very erudite reasoning for not preferring group work,

> "Though it may offer the opportunity to have multiple options and vantage points to certain problems, my personal preference is to work alone. I find that if I can follow my mind on a problem by myself, there is a distinct ease I feel as the extraneous effort of having to argue my point to others is lacking. If I have faulty findings, then they are wrong, but until I find a problem, I will continue on my path."

This young male student was very polite and mature in his reasoning, but some of his young male colleagues were very caustic in their explanations for not liking group work. A male environmental science student in the range of 21-23 years of age, offered this terse explanation, "I don't like relying on clueless 18 year olds." Two young (18-20 years of age) male physical science students did not refer to "18 year olds" but were disdainful of other students in general, as evidenced by the following quotes: "The people in this class are either obnoxious or incapable of doing work for a group," and, "Because people are stupid and will bring my grade down." Fortunately, these three young men were not typical of the entire group of physical science and environmental science students.

Summary

In summary, both the physical science and environmental science courses that support the AAT degree at Bayview Community College were designed before the advent of the AAT degree and were very robust and well established at the time of my site visit. The chairs of the physical science and biology departments played key roles in the design of the two courses and were the dominant factors affecting how the faculty approached and implemented the course policies on a day-to-day basis. The instructors had some leeway in the expression of personal teaching styles, but the content was more rigidly controlled in the physical science course than in the environmental science course.

Personal knowledge of the AAT degree varied, and there was a range of opinions (either tacit or directly stated) about the AAT degree requirements. The instructors exhibited the least knowledge of the degree, mainly because they were never formally introduced to the degree or its requirements. This may in part be due to the two science courses being well-established, long-standing courses before the AAT degree was even conceptualized, and the fact that they were designed to be general education courses. But, in one form or another, all of the respondents had something positive to say about the content and/or the pedagogy requirements of the degree. In general, the instructors appeared to be satisfied with how the courses were designed and comfortable with their roles in the teaching of the courses. However, as far as the elementary education majors are concerned, I believe they could be better served if the instructors had more formal knowledge of the AAT degree and its mandates.

In general physical science students had a greater perception of the presence of critical thinking skills that did the environmental science students. On the average, more students perceived the presence of the explanation of scientific information skill than any other critical thinking skill. Students did not perceive the analysis of numerical data since the two science courses were mostly conceptual in nature. The large majority of the students reported positive learning experiences and attributes of their instructors that helped the learning process. A lesser majority preferred to work in groups.

Chapter Nine: Cross-Case Analysis

In review, this qualitative research project attempted to fill a void in the literature concerning the attitudes of science faculty at Maryland community colleges who are or have been involved in making a paradigm shift necessitated by the mandates of the AAT degree. The Associate of Arts in Teaching (AAT) degree centers on a chosen set of outcomes that are based on standards of pedagogy and content recommended by the National Council for Accreditation of Teacher Education (see Appendix A). NCATE stresses the need for inquiry-based pedagogy and for students to learn science as a process of inquiry. Science faculty charged with teaching courses that support the AAT degree may have been faced with the challenge of either changing the content and/or pedagogy of their existing courses, or creating new courses.

Nineteen faculty and 149 students from four Maryland community colleges participated in this qualitative study. Four types of data were collected during the spring semester of 2004 (individual faculty interviews, classroom and campus observations, documents, and student questionnaires) and later analyzed on a case-by-case basis. A cross-case analysis was performed in order to individually answer each of the five research questions. The answers to the research questions overlap considerably, and provide useful information to change agents and faculty who are requested to make curricular changes in content and /or pedagogy.

Research Question #1

What are the science faculty's attitudes toward the science content and pedagogy requirements of the new AAT degree?

The science faculty's attitudes toward the science content and pedagogy requirements of the AAT degree generally appeared to be strongly related to their awareness and formal knowledge of the degree (see Table 16). Although I inferred attitudes toward degree's pedagogy requirements by the teaching faculty's attitudes toward and use of constructivist teaching techniques in the individual case studies, Table 16 refers to explicitly expressed attitudes toward the degree's pedagogy and content requirements. The science (teaching) faculty who were very cognizant of the degree requirements were enthusiastic about the degree and its potential effect on the science education of the elementary education majors (recorded as S's in Table 16). The faculty member who had a moderate awareness of the degree requirements did not have as well of a defined attitude toward the requirements, but was positive toward what she knew of the degree (M in Table 16). The faculty who were not aware of the degree requirements (recorded as N's in Table 16) did not express any explicit attitude toward the degree. Of the non-teaching faculty interviewed, the chair of the physics department at Bayview and the four directors of teacher education all had very clear and positive attitudes toward the degree requirements, although one of the directors was not very well versed with the pedagogy requirements. The chairman of the biology department at Bayview was not really aware of the degree and its requirements.

Table 16
Teaching Faculty Awareness and Attitudes Toward AAT Degree Requirements

	Physical Science	Earth and Space Sci.	Biology	Environmental Sci.
Oakmont	N*	N	M**	
Lakeside	S***	S	N	
Beltway	S	S		
Bayview	N, N, N			N, N

*N = no awareness, no explicit attitude
**M = moderate awareness, positive attitude
***S = total awareness, strongly positive attitude

I noted two major factors that affected the science faculty's attitudes toward the requirements of the AAT degree. The first factor, the level of communication between the faculty charged with implementing the science courses and those who desired the courses to be implemented, definitely affected the attitudes toward the requirements of the degree. As previously stated, a greater awareness of the degree requirements appeared to coincide with positive attitudes toward the degree. Secondly, personal interest in pedagogy, and science education in general, also seemed to influence attitudes toward (and awareness of) the AAT degree requirements. These two factors are discussed in the following paragraphs.

The four schools clearly differed in the amount of communication between faculty members. Oakmont and Bayview did not have strong channels of communication, while Lakeside and Beltway did. At Oakmont, where the AAT degree was just starting, there was a serious lack of communication that began with the director of teacher education. Although the director was able to determine which outcomes were addressed in each of the three science courses, she was not aware of what actually occurred in the classrooms, and was unwilling to become involved with actively assisting the instructors. She did not perceive herself to be in a position to exercise any control over the way the science courses were taught, either in terms of content or pedagogy. The chair of the science department did not appear to take an active role in communicating the requirements of the AAT degree or assisting the science instructors. This lack of communication led to a sense of isolation felt by the earth and space science instructor, and to a lesser extent, the biology instructor. Lack of communication also contributed to the physical science instructor's misinterpretation of pedagogy requirements. The three science instructors did not network with each other or ask for assistance from the director of teacher education. I noticed there was not much interaction with AAT faculty from other schools, although the earth and space science instructor used a syllabus taken from another school, and the physical science instructor had attended some MAPT meetings. When all this lack of communication is put together, it is easy to see why the earth and space science instructor did not have well defined attitudes about the degree, and the physical science instructor was satisfied with what he incorrectly perceived were AAT degree pedagogy requirements. It was only through personal interest that the earth and space science instructor had some knowledge of the degree, but not enough knowledge to have a well-defined attitude. The biology instructor also took a personal interest in the degree and had some knowledge of degree requirements because of communication with a colleague. She did exhibit a positive attitude toward what she knew of the requirements.

The lack of communication I observed at Bayview was of a totally different nature than the lack of communication at Oakmont. The science courses that supported the AAT degree at the time of my visit had been in existence for several years, and were very mature before the advent of the AAT degree. The chairs of the physics and biology departments were the main forces behind the creation and implementation of the two science courses that ultimately supported the AAT degree. Both the physical science course and the environmental course were designed for the general student population. The director of teacher education was well aware of the content and pedagogy of the physical science course, and through discussions with the department chair, she determined that the physical science course did meet the AAT requirements. I am not sure if she discussed the environmental science course with the chair of the biology department or not, but she determined that this course was also compatible with AAT requirements. Since the director of teacher education thought that the physical science and environmental science courses were in compliance with the AAT degree requirements, and were regular general education courses, she may not have believed there was a need for any further communication with the science faculty teaching the courses. However, this lack of communication between the director of teacher education and the science faculty resulted in a complete unawareness of the degree on the part of the science faculty. Of the entire faculty interviewed at the four campuses, the science faculty at Bayview were the least personally interested in or concerned about the degree.

There were high levels of communication between faculty and administrators and among the teaching faculty at the other two schools. At Lakeview, the director of teacher education communicated regularly with the chair of the science department and the physical science instructor. She was aware of the physical science instructor's interest in constructivism and inquiry, and asked him to become involved with the AAT degree. In turn, the physical science instructor worked closely with the new earth and space science instructor and assisted her in the design and implementation of the earth and space science course. The high level of communication and collaboration between the physical science instructor and the earth and space science instructor, their interest in public education, and their personal interests in the degree and constructivist pedagogy, all reinforced their positive attitudes toward the degree requirement. The only apparent glitch in the chain of communication was with the biology instructors. The biologist that I interviewed was not aware of the degree requirements; therefore I assumed that she did not harbor any attitudes toward the degree. The director of teacher education was under the impression that the biology course lacked inquiry-based learning opportunities, but did not want to pursue the issue for fear of upsetting instructors who were well-entrenched and nearing retirement. When I interviewed a biology instructor, studied the laboratory manual, and overheard a portion of a biology laboratory, it was clear that there was inquiry built into some of the laboratory exercises. Had the director of teacher education studied the biology laboratory manual, and asked the biology instructors to explain what went on in their course (in other words, communicated with the biologists), she might have been less critical of the biology course and more willing to engage in further dialogue.

The three faculty I interviewed at Beltway exhibited the most awareness and most strongly positive attitudes toward the degree requirements of all the faculty interviewed. These faculty had been in close company for over 20 years, and worked together to improve the education of science teachers. They were personally interested in the degree, inquiry-based pedagogy, and science education in the public school systems. However, there did not seem to be much communication with biology instructors, and only a few biology instructors were reported to be receptive to constructivist pedagogies.

In summary, the level of awareness of, and attitudes toward, the requirements for the AAT degree varied. Communication and personal interests in the degree and in constructivist pedagogy influenced the level of awareness and attitude toward the degree requirements. In general, the instructors who had extensive knowledge of the degree had very positive attitudes toward the content and pedagogy requirements of the degree. It is interesting to note that faculty at Lakeside, Beltway, and Bayview all were more interested in complying with their local county science content standards than they were in complying with state content standards. But this is not a shortcoming since the counties have to comply with state standards.

Research Question #2

What changes (including the type and degree of the change) have faculty made in the course content and pedagogy in order to satisfy AAT degree requirements?

Very few faculty made substantive changes in course content or pedagogy in order to satisfy the AAT degree requirements. In fact, the AAT degree was a non-issue at Bayview Community College, and to some extent at Beltway Community College as well. Both of these schools had well-established science courses before the advent of the AAT degree, and these courses, except for biology at Beltway, met the AAT content and pedagogy requirements without the need for any changes. The director of teacher education stated that a small group of biologists was adding more investigative work into the laboratory, but this was not done in response to the AAT degree.

