TEACHER PROFESSIONAL DEVELOPMENT THROUGH COLLABORATIVE CURRICULUM DESIGN IN GHANA'S POLYTECHNICS

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DISSERTATION

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Promotor	Prof. Dr. J. M. Pieters
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This dissertation has been approved by the promotor and assistant promotor.

To Eyram my daughter

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Marie Afua Baah Bakah, 2011

CHAPTER 1
Introduction

Polytechnics in Ghana have transformed over the years until 2007 when they were given the mandate, by law, to run degree programmes along with the already existing higher national diploma (HND) programmes. There was the need to update the HND programmes and develop degree programmes. In this introductory chapter is a definition of the problem which encompasses the era of curriculum development in the polytechnics and the internal and external efforts to streamline polytechnic education and ensure quality. Following this is the context regarding the development of polytechnics in Ghana, and the relation to national development. Furthermore is a look into capacity building for polytechnic teachers in curriculum reform. It concerns the need for competent teaching staff to develop and maintain relevant curricula. Literature is presented on teacher professional development and curriculum reform and on collaborative curriculum design in light of the developments in the area of study. There is a description of the dissertation and research questions, followed by the research methodology and overview of the rest of the book.

1.1 THE DISSERTATION

This dissertation entitled *Teacher professional development through collaborative curriculum design in Ghana's polytechnics is* a research conducted among polytechnic teachers in Ghana. Polytechnic development, curricular reform, improving the quality of teaching and teachers' knowledge needs prompted this research. The aim of the research as detailed in this dissertation is to provide professional development support for teachers to (1) update their courses through collaborative course design in design teams; (2) effectively engage in curriculum design to ensure curriculum relevance; (3) update their knowledge and skills in their respective domains; (4) apply relevant knowledge in their classroom practices and (5) enhance collegial interaction and collaboration. The main research question for the dissertation is: *what is the impact of collaborative curriculum design on teacher professional development and curriculum practices?* The following sections provide details about the problem, context and methodology.

1.2 PROBLEM DEFINITION

1.2.1 Curriculum challenge during reform

Polytechnics in Ghana are institutions that provide tertiary level education in applied sciences, applied arts and engineering. According to Mentz, Kotzé and Van der Merwe (2008), a polytechnic degree gives skills and know-how for the changing demands of working life. In response to a Ghana Government mandate to develop comprehensive vocational and technical education and training, stakeholders in polytechnic education have questioned measures being put in by the polytechnics to ensure that existing human and material resources commensurate their new status as tertiary institutions (Nsiah-Gyabaah, 2005). A number of programmes and projects have been commissioned and are still being executed in the polytechnics as means of preparing and equipping the polytechnics' human and material resource base. Notable among these are the Dutch sponsored NUFFIC/NPT 045 Project which was aimed at *Building the Managerial and Leadership Capacity of Polytechnics in Ghana* (Honyenuga & Kouwenhoven, 2009; Maassen & Azigwe, 2009). In addition, the government constituted the Council for Technical and Vocational Education and Training (COTVET) to regulate and give direction for effective management and development of competency-based curricula for polytechnics and technical institutions. In spite of the structures, policies and projects in place, polytechnic education in Ghana has suffered major setbacks which could be linked to factors such as (1) weak linkages with industry in terms of curriculum development which have further led to a mismatch of supply and demand skills (Owusu-Agyeman & Van den Oosterkamp, 2009; UNESCO, 2006). Furthermore (2) as at the year 2006, the existing polytechnic curricula did not meet the United Nations Educational Scientific and Cultural Organisation (UNESCO), and International Labour Organisation (ILO) criteria of providing scientific knowledge, technician versatility and a cluster of core competencies and generic skills required for rapid adaptation to new ideas and procedures for study career development (Effah, 2006). Thus, although the original curricula of the polytechnics have been designed to cater for the needs of industries, there is the need for continuous update and evaluation of content to meet the challenges of industrial growth and expansion, current labour market policies and national policies.