The Oakmont faculty did institute some changes to accommodate the AAT degree requirements, but the major change occurred in the creation of a new earth and space science course. Since this was a new course, and the first time it was offered, I cannot say that the instructor made purposeful changes to the course. The physical science and biology courses existed long before the advent of the AAT degree. The only change made in the physical science course was the inclusion of a few more activities. The instructor did not change the course content or pedagogy. The biology course content was not substantially changed in the section that was set aside for AAT majors. Most of the content changes came because the instructor did not present the material in as much detail. This section of the biology course used a different laboratory manual that included more constructivist exercises. The physical science instructor at Lakeside Community College did make tangible changes to his course content and pedagogy in response to the AAT degree. He based his content upon the local county essential curriculum for K-8, Project 2061, and other national standards. He reduced the overall scope of topics, especially in chemistry, that were traditionally covered in a physical science course in order to concentrate on major topics in physics, and tried to integrate the various topics. The significant changes in pedagogy were a switch to presenting material from a conceptual point of view instead of a heavy emphasis on mathematics, and adding a significant amount of inquiry-based exercises into the laboratory. The earth and space science course at Lakeview was specifically created in response to the AAT degree. Since this was a new course, the instructor did not make changes, but purposefully designed the course in order to meet AAT pedagogy and content requirements.

In summary the type and degree of changes made in response to the AAT degree pedagogy and content requirements varied. The most evident changes occurred in the Lakeside physical science course and the Oakmont biology course. There were no changes made at Beltway or Bayview in response to the AAT degree.

Research Question # 3

What changes have faculty made in student assessment techniques in order to satisfy AAT degree requirements?

The changes in assessment techniques mirror the changes in content and pedagogy. No changes were made at Beltway or Bayview in specific response to the AAT degree requirements. As stated before, all of the relevant science courses (except for Beltway's biology course) were in existence before the AAT degree was instituted and already fulfilled the requirements of the degree.

Oakmont's physical science instructor made a minor change in assessment in response to the AAT degree, but this assessment did not account for a significant amount of the students' final grade in the course. The AAT students in the physical science course were required to evaluate educational websites as part of their journal assignments. The non-AAT students were not required to make this inclusion. But, when compared to the traditional student assessments done in the other sections of the biology course, I could easily see that the biology instructor did make noticeable changes in student assessment. She included authentic assessments such as student presentations and lessons presented by students, and other constructivist-based assessments (evaluations and critiques) in her overall student assessment package. These assessments accounted for 30% of the students' final course grades.

The physical science instructor at Lakeview modified the grading structure of the physical science course by the inclusion of authentic student assessments. Students were required to create a lesson plan and then present the lesson to their laboratory partners for 12.5% of their final course grade. Another 3% of the final grade was based on the compilation of a teaching notebook; this notebook allowed the students an opportunity to reflect upon their learning.

In summary, there was not much change in assessment techniques in response to the AAT degree. Although there were examples of authentic assessment in *The First Sixty Hours* (the document that describes the desired outcomes of the AAT degree), such assessments would be difficult for some instructors to design and implement because they were not familiar with authentic assessment and did not comprehend the philosophical and pedagogical justifications for authentic assessment. The instructors who were very familiar with inquiry would understand the examples given in *The First Sixty Hours* and they included authentic student assessments in the determination of final course grades.

Research Question #4

What factors affect the science faculty's implementation of the changes necessary to comply with AAT degree requirements?

Stark and Lattuca (1997) noted three major types of influences on curricular change: external, organizational, and internal. The extent of each influence, and whether it was positive or negative, varied considerably at the four institutions studied. These three influences sometimes overlapped and were somewhat fluid. For example, what could be considered an organizational factor at one school could be considered an internal influence at another school. Since each influence is important, each will be discussed in a separate section.

External Influences

External influences include (but are not limited to) society as a whole, the media, the economy, governmental organizations, disciplinary and professional associations, public and private funding agencies, and accrediting agencies (Stark & Lattuca, 1997). Each of the four schools experienced external influences. Factors such as demands for teacher training and certification and the difficulties students were facing in transferring to four-year colleges were issues at all of the community colleges, and were at the root of the development of the AAT degree. Any college that wanted to offer the AAT degree naturally was influenced by the mandates of the degree.

The Maryland Articulation Partnership for Teachers (MAPT) grant (including its external funding from the National Science Foundation) and workshops were a strongly positive external influence at Lakeside, extolled by the director of teacher education and both the physical science and earth and space science instructors. The MAPT workshops gave participating faculty hands-on experiences with inquiry-based learning and provided a modest stipend for the participants. However, the MAPT initiative had no effect at Oakmont. Even though one faculty member did participate in the grant, his misconceptions about the requirements of the degree were not altered. Since Beltway's director of teacher education secured the funding for the MAPT initiative, and the earth and space science instructor was very active in the planning and running of the workshops, this initiative really cannot be considered to be an external factor that affected the faculty at Beltway. But, external grant funding supported the implementation of this initiative. Bayview faculty did not participate in the MAPT initiative, and were not affected by it.

Organizational Factors

Organizational influences are directly related to the infrastructure of the college, especially its mission and governance structure (Stark & Lattuca, 1997). Organizational factors affecting the science faculty varied among the schools. I identified three organizational factors that were important at all of the schools: administrative awareness of the degree requirements, communication with science faculty, and support of the faculty. For the most part, the directors of teacher education were aware of the degree requirements. But this awareness was not always communicated to the science faculty. There was a serious lack of communication at Oakmont Community College. This lack of communication may be responsible for the isolation felt by two faculty members. It also reinforced one faculty member's misconceptions of the requirements of the AAT degree. The lack of communication from the administration was exacerbated by the lack of communication from and with other faculty, and in one instance, the disdain for communications from the administration. The lines of communication were open, reciprocal, and very well used by the faculty at Lakeside and Beltway, with the exception of links to the biology faculty. At Bayview, the director of education and the chairs of the biology and, especially physics, departments, apparently had some communications regarding the AAT degree, but there were no formal communications whatsoever with the teaching faculty.

In general, the faculty that I interviewed were not very specific about types of administrative support they had requested or had received, and did not appear to have actively sought specific types of support. I got the impression that material support was a non-issue and the most important type of support the administration could have given the faculty was in the form of moral support or recognition of their efforts. For example, although two of the teaching faculty at Oakmont did not outright state that they were not supported by the administration, their comments during interviews suggested that they did not receive, and did not request, support from the administration. However, these instructors indirectly indicated that moral support would have been appreciated. One of these faculty appeared to be somewhat intimidated by the administration and was in need of assurance. At Lakeside and Beltway, where the lines of communication were stronger than at Oakmont, the physical science and earth and space science teaching faculty perceived a strong amount of positive administrative moral support. In fact, one Beltway faculty was almost giddy when he described the tremendous amount of support he received from the director of teacher education on down to the secretarial staff.

Internal Factors

According to Stark and Latucca (1997), internal factors that exert influence on college curricula include such factors as faculty backgrounds, disciplines, educational beliefs, and student characteristics and goals. I chose nine internal factors (and their interactions) that I thought could affect faculty as they transitioned into the AAT science courses. These relevant factors are summarized in the Concept Map (see Figure 1, p. 31). I divided these factors into three interrelated groups. The first group includes attitudes toward the manner of the request for change, the awareness of the intent and purpose of the AAT degree, participation in the change process, and belief in the change. Prior use of constructivist pedagogy, academic and professional background, and teaching philosophy are the components of the second group, and the last group brings together the students' attitudes toward learning and the faculty's attitudes toward students. Interestingly, one of the factors that I chose turned out to be somewhat irrelevant, and I noted new factors that I had not considered before.

In the first group of factors, attitudes toward the manner of the request for the change (for example, was the faculty bluntly told to make changes or was the faculty invited to discuss possible changes) turned out to be completely irrelevant in this study. None of the interview respondents who had made changes mentioned the manner of the request, and may not have understood the point of my questions concerning the manner of request. This lack of response, either positive or negative, indicates that this was not an issue with the faculty. The teaching faculty at Beltway and Bayview were not even involved in changes made in response to the AAT degree. The awareness of the intent and purpose of the AAT degree paralleled the amount of communication and collaboration present, the individual faculty's interest in constructivist pedagogy, and the individual faculty's interest in science education in the public school system. Communication/collaboration and individual interests seemed to heighten the individual faculty's awareness of AAT degree requirements. Participation and belief in the change needed for the AAT degree had a strong bearing on the amount of change that occurred at the schools, either prior to or after the advent of the AAT degree. The faculty who did make changes in content or pedagogy believed that the changes they were making were important to the overall educational process. In general, the faculty who were not involved in any change process were not fully aware of the AAT degree, or its requirements.

The second group of factors, prior use of constructivist pedagogy, academic and professional background (e.g., membership in professional organizations and participation in faculty development initiatives), and teaching philosophy, were crucial to changes that occurred in content and pedagogy. Except at Bayview, where the need for teaching faculty to change their courses was not present, an instructor's academic background and prior use of constructivism had a profound effect on the type and degree of curricular change. The instructors who experienced constructivism in their collegiate education, especially in graduate level work, were very enthusiastic about constructivism and inquiry-based learning, and were very willing to incorporate inquiry-based learning or other constructivist techniques into their classrooms.

Instead of participation in professional organizations influencing an instructor's attitude toward constructivism, I got the impression that the instructor's experiences with constructivism, either in their own education or in the education of their students, had a very positive effect on the faculty's participation in, and benefits from, professional organizations, and helped shape their teaching philosophy. For example, the two Lakeside faculty who had experienced constructivism in their educations benefited from their participation in the MAPT initiative. They enthusiastically related how important the workshops were with respect to collaborating with peers and learning about constructivist techniques applicable in their own classrooms. They also mentioned tenets of constructivism in their teaching philosophies. In comparison, the faculty member from Oakmont who did not have a background in constructivism did not appear enthusiastic about his participation in the grant. Unfortunately, his preconceived misconceptions of the AAT degree and his lack of interest in learning about constructivism, were not positively affected by his participation in the workshops, possibly because he really did not understand or value constructivism and inquiry-based learning. When asked about his philosophy of teaching, this instructor did not mention any tenets of constructivism. His teaching philosophy was centered more on personal attributes (such as his respect for the student as an individual and his efforts to make students feel worthy of his attention) that helped students learn, not on instructional techniques.

Instructors' experiences in constructivism in their own educations, and their prior use of constructivism in their classrooms seemed to be important in their students' perceived gains in critical thinking. In comparing the percentages of students who perceived aspects of critical thinking taking place to how much previous use of constructivism the instructors had, it appeared that the more practiced instructors were with the use of constructivism and inquiry-learning, the more effective the course activities were with respect to perceived gains in critical thinking skills.