1.3 THE RESEARCH CONTEXT

1.3.1 Development of polytechnics in Ghana

Polytechnics in Ghana were originally called technical institutes (at the secondary level) when they were established in 1951. In 1963, the technical institutes were re-designated as polytechnics but they continued to operate essentially as non-tertiary institutions which offered mostly advanced craft courses and a few technician programmes (Nsiah-Gyabaah, 2005). The polytechnics inherited the physical and academic facilities of the technical institutes that were converted to polytechnics. A Polytechnic Law, PNDCL 321, 1992 was promulgated to give legal backing to the upgrading of polytechnics. From 1993 onwards, the state-owned technical and vocational oriented polytechnics were upgraded to tertiary status to offer additional career-focused programmes in the sciences, technology and business management leading to the award of Higher National Diploma (HND) (NTCE, 2001). In 1994, the polytechnics commenced the running of HND programmes. In 2007 there was another step in the academic growth of the polytechnics in Ghana with the government directive (Ghana Government Polytechnic Law 745, September, 2007) to run bachelor degree programmes as part of strategies to improve on the capabilities and capacities of the polytechnics to meet the manpower needs of the nation. Thus Polytechnic Law (PNDCL 321 of 1992) has since 2007 been replaced by the Polytechnics Law (Act 745). This gives a clear mandate to the Polytechnics as embedded in their aims and objectives as follows:

1. Provide tertiary education through full time courses in the field of manufacturing, commerce, science, technology, applied social sciences, applied arts and such other areas as may be determined by authority for the time being responsible for higher education;
2. Encourage study in technical subjects at tertiary level; and
3. Provide opportunity for development, research and publication of research findings.

The above objectives clearly indicate that the central focus of polytechnic education is its career-oriented nature. The career-oriented and craftsmanship programmes of the polytechnics are run only after approval from and accreditation by the National Accreditation Board (NAB). The autonomy granted the polytechnics gives them the degree of self-governance necessary for effective decision making concerning the functioning of the institution with respect to their academic work, standards, management and other related activities that are in line with the system of public accountability (Aidoo-Taylor, 2009). Currently, there are 10 polytechnics in Ghana administered under the National Commission on

Tertiary Education (NCTE); these are Accra, Bolgatanga, Cape Coast, Ho, Koforidua, Kumasi, Sunyani, Takoradi, Tamale and Wa Polytechnics.

1.3.2 Polytechnics and national development

A key objective of up-grading the polytechnic was to improve output particularly in technical and vocational level training. In 1991, Government of Ghana White Paper on the reforms to the tertiary education system specifically stated that the polytechnics have a distinctive and important role to play in middle level manpower development (Owusu-Agyeman & Van den Oosterkamp, 2009). The reforms were predicated on the fact that Ghana needed skilled and educated entrepreneurs, managers and leaders to feed into the development strategy of the country. The Polytechnics Act 745 therefore mandates the polytechnics to conduct research, train and develop skills relevant for the job sectors to enhance their productivity and efficiency. The Growth and Poverty Reduction Strategy II under the purview of the National Development Planning Committee spells out the national development agenda of the country of which polytechnic graduates are to serve as part of the key human resources for quality and efficient public service delivery in order to speed up the growth of the private sectors. The outputs from polytechnics are expected to align with efficient and effective manpower demand in both the public and private sectors. Polytechnics are to contribute to Ghana's employment and human resource capacity building by providing technological and commercial education at tertiary level and to provide other related services such as research and consultancy to improve productivity in industry and commerce. In general, polytechnics aim at promoting industrialization and economic development in Ghana.

1.3.3 Challenges in capacity building for polytechnic teachers in curriculum reform

Teachers are the key players during curriculum reform in the polytechnics with regard to upgrading of HND programmes and designing Bachelor of Technology programmes. One of the major internal challenges faced by the polytechnics in meeting demands of relevant curriculum and quality teaching and learning was the need for a knowledge and skill update of teachers who had been caught up in institutional revival since curriculum design became their responsibility (Gervedink Nijhuis, Bakah, & Akomaning, 2009; Nsiah-Gyabaah, 2005; Nsiah-Gyabaah & Ankomah, 2009). Even though arrangements were in place for teachers' further academic studies in terms of acquisition of master's and PhD degrees by academic staff, these were dependent on funding from government and donor agencies which were not readily available (Gervedink Nijhuis et al.,

2009). Even if scholarship was available, it was only accessible by few people who took years to complete their studies and return to post. Studies have shown that the polytechnics' teachers need to improve their knowledge and skills as they continue to practice their career (Gervedink Nijhuis et al., 2009; Nsiah-Gyabaah, 2005) and get involved in the design of HND and B. Tech curriculum (Owusu-Agyeman & Van den Oosterkamp, 2009). The success of curriculum reforms, like the ones indicated here in the polytechnics, is dependent on teachers' knowledge and skills to facilitate their participation in the reform which is critical as content, instruction and curriculum development largely falls within their control (Borko, 2004; Fullan, 2007; Penuel, Fishman, Yamaguchi, & Gallagher, 2007). The delivery of quality technical and vocational education is dependent on the competence of the teacher, a competence measured in terms of theoretical knowledge, technical and pedagogical skills as well as being abreast with new technologies in the workplace. Enhancement of the abilities of polytechnic teachers is also a major step in improving the quality of teaching and preparing polytechnic graduates to contribute meaningfully to national development. Ladd and Fiske (2008) contend that quality professional development programmes improve the quality of the existing teaching population. In addition, studies have found that professional development can improve teacher quality by changing teacher practices (Wenglinski, 2002).

1.4 TEACHER PROFESSIONAL DEVELOPMENT AND EDUCATIONAL REFORM

Since the late 1960s, theory and research on organizations have emphasized learning as a crucial factor in productivity and change (Argyris & Schon, 1978). Learning has been associated with effective planning, problem-solving, and experimentation (Weisbord, 1989). Similarly, teacher learning has become more pronounced in the education literature and associated with the implementation of planned change (Fullan, 2007). Arguments abound that changes in the nature of teachers' work, subject matter and student populations challenge prevailing beliefs and practices and require on-going development of knowledge and skills (Hiebert, Gallimore, Stigler, & Smylie, 2002). The key to better education practices and desired educational outcomes is to have a motivated and superior teaching workforce. Without the teacher's know-how, educational change efforts really suffer (Van Driel, Beijaard, & Verloop, 2001).

It is necessary to continually engage teachers in the process of learning to become effective. 'Professional development is described as those processes and activities designed to enhance the professional knowledge, skills, and

attitudes of educators so that they might, in turn, improve the learning of students' (Guskey, 2000, p. 16). Ingvarson, Meiers and Beavis (2005) stated that professional development of teachers is now recognised as a vital component of policies to enhance the quality of teaching and learning in educational institutions. Continued professional growth of teachers is widely accepted as an essential ingredient to any educational reform (Fullan, 2007). The case of Ghana's polytechnics is crucial in the wake of reforms in the provision of relevant higher technical and vocational education. There is broad consensus among teacher learning researchers that "reform oriented" professional development tends to be more effective than "traditional" course based professional development (Loucks-Horsley, Hewson, Love, & Stiles, 1998; Penuel et al., 2007; Putnam & Borko, 2000). Evidence from a wide range of studies of schools engaged in reform suggests that those that make extensive use of teacher collaboration are particularly successful in promoting implementation, in part because reforms have more authority when they are embraced by peers (Bryk & Schneider, 2002). Quality professional development for teachers has never been more important than it is today as the challenges they face intensify and the expectations for quality education increase.

The learning of teachers is intertwined with their on-going practice, making it likely that what they learn will indeed influence and support their teaching practice in meaningful ways (Correnti, 2007; Putnam & Borko, 2000). Desimone, Porter, Garet, Yoon and Birman (2002) indicate that given the size of investment in professional development, and the dependence of education reform on providing effective professional development, the knowledge base on what works must be strengthened. Thus, understanding what makes professional development effective is critical to understanding the success or failure of many education reforms.

1.5 COLLABORATIVE CURRICULUM DESIGN AND TEACHER DEVELOPMENT

Collaborative curriculum design is gradually advancing in education as a means to create teacher ownership during curriculum innovation (Borko, 2004; Villegas-Reimers, 2003). Collaborative curriculum design processes have the potential to contribute to the professional development of the teachers involved as well (Borko, 2004; Deketelaere & Kelchterman, 1996; Jarvis, Holford & Griffin, 2003; Penuel et al., 2007). There is a growing consensus that professional development yields the best results when it is long-term, school-based, collaborative, focused on students' learning and linked to curricula (Darling-Hammond & Sykes, 1999;

Garet, Porter, Desimone, Birman, & Yoon, 2001; Loucks-Horsley et al., 1998). Penuel, et al. (2007) reported from a large-scale survey that professional development which is specific and linked to the curriculum, influenced teachers' knowledge and practice and impacted implementation of curriculum reform.