The last group of internal factors brings together the students' attitudes toward learning and the faculty's attitudes toward students. Although I did not directly ask the students about their attitudes toward learning, observational data and information gained from interviews shed light upon this important factor. It appeared that the students' attitudes toward learning may have been influenced by their instructor's skill in constructivist and inquiry-based teaching methods. For example, according to my classroom observations, comments from the director of teacher education, and data from student questionnaires, the physical science students at Oakmont who participated in this study did not appear to be comfortable with their learning experiences and only 13% of the responses in the student questionnaire indicated that the students' were perceiving gains in critical thinking skills. The instructor of this course did not use inquiry-based learning. The earth and space science instructor informed me that her students were reluctant learners and had trouble in adjusting to student-centered learning. But her students reported the highest percentage of perceived gains in critical thinking of all the student participants at Oakmont. Of the three instructors, the biologist was the most aware of, and had more background in constructivism than the other two instructors. Even though the biology students reported a smaller percentage of perceived gains in critical thinking skills, these students were observed to be much more animated and interested in the learning process than the students in the earth and space and physical science courses. Several of them alluded to constructivist teaching techniques in their student questionnaire responses. They also interacted more with their instructor. But, when all of the Oakmont student participants are considered as a group and compared with student participants from the other schools, they reported the lowest percentage in frequency of perceived instances of critical thinking.

If the situation at Oakmont is contrasted to that of Beltway's, one would see more evidence in a possible link between the instructor's skill in inquiry-based pedagogy and student attitudes toward learning. Both the physical science and earth and space science instructors were seasoned veterans in the field of inquiry-based learning. Their students appeared to be very comfortable in the classrooms and interested in the learning process. Both of the instructors indicated that the students responded very positively to inquiry-based learning. The group of Beltway students reported the highest percentage in frequency of perceived instances in critical thinking.

All of the instructors and administrators had positive attitudes toward their students and, contrary to what the literature suggests (Murray, 2000) and my personal experiences with science faculty who dislike having to teach elementary education majors, the instructors felt that the quality of the AAT students was just as good, if not better, than the quality of their non-elementary education majors. But the instructors generally did admit that elementary majors were very weak in mathematics and intimidated by science. The instructors enjoyed working with their students, and for the most part, felt the students were receptive to and interested in learning.

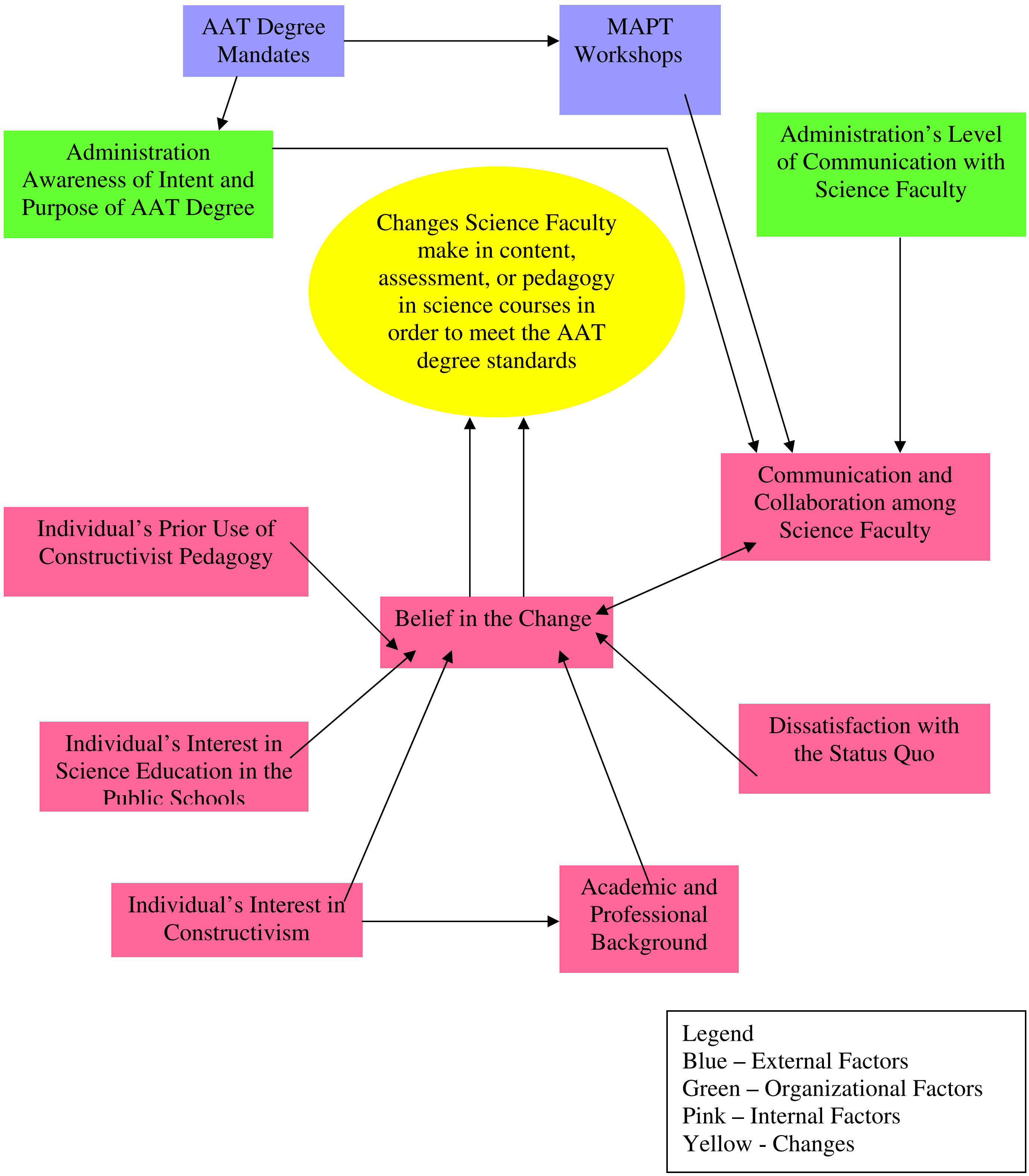
I did note one intriguing difference in attitudes toward students between the chair of the physics department at Bayview and the instructors at Beltway. The chair of Beltway's physics department specifically designed the physical science course to be geared for the general student population, and welcomed any student into the classroom. He maintained that constructivist and inquiry-based learning was beneficial for all students. When I asked the physical science instructor from Beltway if non-AAT majors took his course, he looked very puzzled and wanted to know why a non-AAT major would want to take his course. It appeared that all three faculty members associated with the AAT degree at Beltway would prefer the non-majors to take other science courses, not their physical science course or their earth and space science course. This seems contradictory to me, because these three faculty were convinced that inquiry-based learning was the best way to educate students, and they were modeling methods they hoped the AAT students would use with their future public school students. I did not understand why these instructors did not want general education students in their courses because these students would also benefit from inquiry-based learning, but I was unable to get this point clarified in the course of the interviews. Perhaps the physical science instructor was treating his course as a sort of education science methods course.

I also found one other important factor mentioned in the literature that I had not listed as a possible internal factor that may affect the faculty as they go through a change process. According to the literature, dissatisfaction with the status quo has been found to be an impetus that causes changes in pedagogy or content (Sunal et al, 2001). At least five faculty mentioned that this was important to them. In fact, dissatisfaction with the status quo was the driving force behind the design of both the physical science course and the environmental science course at Bayview Community College. The chair of Bayview's physics department was so unhappy with the student response to the traditional teaching methods he initially used in his first three weeks of class that he abruptly changed to using more conceptual and constructivist techniques. The chair of the biology department was deeply concerned about the high rate of attrition and disconnect between the lecture and the lab in the traditional environmental course and he, too, changed the course structure.

In summary, all of the schools were affected by the external factor of the mandates of the AAT degree, and faculty at one school were positively affected by the MAPT grant that was initiated at Beltway Community College. I found the administration's communication with the faculty was an important organizational factor that I had not considered during the design of my study. Open communication between the administration and the faculty turned out to be important both in terms of communicating the importance of the mandates of the AAT degree and providing moral support to the faculty responsible for designing or teaching the relevant science courses.

After carefully studying the data, I determined that an individual's belief in the change was the main internal factor driving the change process. The most important internal factors leading to the belief in the change were prior exposure to and use of inquiry-based learning, the individual faculty's personal interests, dissatisfaction with the status quo, and communication. Personal interest in inquiry-based learning was very important and was the seed to changes in pedagogy before and after the advent of the AAT degree, and seemed to be the compelling factor that allowed the faculty to benefit from participation in professional organizations. Personal interest in the training of public school teachers, along with the alignment of course curricula with local county guidelines, and realizing the need for curricular and pedagogical changes were important in the faculty's participation in the change process. Dissatisfaction with the status quo was mentioned by faculty at all four research sites. The faculty who communicated with each other, and who were more collegial, had an advantage of increased support and understanding from their colleagues. These factors and their interactions can be summarized Figure 2A, the revised concept map.

Figure 2A
Revised Concept Map – Factors that Affected the Science Faculty



Research Question #5

From the perspective of the students, what course activities promote critical thinking?

The reader needs to keep in mind the variation of courses and numbers of students, course structures, and student assessments employed in the different courses when interpreting the data on the students' perspectives of critical thinking. The disparity in the number of student participants in each course, and the number of participants at each school, tend to complicate the analysis of the overall data (see Table 17). This table shows the number and percent of student participants according to college (horizontal row) and according to the type of course (vertical column).

Table 17
Number of Student Participants According to College and Course

	Physical Science		Earth and Space Sci.		Biology		Environmental Sci.		Total	
	N	%	N	%	N	%	N	%	N	%
Oakmont	14	9	6	4	16	11			36	24
Lakeside			15	10					15	10
Beltway	13	9	11	7					24	16
Bayview	41	28					33	22	74	50
Total	68	46	32	21	16	11	33	22	149	100

The students were asked if the science course they were enrolled in helped them to improve core critical thinking skills in the following areas: interpretation of written information, analysis of numerical data, ability to explain scientific information to others, and ability to evaluate strengths and weakness of information and arguments. The students were then asked to elaborate on each positive response by naming a specific assignment that helped the most, and explaining how that particular assignment was helpful. The students readily gave yes or no responses, but often had trouble with expressing which assignments were helpful and why these assignments were helpful. I was only able to categorize 154 of the 295 positive student comments, or 52%, into specific course assignments or type of assignments. This means that 48% of the responses could only be used in the determination of whether or not aspects of critical thinking were perceived to be occurring, not in the pinpointing of specific course activities. The combination of variations in the student population and loss of potential data may be a shortcoming in the execution of my experimental design, but the data I did obtain is still useful in answering the research question.