In this research, collaborative curriculum design was assumed to be necessary for polytechnic engineering teachers who updated their syllabuses due to curriculum reform. The co-design took place in design teams and was supported by knowledge updates at industries in Ghana related to their subject areas. Collaboration in design teams, according to Handelzalts (2009) and Simmie (2007) contribute to enhanced teacher knowledge, skills and practices. The construct of "collective participation" in Garet et al.'s (2001) research refers to professional development in which teachers participate alongside colleagues from their school and district. Supporting the notion that this would be an effective strategy for teacher learning, a large body of theory and research is focused on the importance of teachers' professional teams (Desimone, 2002), and recently acknowledged by Desimone (2011). Others have proposed that efforts to improve teaching quality through collaboration build relational trust in a school building (Penuel et al., 2007). Such trust allows leaders and teachers more latitude and discretion in making difficult decisions, creates clearer understandings of role obligations, and sustains commitment to improving student outcomes (Frank, Zhao, & Borman, 2004, Penuel et al., 2007). Interactions among teachers constitute a resource to teachers in support of their implementation of reforms, which can be considered a form of social capital (Penuel, Frank, & Krause, 2006).

1.6 RESEARCH QUESTIONS

This research was designed to investigate teacher collaborative curriculum design in design teams and how it affects teacher professional development and classroom practices as the polytechnics underwent curriculum innovation and progress in their evolution as tertiary institutions. Teachers' collaborative course update was facilitated through design teams during which they were supported through industry visits to strengthen their knowledge-base for effective contribution to a relevant curriculum. The research therefore focused on investigating teacher professional development during the collaborative course design process. The main question that guided the conduct of the entire study was:

What is the impact of collaborative curriculum design on teacher professional development and curriculum reform practices?

The research approach applied in this dissertation to unearth responses to the main research question was design based research. The four main phases of the research were the context and needs analysis, first implementation, second implementation and impact study. The following sub-research questions guided the research phases:

1. What training and development needs of teachers exist in a curriculum reform scenario?
2. What is the impact of design teams, as a professional development arrangement, on teachers' knowledge and skills?
3. What is the impact of design teams on teacher professional learning and curriculum reform practice?
4. How does teacher participation in collaborative curriculum design activities impact on their professional growth?
5. What is the potential for sustainability and large-scale implementation of design teams in the polytechnic?

1.7 METHODOLOGY

1.7.1 Design-based research

Design-based research according to Barab and Squire (2004) is a series of approaches, with the intent of producing artifacts and practices to contribute to a design theory that accounts for and potentially impact learning and teaching in naturalistic settings. Akker van den, Gravemeijer, McKenney and Nieveen (2006) in their extensive work on design-based research have indicated that the compelling argument for initiating design research stems from the desire to increase the relevance of research for educational policy and practice, developing empirically grounded theories through combined study of both the process of learning and the means that support that process and finally but not the least increase the robustness of design practice. There is little debate that, in any domain, the design-based research process tends to be iterative (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003; Reeves, Herrington, & Oliver, 2005). These motives provide a stage for considering design-based research. Wang and Hannafin (2005) define design-based research as a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in

real-world settings. Wang and Hannafin indicate that design-based research leads to contextually-sensitive design principles and theories.

Reeves (2006) has stated that design research protocols require intensive and long-term collaboration involving researchers and practitioners. As indicated by Edelson (2002), the process of designing is open-ended and complex, requiring interdependent decisions, extensive investigation and iterative refinement. In our research, there was collaboration between the researcher and staff of the polytechnics studied. Design-based research approach was used to find out how teachers' participation in design teams enabled them to effectively engage in a collaborative curriculum design and maximise opportunities thereof for their professional development. The design-based research was appropriate for this study because it entailed a context and needs analysis stage which provided empirically-based awareness about the problem in context. In effect, design-based research allowed for the problem to be situated in educational practice and actively involved educational practitioners. Based on the context, a professional development programme was implemented in two iterations of design, implementation, evaluation and refinement. Data collection during each iteration generated information on how to refine the programme and whether the professional development programme yielded desired impact, since design research integrates the development of solutions to practical problems in learning environments with the identification of reusable design principles (Reeves, 2006). After the iterations, a final study was conducted to ascertain the sustainability and up-scale of the professional development programme. The method was useful in finding realistic answers to the question posed for the research.

Quantitative and qualitative data were collected during the research. Quantitative data was mainly composed of questionnaires with five point Likert scales for both teachers and their students. Qualitative data sources were structured and semi-structured interview guides (teachers and leadership), teacher-written reports and researcher logbook. The variety of data sources used in the research guaranteed triangulation to increase the quality of data. The collaborative curriculum design took place within the context of the polytechnics. The two iterative stages in this dissertation were therefore conducted as multiple case study research (Yin, 2003). At the preliminary and final stages, which are the context and needs analysis study and impact assessment studies respectively, cross-sectional survey (Gray, 2004) was used to acquire substantial data across teachers and leadership. The focus of collaborative curriculum design was on the design teams, visiting industries, redesigning common curriculum and teaching try-out of updated courses. During the entire study, six design teams were followed in two polytechnics. The

results were analyzed on team and across team level within each polytechnic and finally on individual level, assessing personal teacher learning encounters and comparing individual professional growth.