Trends in the percent of yes responses

The trends in the percent of yes responses as to whether or not critical thinking was occurring in the science courses (see Table 18), both within and among schools, are consistent and can be explained easily when the types of student assessments, emphasis on certain course activities, and maturity of the AAT courses are considered. At Oakmont Community College, both the biology and earth and space science instructors assessed the students on oral presentations, where the students were responsible for explaining scientific information to others. This may account for the 56% of yes responses for the critical thinking skill of explaining scientific information to others. Oakmont students rated the evaluation of information and arguments as being the area where they perceived the least amount (17%) of critical thinking incidents.
Two of the three instructors (biology and physical science) placed a very minor emphasis on this skill in their student assessments. Eighty percent of the earth and space science students at Lakeview Community College also rated the critical thinking skill of

Table 18
Number and Percent of Yes Responses to Critical Thinking Questions

	Interpretation of Written Information		Analysis of Numerical Data		Explanation of Scientific Information		Evaluation of Information		Overall	
	N	%	N	%	N	%	N	%	N	%
Oakmont (N = 36)	16	44	7	19	20	56	6	17	49	34
Lakeside (N = 15)	7	47	2	13	12	80	3	21	24	41
Beltway (N = 24)	20	83	7	29	21	88	11	46	59	61
Bayside (N = 74)	48	65	25	34	59	80	30	42	162	55
Overall	91	61	41	28	112	75	50	34	294	49

explaining scientific information to others as being the skill where they perceived that the most critical thinking was occurring. Although assignments that assessed this skill were not given much weight toward the final grade, the POE (Predict, Observe, Explain) centers required a lot of work from the students, as did the lesson plans/projects. Since the instructor did not place any emphasis on numerical analysis, one would naturally expect students to give occurrence of this skill a very low rating (13%). Student responses at Beltway Community College and Bayside Community College indicated that gains in the skill of explanation were perceived to occur most often (88% and 80%, respectively). They also agreed that they perceived the least gains in the analysis of numeric data. This again, is consistent with the emphasis placed on explaining reasoning and discussing events in the courses at Beltway, where the students were not expected to give in-depth mathematical explanations.

There are very stark differences in the overall perceived occurrences in gains in critical thinking skills among the four schools, ranging from a high of 61% to a low of 34% (see Table 18). These numbers show a sizeable gap between the schools with the lowest and highest averages. Beltway students perceived the most gains in every critical thinking skill except numerical analysis (29%), where Bayview recorded the highest percent (34%) in this critical thinking skill. Beltway students on the average perceived the most gains in critical thinking skills (61%), followed by 55% of Bayside students, 41% of Lakeside students, and 34% of Oakmont students. The trend of these percentages follows the trends in maturity of the AAT degree and the instructor's familiarity with inquiry-based learning. The two instructors at Beltway Community College had been doing inquiry-based learning for years and had the AAT degree in place before the other schools. In fact, the director of teacher education at Beltway foresaw the need for better science training for elementary teachers, and was instrumental in developing workshops to enable teachers to gain certification and better skills in science.

The two science courses required for the AAT degree at Bayview Community College were also in place before the advent of the AAT degree. Although two of the physical science instructors that I interviewed were not familiar with inquiry-based learning, the department chair was very proficient in the use of inquiry-based learning and developed conceptual laboratory exercises that emphasized inquiry. He also gave his instructors very detailed instructions and demonstrations into how to approach inquiry-based learning. This enabled the instructors who were not familiar with inquiry to conduct successful inquiry-based exercises. The two environmental science instructors that I interviewed were very interested in constructivist learning activities and were in the process of completing a laboratory manual that emphasized constructivism and included some inquiry-based exercises. But these instructors were a little less experienced with inquiry, and one instructor stated that true inquiry was difficult to achieve, but very effective when it was achieved.

The two instructors at Lakeside Community College had varying degrees of experience with constructivism. The physical science instructor (whose students did not fill out the questionnaire) was very familiar with constructivist techniques and based his laboratory on inquiry. The earth and space science instructor, who is constructivist at heart, still used many instructivist techniques in the laboratory, although she did have some inquiry-based exercises. It is important to note that the earth and space science course was still in its developmental stage and the instructor indicated that she was in the process of making the course more robust with constructivist exercises. Even though the earth and space science instructor was solely responsible for the course, she was well supported by the physical science instructor. The physical science instructor helped with the initial setup of the earth and space science course and served as a mentor to the younger earth and space science instructor.

The AAT program at Oakmont Community College was still in its infancy at the time of my site visit. Even though the director of teacher education and the chair of the science department were in favor of the AAT degree, the instructors of the AAT science courses did not appear to be well supported by the administration. I got the impression that the earth and space science instructor and the biology instructor, who were trying to incorporate constructivist techniques, were floundering and did not have much guidance or assistance. The physical science instructor was clearly not using inquiry-based pedagogy, but the director of teacher education thought that this course was more inquiry in nature. Since the AAT science courses were in such a state of transition (except for the physical science course), it is understandable that only 34% of the students perceived gains in critical thinking skills. The lack of inquiry-based and constructivist learning may have contributed to the low number of students who perceived gains in critical thinking skills.

Classroom activities and perceived gains in critical thinking

It is very difficult to discern which specific classroom activities influenced students' perceptions of perceived gains in critical thinking skills. The students offered many different comments, but as stated before, I could only use 52% of the comments in this part of the analysis because the other 48% were very general in nature and could not be categorized (see Table 19A).

Table 19A
Most Commonly Mentioned Activities Associated with Perceived Gains in Critical Thinking

Type of Activity	Number of Comments (from a total of 154)	Frequency in Percentages
Laboratory Exercises	67	44
Internet Assignments	31	20
Models, Graphs, Maps	21	14
Journals	13	8
Lectures	11	7
Other Activities	11	7

By far, the most frequently mentioned activities associated with perceived gains in critical thinking were laboratory exercises. All students, no matter the school or the type of science course they were taking, were exposed to a significant amount of laboratory work, from about three to almost six hours a week. Since all students were exposed to the same general activity, one would expect a higher frequency than with an activity that did not occur in all of the courses or at all of the schools. The laboratory experiences ranged from exercises where scientific knowledge was confirmed (for example, determining the value of gravity by doing experiments) to completely inquiry-based exercises. If the activities with models, maps, and graphs are included as being part of the laboratory exercise, which often they are, the number of comments pertaining to laboratory work swells to 88, or 57% of the total categorized comments. Laboratory work generally entails the use of both the higher order thinking skills listed in Bloom's (1956) Taxonomy, and the core critical thinking skills identified by Jones (1995) and Facione (1990).

Although the laboratory is perceived by the students to be very important with respect to perceived gains in critical thinking skills, students did perceive gains in critical thinking skills from participating in other activities. Internet assignments were given to students from all of the schools except Lakeside, and 20% of student responses indicate that the Internet assignments were helpful in perceived gains in critical thinking. Although overall only 8% of the students mentioned journal assignments in conjunction with perceived gains in critical thinking skills, this low percentage may be misleading and not truly indicative of the importance of journals. For example, all but one clearly positive comment on journals came from Bayview students. The journal assignments counted toward the students' final grade in all of the sections of physical science and in the evening section of the environmental science course. The format and function of journal assignments were clearly stated in the course policy documents given to the physical science students, and the environmental science students also had some guidelines as to what the student should include in their journal assignments. I believe that the combination of the journals counting toward the final course grade and the explanation of the importance of the journal led students to link the journal with perceived gains in critical thinking skills. This combination was not present at the other schools, and it is tempting to speculate on how the overall percentage of students citing journal assignments would change if all of the instructors had shown equal amounts of emphasis and explanation of journal assignments.

The last type of assignment that I could categorize is the lecture. Only seven percent of the students perceived gains in critical thinking skills from listening to their instructors lecture. Although, according to constructivists, students are considered to be passive learners and not actively involved in the learning process in receiving information from a lecture, this may not be the case for all students. Perhaps the percentage of students who perceived gains in critical thinking through lectures were more active listeners, who "hear between the lines."

In summary, it appears that the students who perceived the most gains in critical thinking skills were enrolled in colleges that have mature AAT programs. The individual instructor's competence with inquiry-based learning seemed to have a positive effect on the number of students who perceived gains in critical thinking skills. The emphasis put on a specific critical thinking skill definitely affected the students' perceived gains in that skill. The laboratory, or activities associated with the laboratory, was reported by the students to give the best opportunity to perceive gains in critical thinking skills, but this observation must be taken in the context of the overall presence of laboratory experiences in all of the AAT science courses at all of the schools involved in this study. Other activities that were not as pervasive as the laboratory, such as journaling, may in reality have more influence on critical thinking than what is suggested by this data.

Chapter Ten: Summary and Recommendations for Practice and Future Research

This qualitative research project attempted to fill a void in the literature concerning the attitudes of science faculty at Maryland community colleges who are or have been involved in making the paradigm shift necessitated by the mandates of the AAT degree. The purpose of this study was two-fold. The first part of the study determined what changes science faculty had made, or were making, in (science) course content, pedagogy, and student assessment in order to satisfy the requirements of the new AAT degree offered by Maryland community colleges. The second part of the study demonstrated which factors had the most effect on the implementation of the changes necessary for the science courses associated with the AAT degree. Student perceptions of critical thinking were included in this section.

The findings presented in the individual cases and the cross-case analysis lead to recommendations for practice that may help those involved in curricular change. The recommendations for practice are geared to two major stakeholders: state-level policy makers and community college personnel who may become involved in a curriculum change. The findings also brought to light some interesting questions that should be considered for further research.

Summary of Findings

Research Question #1 – What are the science faculty's attitudes toward the science content and pedagogy requirements of the AAT degree?

Eight of the thirteen teaching faculty interviewed were not aware of the AAT degree requirements and did not have any explicit attitudes toward the content and pedagogy requirements of the degree. One faculty member exhibited a moderately positive attitude and the remaining three faculty demonstrated strongly positive attitudes toward the requirements of the AAT degree.

Research Question # 2 - What changes (including the type and the degree of the change) have faculty made in the course content and pedagogy in order to satisfy AAT degree requirements?

Table 20 summarizes the type of changes that occurred in science courses in response to the AAT degree. A totally new earth and space science course was created at both Oakmont and Lakeside. No changes were made in the following courses: Lakeside biology; Beltway biology, physical science, and earth and space science; Bayview physical science and environmental science.

Table 20
Changes Made in Course Content and Pedagogy in Response to the AAT Degree

	Changes in Course Content	Changes in Pedagogy
Oakmont Physical Sci	No changes, inclusions of a few activities	None
Oakmont Biology	Section set aside for AAT majors Same content presented in less detail	New laboratory manual with more constructivist activities; more student centered activities
Lakeside Physical Sci	Reduced scope of topics in chemistry, increased emphasis on major topics in physics	Less math, more conceptual lectures; added significant amount of inquiry based exercises into the laboratory

Overall, there was very little change in content or pedagogy in response to the AAT degree.

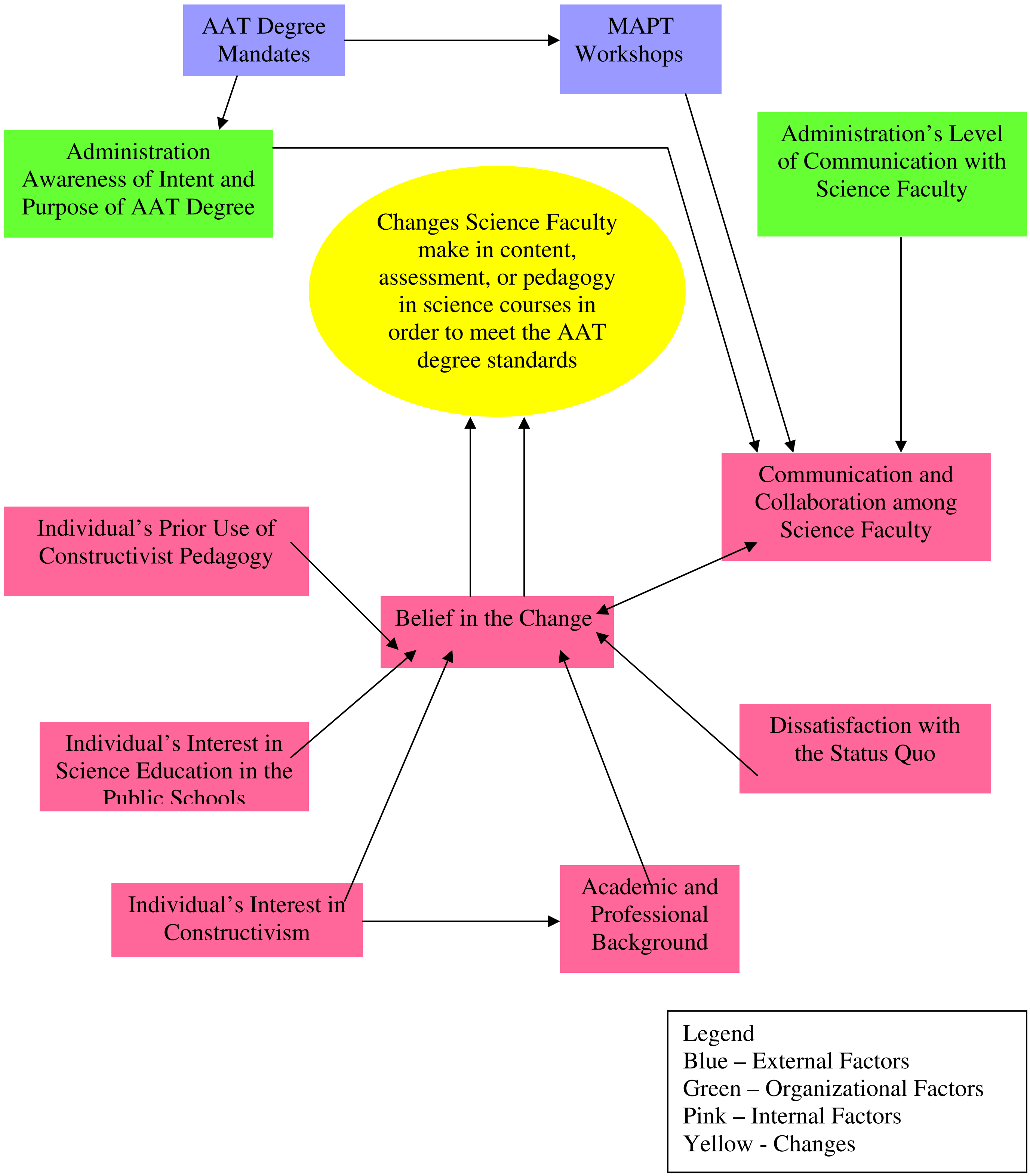
Research Question # 3 - What changes have faculty made in student assessment techniques in order to satisfy AAT degree requirements?

No changes were made in any of the courses at Beltway and Bayview. The Oakmont physical science instructor made a minor change in his journal assignment by requiring AAT majors to evaluate an educational website. The Lakeview physical science instructor modified the grading structure of the physical science course by the inclusion of authentic student assessments (creation and presentation of a lesson plan; compilation of a teaching notebook) that accounted for 15.5% of the final course grade. The Oakmont biology instructor did make noticeable changes in student assessment. She included authentic assessments, such as student presentations and lessons presented by students, and other constructivist-based assessments (evaluations and critiques) in her overall student assessment package. These assessments accounted for 30% of the students' final course grades.

Research Question #4 - What factors affect the science faculty's implementation of the changes necessary to comply with AAT degree requirements?

The factors that affected the science faculty's implementation of the changes necessary to comply with AAT degree standards can be summarized in Figure 2B, the revised concept map. Arrows are drawn to show how one factor influenced another factor. Each arrow points away from an influencing factor towards a factor that is being influenced.

Figure 2B
Revised Concept Map – Factors that Affected Science Faculty



Research Question #5 - From the perspective of the students, what course activities promote critical thinking?

The following table lists the most commonly mentioned activities associated with the students' perceived gains in critical thinking skills.

Table 19B
Most Commonly Mentioned Activities Associated with Perceived Gains in Critical Thinking

Type of Activity	Number of Comments (from a total of 154)	Frequency in Percentages
Laboratory Exercises	67	44
Internet Assignments	31	20
Models, Graphs, Maps	21	14
Journals	13	8
Lectures	11	7
Other Activities	11	7

Recommendations for Practice

Recommendations for State Level Policy Makers

The basic document that describes the content and pedagogy requirements of the AAT degree, *Maryland Outcomes for Teacher Preparation – The First Sixty Hours: Elementary/Middle School* (TEAC, 2001) emphasizes the pedagogical method of inquiry, as evidenced by a statement listing the professional development standard in science, "*Inquiry is so basic to science that every activity should support it in one way or another"* (italics in text; TEAC, p. 19*). The First Sixty Hours* describes the minimum knowledge and skills required for elementary teachers and lists expectations (outcomes) of teacher candidates related to each content area (see Appendix A). The outcomes specifically state that, "the teacher candidates accomplish the knowing, understanding, and applying of knowledge through inquiry strategies derived from the constructivist view of the learning process" (TEAC, p. 20). Even though this document is very specific about the level of mastery the teacher candidate should attain through the use of investigative activities, or inquiry, the document does not fully define investigative activities or inquiry-based learning. Lack of these definitions implies that faculty who will be teaching the teacher candidates, or elementary education majors, understand inquiry and are proficient in the use of inquiry-based learning. The results from this research study demonstrates that some science faculty need further help to design and implement true inquiry-based learning opportunities for students.

In order to rectify this situation, the Maryland Higher Education Commission and the Maryland State Department of Education should revise *The First Sixty Hours* to include more information on how to implement inquiry-based learning. They should then institute faculty development programs designed to introduce, explain, and model best practices in inquiry-based learning. Background information and relevant readings can be disseminated through the Internet and distance learning formats. The most crucial aspect of the faculty development program is the modeling of best practices in inquiry-based learning. This modeling should be done by faculty who have substantial experience in inquiry-based learning. Short one- or two-day workshops (such as the MAPT workshops) that offer models are not successful in helping instructors break out of the instructivist mode into the constructivist mode. Instructors who are not familiar with inquiry-based learning need to be slowly immersed and steeped in constructivism, and given opportunities and time to convert exercises that they use in an instructivist mode into inquiry-based exercises. This models one of the tenets of constructivism, where students build new knowledge based on existing knowledge.

In order to accomplish the modeling of best practices, the state agencies could sponsor an “exchange” program where faculty spend a week at another college. Faculty who need assistance with inquiry-based techniques could go to schools strong in inquiry, such as Beltway Community College, and shadow veteran constructivists. Master constructivists could also spend a week at colleges, such as Oakmont, where faculty need help with inquiry-based learning techniques. If the state coordinated campus visits so that the visiting instructors would be gone from their home institutions during spring breaks, there would be minimal loss of class time. State agencies would have to follow-up with assistance in long-term faculty development. Faculty who are familiar with inquiry-based learning could benefit from short workshops such as the MAPT workshops. The state would definitely have to offer financial enticements for the participating faculty and their schools, but the state’s financial investment would be paid back in terms of better educated elementary science teachers.

Recommendations for Community College Personnel

My first recommendation for community college personnel (administrators, teaching faculty, and teaching support staff) is similar to my recommendation to state policy makers. Administrators from community colleges could mirror the faculty development model that I proposed for the state policy makers to enhance faculty members’ understanding of inquiry-based learning. They could also sponsor in-house workshops designed to stimulate interest in inquiry-based learning and give release time for faculty who are involved major pedagogical changes. Teaching faculty should become more active in researching literature on best practices and forming collaborations with other faculty who are interested in constructivism and inquiry-based learning.

My second recommendation comes from two sources of information. The first set of information about factors that affect faculty as they undergo a curricular transition is the data from this study, and explains why I also chose to look at college personnel as a whole as well as separating them into groups such as administrators and teaching faculty. A high level of administrative encouragement, and frequent and collegial communications between the administrators and faculty and within the group of faculty teaching the AAT science courses seemed to have positive effect on a faculty member's ability to conduct successful inquiry-based learning exercises. Since open communication among all the stakeholders is important, they should be considered as one functional unit instead of being subdivided into administrators and teaching faculty. The second source of information is from the literature. Studies have shown that faculty are more amenable to long term changes when they have a substantial amount of control over the change process and when they are part of a team working toward a common goal (Sunal, et al, 2001; National Research Council, 1996).

With this in mind, the college personnel should choose a change model that is appropriate for faculty undergoing a change in curriculum and that is in harmony with the culture of the institution. There are several change models that personnel could use in order to facilitate curricular change. Tenets of Schlossberg's Transition Theory, the 4 S's of situation, self, support, and strategies (Schlossberg, Waters, & Goodman, 1995) can be used to support a framework based on Wagner's (2001) SURE model. This model proposes four essential conditions for adult learning that can be applied to guide curricular change:

- Shared vision of the goals of learning, good teaching, and assessment;
- Understanding the urgent need for change;
- Relationships based on mutual respect and trust; and
- Engagement strategies that create commitment rather than mere compliance (Buy-in Versus Ownership section, ¶4).

The individual science faculty's ability to make the changes necessary in order to comply with AAT requirements in part depends on the components of Schlossberg's theory (such as level of optimism) that can be considered as assets versus those that may be considered as liabilities. If the college personnel all work together to achieve the four conditions of Wagner's SURE model, curricular changes should be more successful and long lasting.

Recommendations for Further Research

A few different ideas on further research surfaced during the cross case analysis. It would be interesting to know if the AAT degree has fulfilled its expectations. Are AAT graduates being accepted into four-year colleges without having to repeat courses? Is the transfer process smoother? Do the AAT students have an improved knowledge base in science? And, ultimately, how well do the AAT graduates perform when they are teaching in the elementary schools? Do they teach science using inquiry-based learning techniques? Do the AAT graduates improve the quality and quantity of science learning in the elementary schools? Long-term longitudinal studies should be designed in order to answer these questions.

Since I was not able to gather enough data to understand the apparent link between inquiry-based learning and the students' perceived gains in critical thinking, this needs to be studied more closely. Just because the students perceived gains, did the gains actually occur? The answer to this question would be very useful to instructors as they create constructivist learning activities for their students. Data from Bracken's (2004) study on how students' perceptions of their advisors' attitudes toward developmental education affected student performance in developmental courses showed a relationship between perceived advisor attitudes and student success in developmental courses. It would be useful to know if Bracken's findings on the relationship between students' perceptions and their performance can be applied to perceived gains in critical thinking skills and actual gains in critical thinking skills.

Another recommendation for further research is to determine what effect constructivist and inquiry-based learning have on K-12 students' attitudes toward science and scientific knowledge. Many traditional-aged college students enter science courses with very poor attitudes toward science and have been taught science as a body of knowledge. These students are either afraid of science or do not like science, and would not take science courses in college unless required to do so. These negative attitudes toward science may engender a lack of confidence in ability to learn science. Data gathered from this study suggests that inquiry-based learning may have a positive effect on the attitudes that college students have toward science. For example, four physical science faculty, one earth and space science faculty, and one environmental science faculty either noted positive changes in student attitudes or better student performance occurring in constructivist-based classrooms.

The two models of how students understand knowledge that were discussed in the literature review, Baxter Magolda's (1992) Epistemological Reflection Model and King and Kitchener's Reflective Judgment Model (1994), focused on college students, and adolescents and adults, respectively. Both models categorize stages of knowing that are important to consider when designing learning activities. Baxter Magolda's model describes four stages of knowing (absolute, transitional, independent, and contextual) that students progress through. King and Kitchener's model outlines seven stages of knowing that can be categorized into three groups: pre-reflective, quasi-reflective, and reflective judgments, and reflective judgment increases with time. Both Baxter Magolda's and King and Kitchener's models agree on college freshmen's attitudes toward learning and knowledge. These researchers independently determined that freshmen generally are in the lowest stages of knowledge and consider knowledge to be certain, or only temporarily uncertain. Knowledge is dispensed by authorities; students receive knowledge from their instructors. Personal beliefs held by the students are only legitimate when the knowledge is temporarily uncertain (Evans, Forney, & Guido-DiBrito, 1998; King & Kitchener, 1994).

The educational processes in secondary schools generally reinforce this adolescent attitude toward knowledge and do not help the student realize that knowledge comes from the learner. Hansen and Stephens (2000) note that too many students have been socialized in their schooling to believe that they cannot learn course material unless it has been "pre-digested" by an instructor. These students rely on the instructor to tell them everything they need to know. They do not understand the need to be actively engaged in the learning process, or that this engagement requires their own critical thinking (Hansen & Stephens, 2000). Traditional student assessments based on judgmental feedback (for example, "This is correct but that is wrong.") cause students to continue or alter their thinking because of an external prompt. Student thinking is not affected by internal realization. This type of feedback tends to make students even more teacher-dependent (Brooks & Brooks, 1999). It is no wonder that students come into college in the first stages of knowing.

I hypothesize that carefully guided inquiry-based and constructivist learning opportunities would allow students to transition through the stages of learning more rapidly and that they would come to college more confident in their abilities to learn science. This in turn may engender more positive attitudes toward science. Confidence in learning science and a positive attitude toward science may help the elementary education major achieve all of the many outcomes listed in *Maryland Outcomes for Teacher Preparation – The First Sixty Hours, Elementary/Middle School* (TEAC, 2001).

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Appendix A

Synopsis of Relevant Excerpts

Maryland Outcomes for Teacher Preparation – The First Sixty Hours
Elementary/Middle School (TEAC, 2001)

National Council for Accreditation of Teacher Education (NCATE)

Curriculum:
Science – Candidates know, understand, and use fundamental concepts in the subject matter of science, including physical, life, earth, and space sciences – as well as concepts in science and technology, science in personal and social perspectives, the history and nature of science, the unifying concepts of science, and the inquiry processes scientists use in discovery of new knowledge to build a base for scientific and technological literacy

Faculty Qualifications, Performance, and Development:
Faculty are qualified and model best professional practices in scholarship, service, and teaching, including the assessment of their own effectiveness as related to candidate performance. They also collaborate in the disciplines and schools. The unit systematically evaluates faculty performance and facilitates professional development.

Science Outcomes

Professional Development Standard – Professional development of teachers of science requires learning essential science content through the perspectives and methods of inquiry. *Inquiry is so basic to science that every activity should support it in one way or another.*

Unifying themes – in each of the science disciplines
1) systems, order, and organization
2) evidence, models, and explanation
3) change, constancy, and measurement
4) evolution and equilibrium
5) form and function

The following … is an outline of the minimum an elementary teacher should know and be able to do in the content area of science. Research has documented that most people teach in a manner in which they were taught. Therefore, the undergraduate science instruction of future teachers should model the pedagogical practices recommended by professional organizations of science and science education. The table shown below lists the area of science addressed by the outcomes and the National Science Content Standards for Grades K-4 and 5-8.

Physical Science
Properties of objects and materials
Position and motion of objects
Light, heat, electricity, magnetism
Properties and changes of properties in matter
Motion and force
Transfer of energy

Life Science
Characteristics of organisms
Life cycles of organisms
Organisms and environments
Structure and function in living systems
Reproduction and heredity
Regulation and behavior
Population and ecosystems
Diversity and adaptations of organisms

Earth and Space Science
Properties of earth materials
Objects in the sky
Changes in earth and sky
Structure of the earth system
Earth's history
Earth in the solar system

Science and Technology
Abilities to distinguish between natural objects and objects made by humans
Abilities of technological design
Understanding about science and technology

Personal and Social Perspective
Personal health
Characteristics and changes in populations
Types of resources
Changes in environments
Science and technology in local challenges
Natural hazards, and Risks and benefits

History and Nature of Science
Science as a human endeavor
Nature of science
History of science

Outcomes (expectations of teacher candidates related to each content area)

1. As a result of investigative activities, the teacher candidate must construct the meaning of the terms and concepts associated with the main content areas as outlined in the national science standards (for each particular area of science).

2. As a result of investigative activities the teacher candidate will understand the concepts and relationships associated with the national standards (for each particular area of science).

3. Based on their learning of the terms, concepts, and relationships, the teacher candidate will be able to use concepts and relationships related to the content area designated in the national science standards (for each particular area of science).

Indicators (actions that provide evidence that teacher candidates have accomplished outcomes)

1. Know terms and concepts: to select, define, recall, use them in another context, describe and classify them.

2. Understand terms and concepts: explain, compare and contrast them, analyze them, employ them in synthesis of more complex ideas, evaluate them, and use them to evaluate other concepts.

3. Use terms and concepts: solve problems involving target terms and concepts, and design and carry out scientific investigations.

Appendix B

Request for Approval to Conduct Research

[West Virginia University Letter Head]

Date

Title
Address

Dear Title,

I am currently working on my Doctoral Dissertation at West Virginia University, in the College of Human Resources and Education. The working title of my dissertation is Exploring Faculty Changes in Science Courses at Maryland Community Colleges in Response to the Associates of Arts in Teaching Degree for Elementary Education Majors. I am specifically interested in the science courses that support the Associates of Arts in Teaching degree for elementary education majors.

I am requesting permission to conduct research at (name of college) in the spring of 2004. I would like to interview the director of teacher education, faculty administrative leaders, and the science faculty who are teaching and/or who have been involved in the planning of science courses related to the AAT degree for elementary education majors. I intend to observe some science classes taught by the faculty that I interview and to give the students in these classes a short questionnaire on critical thinking. Lastly, I would also like to analyze documents such as course syllabi and instructional materials. Participation in this research project is entirely voluntary and the research participants have the right to not respond to every item in the research instruments. Students will not be penalized in any way if they choose not to participate in this study and their class standings or grades will not be jeopardized. I can assure you that confidentiality and anonymity will be strictly maintained for all of the research participants as well as for the school; the name of your institution will not appear in my dissertation or in any subsequent publications.

The Institutional Review Board (IRB) at West Virginia University has requested that I obtain a letter on your college letterhead that grants permission to conduct research on your campus. Attached is a template that you can use for the IRB approval letter. You may return the IRB approval letter in the self-addressed stamped envelope provided. If you have any questions concerning this research project you may contact me by phone or email (301-784-5246 or bahearn@allegany.edu). Your support and cooperation will be greatly appreciated.

Sincerely,

Bettie Cecelia A'Hearn

Doctoral Candidate
West Virginia University, College of Human Resources and Education
Enclosure (1)

Appendix C

Template Letter of Approval

Date: ____________________

Bettie Cecelia A'Hearn
Doctoral Candidate
West Virginia University
18602 Opessa St., SE
Oldtown, MD 21555

Dear Ms. A'Hearn,

I hereby grant you permission to conduct your dissertation research at Allegany College of Maryland during the fall semester of 2003, provided that you adhere to the research methods described in your letter and maintain strict confidentiality and anonymity for all participants in the study. You may interview faculty and faculty administrative leaders, observe classes and give questionnaires to the students in those classes, and have access to relevant documents. You may not refer to the College by name in any publications unless you obtain explicit permission in writing at a later time.

Sincerely,

Dr. Gene Hall
Vice President of Academic Affairs

Appendix D

Invitation Letter to Directors of Teacher Education and Department/Division Chairs

[West Virginia University Letter Head]

[Date]

To: (Name of Director)
(Name of College)

From: Bettie Cecelia A'Hearn
Doctoral Student, West Virginia University

Dear (Name),

I am currently working on my Doctoral Dissertation at West Virginia University, in the College of Human Resources and Education. The working title of my dissertation is *Exploring the Changes Faculty Make in Content, Assessment, and Pedagogy in Science Courses at Maryland Community Colleges in Response to an External Mandate.* I am specifically interested in the science courses that support the Associate of Arts in Teaching degree for elementary education majors. I have (name of Dean)'s permission to conduct research at (name of school) during the spring of 2004. I anticipate being on your campus sometime during the months of February or March.

I would appreciate your assistance in this research project by allowing me to conduct an interview with you about the AAT degree, with respect to (name of school). The interview should only take about one hour to complete. Your participation is completely voluntary. Confidentiality and anonymity will be strictly maintained.

I have enclosed a reply letter that you can fill out and return in the self-addressed stamped envelope provided, or you can respond by email. If you have any questions about the research project please contact me at 301-784-5246 or email at bahearn@allegany.edu. Your support and cooperation will be greatly appreciated. Thank you for considering this request.

Sincerely,

Bettie Cecelia A'Hearn

Appendix E

Invitation Letter to Teaching Faculty

[West Virginia University Letter Head]

[Date]

To: (Name of Science Faculty)
(Name of College)

From: Bettie Cecelia A'Hearn
Doctoral Student, West Virginia University

Dear (Name),

I am currently working on my Doctoral Dissertation at West Virginia University, in the College of Human Resources and Education. The working title of my dissertation is *Exploring the Changes Faculty Make in Content, Assessment, and Pedagogy in Science Courses at Maryland Community Colleges in Response to an External Mandate.* I am specifically interested in the science courses that support the Associate of Arts in Teaching degree for elementary education majors. I have (name of Dean)'s permission to conduct research at (name of school) during the spring of 2004. I anticipate being on your campus sometime during the months of February or March.

I would appreciate your assistance in this research project by allowing me to conduct an interview with you about the planning and/or implementation of science courses that support the AAT degree. The interview should only take about one hour or so to complete. Your participation is completely voluntary. Confidentiality and anonymity will be strictly maintained. I would also like your permission to observe your class, if you are teaching a science course that supports the AAT degree during the spring semester. I would also like the students in this class to fill out a short questionnaire about critical thinking. I have enclosed this questionnaire.

I have enclosed a reply letter that you can fill out and return in the self-addressed stamped envelope provided, or you can respond by email. If you have any questions about the research project please contact me at 301-784-5246 or email at bahearn@allegany.edu. Your support and cooperation will be greatly appreciated. Thank you for considering this request.

Sincerely,

Bettie Cecelia A'Hearn

Date: __________

From: _________________

School: ____________________

Please check the appropriate response:

_____ I am willing to participate in your doctoral research project. I understand that my participation and, if appropriate my students' participation, is completely voluntary and that strict confidentiality and anonymity will be maintained at all times.

_____ I do not wish to participate in this research.

Appendix F

Research Questions and Concept Maps with Links to Data Sources

Key:
SF = Interview Questions for Science Faculty
DTE = Interview Questions for Directors of Teacher Education/Department Chairs
SQ or Student Questionnaire = Responses from Student Questionnaire
DAP = Information from Document Analysis Protocol
COP = Information from Classroom Observation Protocol

Research Questions

1. What are the science faculty attitudes toward the science content and pedagogy requirements of the new AAT degree?
   SF 5, 6, 17, 18, 22-24, 30

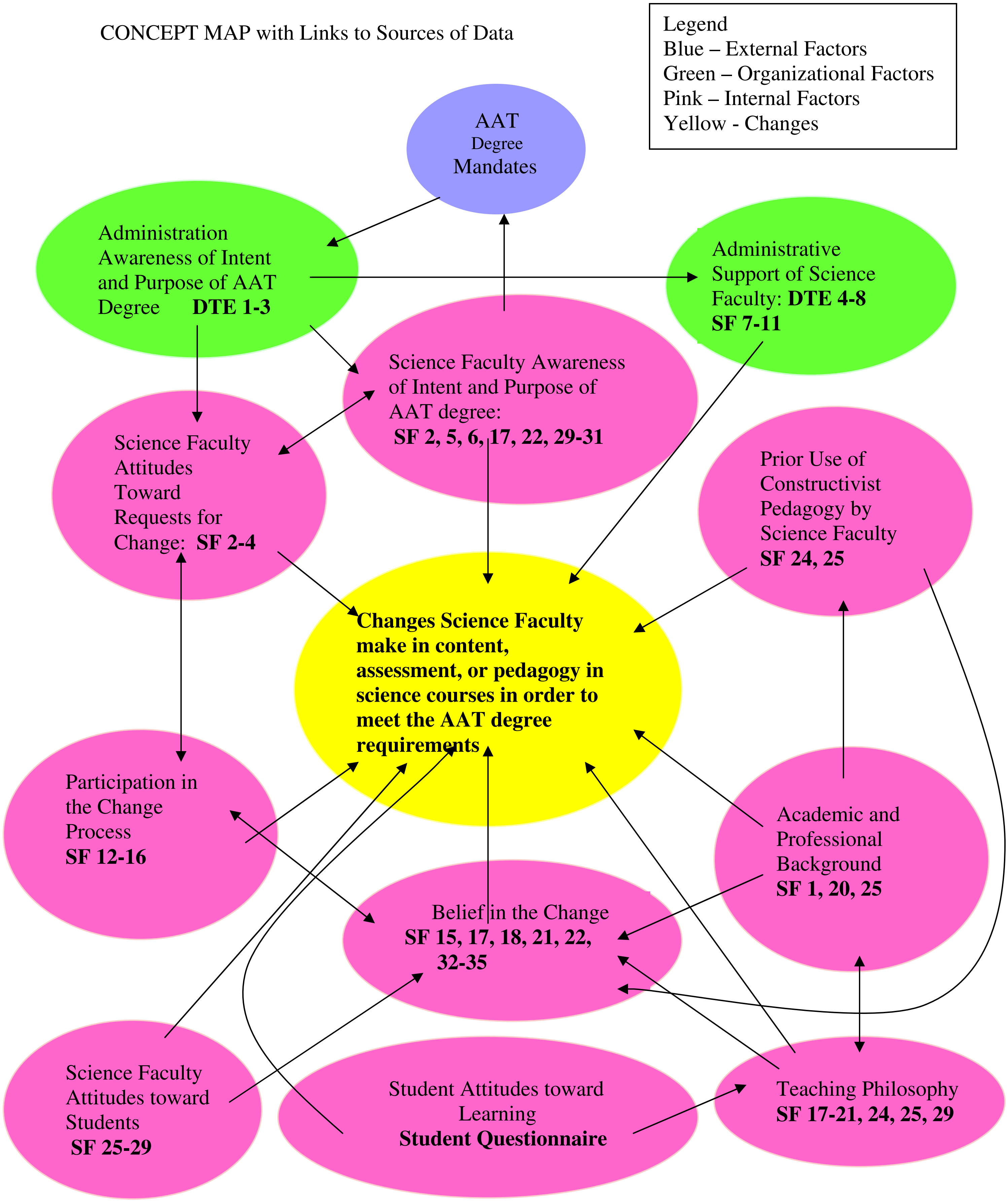
2. What changes (including the type and degree of the change) have faculty made in the course content and pedagogy in order to satisfy AAT degree requirements?
   SF 17, 23
   DAP
   COP

3. What changes have faculty made in student assessment techniques in order to satisfy AAT degree requirements?
   SF 30, 31
   DAP
   COP

4. What factors affect the science faculty's implementation of the changes necessary to comply with the AAT degree requirements?
   see Concept Map with Links to Data Sources on the following page

5. From the perspective of the students, what course activities promote critical thinking?
   SQ
   COP

CONCEPT MAP with Links to Sources of Data



Appendix G

Interview Protocol for Directors of Teacher Education and
Chairs of Science Departments

The following protocol may be modified according to how the participants answer questions. Other questions may be asked in order to add depth about a particular response.

Interview Script

Good morning (or appropriate time of day). Thank you of agreeing to participate in this study. As stated in the letter you received, the information that I gather will be used as part of my doctoral dissertation. I am a doctoral student at West Virginia University, in the College of Human Resources and Education. The purpose of my study is two-fold. The first part of the study will determine what changes science faculty make in (science) course content, pedagogy, and student assessment in order to satisfy the requirements of the new AAT degree offered by Maryland community colleges. The second part of the study will demonstrate which factors have the most effect on the implementation of the changes necessary for the science courses associated with the AAT degree.

Before we start the interview, I want to remind you that your participation is strictly voluntary. Your responses (as well as your college) will remain anonymous and confidentiality will be carefully maintained. In order to ensure completeness and accuracy of the data collected I would like your permission to audiotape the interview. You will be given the opportunity to read the draft of the paper in order to verify the accuracy of the information obtained in the interview. Again, I want to thank you for your participation, do you have any questions before we begin?

Interview Questions

1. How did you learn about the AAT degree in Elementary Education?

2. Describe the purpose and intent of the AAT degree.

3. Are there any specific requirements the science courses should meet? Explain.
    a. Content
    b. Pedagogy

4. How do you see your role, if any, in working with the science faculty in planning or implementing the science courses that support the AAT degree?

5. Have the science faculty asked for any specific help or faculty development opportunities? Explain.

6. Who would offer or has offered the faculty development opportunities?

7. How willing are the science faculty to participate in faculty development?

8. What types of resources are available to faculty?
    a. Time
    b. Money
    c. Schedule changing
    d. Materials/equipment
    e. Other

9. Do you have a feel for how willing the science faculty are to work collaboratively with each other to implement and assess the science courses offered in support of the AAT degree?

10. Do you have a feel for how willing the science faculty are to work collaboratively with other non-science faculty or administrators to implement and assess the science courses offered in support of the AAT degree?

11. What is your opinion of the AAT degree? Will it improve the education of the elementary education major? Explain.

12. These are all the questions I wanted to ask. Do you have any comments; have we left anything out that you feel is important?

Appendix H

Interview Protocol For Teaching Faculty

The following protocol may be modified according to how the participants answer questions. Other questions may be asked in order to add depth about a particular response.

Interview Script

Good morning (or appropriate time of day). Thank you for agreeing to participate in this study. As stated in the letter you received, the information that I gather will be used as part of my doctoral dissertation. I am a doctoral student at West Virginia University, in the College of Human Resources and Education. The purpose of my study is two fold. The first part of the study will determine what changes science faculty make in (science) course content, pedagogy, and student assessment in order to satisfy the requirements of the new AAT degree offered by Maryland community colleges. The second part of the study will demonstrate which factors have the most effect on the implementation of the changes necessary for the science courses associated with the AAT degree.

Before we start this part of the interview, I want to remind you that your participation is strictly voluntary. Your responses (as well as your college) will remain anonymous and confidentiality will be carefully maintained. In order to ensure completeness and accuracy of the data collected, I would like your permission to audiotape the interview. You will be given the opportunity to read the draft of the paper in order to verify the accuracy of the information obtained in the interview. Again, I want to thank you for your participation, do you have any questions before we begin?

Interview Questions

1. Would you tell me a little bit about yourself?
    a. Academic background – types of degrees
    b. Membership in professional organizations
    c. Number of years taught
    d. Subjects taught and courses you are currently teaching
    e. Which of these courses are AAT courses?

2. How and when did you learn about the AAT degree, especially with respect to the science courses?

3. Who requested that you design and implement the new courses or course changes necessary for the AAT degree?
    a. External impetus
    b. Organizational impetus
    c. Internal impetus

4. What are your feelings about how this request was made – interested, turned off?

5. What types of background or reference materials have you read concerning the AAT degree and the science courses needed for this degree?

6. How did you obtain these materials?

7. What types of faculty development opportunities have you had in general? With respect to the AAT courses?

8. What is your opinion of your professional development activities?
What types of professional development activities would you like to have?

9. What types of administrative support would help you plan and implement the changes needed for the AAT degree?
    a. Time
    b. Money
    c. Schedule changing
    d. Materials/equipment
    e. Other

10. What types of support have been offered by the administration?
    a. Time
    b. Money
    c. Schedule changing
    d. Materials/equipment
    e. Other

11. What types of support have you specifically asked for? Did you get this support?

12. How long have you and your colleagues been involved in the change process?

13. How many semesters have you or your colleagues been teaching AAT related science courses, whether these are new courses or existing courses that have been modified?

14. Tell me about the process you (and your colleagues) went through in order to design or modify science courses to support the AAT degree.

15. How much input did you, as an individual, have in the design or modifications of the science courses that support the AAT degree? Were you satisfied with the amount of input you had?

16. How complete do you feel the change process is? How much more do you need to accomplish? Explain.

17. Tell me about the science content requirements of the new AAT degree. Is the content very different from the content of courses that the elementary education majors previously took? What changes have you made in content in order to satisfy AAT mandates?

18. What is your opinion of the science content requirements? What do you like and don't like about the content of the new or revised courses?

19. Could you describe your teaching philosophy?

20. What are some of the major influences that have helped in forming your philosophy?
    a. Previous instructors
    b. Professional organizations
    c. Peers
    d. Organizational goals and influences
    e. Other

21. How does your teaching philosophy influence your teaching of the AAT science courses? Has your teaching of the AAT science courses influenced or changed your teaching philosophy? Explain.

22. Is there any specific way the AAT science courses should be taught? In other words, could you describe the pedagogy requirements for AAT science courses?

23. Have you, or do you need to make any changes in pedagogy or teaching methods in order to accommodate the intent of the AAT degree courses?

24. What is your opinion, or how do you feel about the constructivist-teaching paradigm? Does it match your own teaching style? Explain.

25. Have you ever used constructivist-teaching methods before, either as a student or as a teacher? Describe.

26. Tell me a little bit about your typical student in your non-AAT science classes.
    a. Ability level
    b. Attitude toward science
    c. Type of learning preferred by students

27. Tell me a little bit about your typical elementary education major in your AAT science classes.
    a. Ability level
    b. Attitude toward science
    c. Type of learning preferred by students

Have you noted any major differences between students with different academic majors? Explain.

28. What do you do to enhance the learning of your students?

29. Do your students influence the way you teach? Explain.

30. What types of student assessments do you normally use in your non-AAT courses? Please give or share documents that address assignments/expectations.

   a. Exams
   b. Quizzes
   c. Reports
   d. Other

31. Do you use the same type of assessments in your AAT science courses? Please give or share documents that address assignments/expectations.

   a. Exams
   b. Quizzes
   c. Reports
   d. Other

Have you made any changes in student assessment in response to the AAT degree? Explain.

32. Do you think the AAT science courses will improve the education and science skill of the elementary education major (with respect to courses traditionally taken by these students)?

33. Are the AAT science courses open to other non-science majors? If so, do you think these courses will improve the science education of non-science majors? Explain.

34. Would you be involved in the AAT degree science courses if you were not asked or did not have to be involved? Why or why not?

35. What would you do if you were in complete charge of designing science courses for the elementary education major? Explain.

36. Those are all of the questions I wanted to ask. Do you have any other comments or have I left out anything that you feel should be discussed? Explain.

Appendix I

Syllabus Analysis Protocol

1. Date obtained:
2. Institution:
3. Instructor:
4. Course Number/Title:
5. Date of Syllabus:
6. Traditional Science Course   AAT Science Course   (circle choice)
7. Goals/Objectives explicitly stated (with respect to core skills of critical thinking):

Core Critical Thinking Skills	Objectives	Assessment Measures	Course Activities
Knowledge or lower order skill, not core skill			
Interpretation			
Analysis			
Inference			
Evaluation			
Explanation			
Self-regulation			
Dispositions			

Inquiry Activities:

8. Teaching Philosophy, expressed or implied:

Type of Philosophy	Indicators (key words or phrases)
Instructivism	
Constructivism	

9. Pedagogy, expressed or implied:

Type of Pedagogy	Indicators (key words or phrases)
Instructivism	
Constructivism	

Inquiry:

10. Assessment Measures listed:

Assignment type	Not Graded	Graded, % of Final Grade	Format of Assessment	Which of Core Crit. Thnk. Asses.	Proportion of Core Crt. Thnk. Used
Exams or Quizzes					
Student Presentations					
Journal					
Class Discussions					
Experiments					
Group Exercises					
Individual Exercises					
Web Assignments					
Other					

11. List any instructional media indicated:

Appendix J

Non-Syllabus Document Analysis Protocol

1. Date obtained:

2. Institution:

3. Instructor:

4. Course Number/Title:

5. Type of Document:

6. Date of Document:

6. Traditional Science Course AAT Science Course (circle choice)

7. Presence of Core Critical Thinking Skills

Core Critical Thinking Skills	Objectives
Knowledge or lower order skill, not core skill	
Interpretation	
Analysis	
Inference	
Evaluation	
Explanation	
Self-regulation	
Dispositions	

8. Presence of 4 E's:

The E	Objectives of Specific Assignments	Assignments and Activities
Engagement		
Exploration		
Explanation		
Elaboration		

Inquiry:

9. Other:

Appendix K

Permission Letter from Dr. Basili

Bettie A'Hearn

From: PATRICIA BASILI [BASILIPA@pg.cc.md.us]
Sent: Thursday, December 12, 2002 1:21 PM
To: Bettie A'Hearn
Subject: Re:

Hi Bettie, Yes of course you may use the observational instrument. You will need to practice on it however. I do have a sheet with examples of each of the tally categories - but there's nothing like trying it. I recently did 22 classes - 3rd grade to high school using it. I have some practice tapes you can use. The problem is - you are so far away. It would be great if we could co-observe some time. It would be wise to also audio or video tape the class you are observing- so you have a second chance to go back and rethink your tallies and assessments. Send me your address and I'll put a copy of the instrument and tally explanations in the mail to you.

Patricia A. Basili, Ph.D
Chair, Department of Education
Prince George's Community College
301 Largo Road
Largo, Maryland 20774-2199
Chesapeake Hall
301-322-0780 (office)
301-336-2851(fax)
pbasili@pgcc.edu

>>> "Bettie A'Hearn" <bahearn@allegany.edu> 12/12/02 01:14PM >>>
Dear Pat, I spoke with you at the last MAPT meeting about my dissertation topic. I want to study the changes that faculty have made in the AAT degree science courses and the factors that have affected the science faculty as they make those changes in pedagogy, content, and assessment. You mentioned that you had developed an instrument assessing constructivist teaching methods. This instrument may be helpful in gathering data for my paper. I was wondering if you would allow me to use the instrument, and if so, be willing to train me how to use it properly. I am currently doing my experimental design and deciding which schools to include in my multiple-case study. Any advice would be greatly appreciated. Thanks for your time and attention.

Bettie A'Hearn
Allegany College of MD
Cumberland, MD
bahearn@allegany.edu

Appendix L

Classroom Observation Protocol
[modified from Dr. Pat Basili's PROJECT OBSURVER Instrument]

Date:

Institution:

Instructor (name and gender):

Number of Students in Class: _____ Male _____ Female

Course Number/Title:

Length of Class Period:

Time Spent on and Description of Classroom Activities:

Teacher Lecturing _____

Student Presentations _____

Watching videos/multimedia _____

Class Discussions _____

Experiments _____

Group Problem-solving _____

Individual Problem-solving _____

Web Assignments ______

Other _____ explain:

% Time spent on constructivist/inquiry activities _____

Which E of the 5 E's of Constructivism does each activity support?

Activity	Engagement Motivation of topic	Exploration Discovery of concepts	Explanation Check of understanding	Elaboration Applicability of concept	Evaluation Assessment of Learning
Teacher lecturing					
Student presentations					
Videos-multimedia					
Class discussions					
Experiments					
Group problem solving					
Individual problem solving					
Web assignments					
Other					

Appendix M

Student Questionnaire
[modified from George Perry's (2003)
Web Site Analysis for Critical Thinking Development]

Script of Introduction

Hello, my name is Bettie A'Hearn and I am a doctoral student in the College of Human Resources and Education at West Virginia University. I am currently doing research for my doctoral dissertation. This research focuses on the planning and implementation of science courses that support the Associate of Arts in Teaching degree designed for elementary education majors.

I am inviting you to participate in my study by completing a brief questionnaire about critical thinking in science classes. Your participation is voluntary and you have the right to not respond to every item on the survey. You can be assured that confidentiality and anonymity will be strictly maintained. Your class standing or grade will not be jeopardized if you choose not to participate.

Questionnaire

1. Name of College:

Course name and time:

2. Gender: MALE FEMALE (circle your gender)

3. Age: 18-20 21-23 24-30 31-40 41-50

51-60 over 60

4. Rank (circle your current student status):

FRESHMAN SOPHOMORE JUNIOR SENIOR NON-DEGREE

OTHER ____

PART TIME FULL TIME

5. Number of Science Courses: <u>one</u> <u>two</u> <u>three</u> <u>four</u> <u>five</u> <u>other</u>
including this one

6. Has this course helped you improve your abilities to interpret information found in books, journals, or from the Internet?

a. _____YES b. _____ NO (check your choice)

7. If you answered yes to question 6, please name a specific assignment that helped you the most in interpreting information. Please explain how this assignment helped you.

8. Has this course helped you improve your abilities to analyze numerical data?

a. _____YES b. _____ NO (check your choice)

9. If you answered yes to question 8, please name a specific assignment that helped you learn the most about analyzing numerical data. Please explain how this assignment helped you.

10. Has this course helped you improve your abilities in explaining scientific information to other people?

a. _____YES b. _____ NO (check your choice)

11. If you answered yes to question 10, please name a specific assignment that required the most scientific explanation? Please explain how this assignment helped you.

12. Has this course helped you improve your abilities in evaluating the strengths or weaknesses of information and arguments?

13. If you answered yes to question 12, please name a specific assignment that required the most evaluation? Please explain how this assignment helped you.

14. What does your instructor do in terms of teaching that helps you learn? Explain.

15. Do you prefer working in groups?

a. _____YES b. _____ NO (check your choice)

16. Please explain why you answered yes or no to question 15.

Thank you for your time and effort and for participating in this study!

Appendix N

Permission Letter from Dr. Perry

Bettie A'Hearn

From: George Perry [gperry@shepherd.edu]
Sent: Thursday, June 22, 2006 1:59 PM
To: Bettie A'Hearn
Subject: RE: permission to use survey

Bettie, It is good to hear from you. Glad you are completingh your dissertation. Here is your permission

I George E. Perry Ed.D. give Bettie A'Hearn permission to use/modify the questionnaire I developed for my Dissertation.

From: Bettie A'Hearn [mailto:bahearn@allegany.edu]
Sent: Thu 6/22/2006 12:41 PM
To: George Perry
Subject: permission to use survey

Hi George, I am finally finishing up my dissertation. You had earlier given me verbal permission to modify your questionnaire. Could you email me a short written permission that I could paste into my appendix?
Thanks, Bettie A'Hearn
bahearn@allegany.edu

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