1.8 DISSERTATION SYNOPSIS

The ensuing chapters encompass detailed reports on the four segments of this dissertation. The main question for the research was; *what is the impact of collaborative curriculum design on teacher professional development and curriculum reform practices?* Chapter 2 provides the description of the context and needs analysis study as carried out in four polytechnics in Ghana and was guided by the research question; *what training and development needs of teachers exist in a curriculum reform scenario?* The study sought the perceptions of teachers and leadership on training and development needs of polytechnics teachers in Ghana. The report on the first implementation of collaborative curriculum design in design teams among teachers in the faculty of engineering in Ho Polytechnic in Ghana and teachers' knowledge and skill acquisition thereof is presented in Chapter 3 with the research question; *what is the impact of design teams, as a professional development arrangement, on teachers' knowledge and skills?* Chapter 4 contains information regarding the second implementation of collaborative curriculum design in design teams among faculty of engineering teachers in Takoradi polytechnic. The research question that aided the conduct of the study in Chapter 4 was; *what is the impact of design teams on teacher professional learning and curriculum reform practice?* The chapter entails details of teachers' practices in design teams for their professional development and classroom practices. In Chapter 5, data from the second implementation are explored further to reveal individual teacher professional growth and its interconnected details as it occurred during teamwork in collaborative curriculum design. The research question for Chapter 5 was; *how does teacher participation in collaborative curriculum design activities impact on their professional growth?* The 6th Chapter is about the results of an impact study on the sustainability and potential for large-scale implementation of design teams in the polytechnics. This sustainability study was conducted eighteen months after implementation of the first intervention study and eight months after implementation of the second intervention study. Guiding the study reported in Chapter 6 was the research question; *what is the potential for sustainability and large-scale implementation of design teams in the polytechnic?* Some identified inherent opportunities are outlined for sustenance and conclusions drawn based on the characteristics of the programme,

contextual features and polytechnic climate. Chapter 7 concludes this thesis with reflections on the research approach, critical findings, implications for practice, and directions for future research. In the appendices are the data collection instruments for the phases in this research[1] and pictures of participants during some stages of collaborative curriculum design activities described in this dissertation. The following quotation from a teacher who participated in this research provides a preamble to the chapters and gives thought to the significance of teacher professional development as advocated in this dissertation.

> *"I'm not new to the generating station. I had the opportunity to work with them during my national service period. But when we went to TICO the other day, there was an entrenched knowledge, in other words, there were some things I took for granted but until that day never appreciated them to that extent. I got to know that the voltages that were used for excitation at these turbo generators were far lesser than what we use in the hydro –generating stations. In the hydro- generating stations, you can have about 500V D.C being applied to your phone circuit whereas when you come to the turbo generators, which are at the thermal power station, you have a maximum of about 35V D.C, see that the range is very vast. All along, I thought they were injecting about 100V D.C so 35V was shocking. I even had to argue with some of the facilitators who were around and they took me to the feed. I observed it and realized that it was true. So I asked myself that what could have been the difference and I realized that even the principle I knew always now came to the fore and that is whenever we talk about magneto motive force, we are talking about the effect in current flow, it has to do with the number of turns times current. I realized that if they are using a low amount of current in terms of amperes, then it means that the number of turns as compared to what we have in hydro-generating stations, are much higher and so makes me appreciate N*I as magnetomotive force and it gave me a clearer picture of that mathematical expression and even though I am much into these generating stations… I never knew this until we went out as design team to go and ascertain and understand some things in order to update our courses and supplement what we teach in the classroom. In view of this, I think if you are in authority in any field, it is not bad to go out there to update your knowledge. This was a real updating because it was something I had always taken for granted but on that day I got to know what we mean when we talk about excitations."*

[1] The soft coyp of instruments used in this study can be sent on request (marieafua@yahoo.com).

CHAPTER 2
Curriculum reform and teachers' training needs: The case of polytechnics in Ghana[2]

Professional development is key to curriculum-based reform, yet there is little empirical evidence upon which to base decisions of design or implementation of training and development (T&D) programmes. This chapter examined T&D needs of Ghana's polytechnic teachers in an existing curriculum reform scenario as they become involved in curriculum design. Forty-four teachers and four heads of mechanical engineering departments and representatives of leadership of four polytechnics granted comprehensive interviews and responded to questionnaires. Findings revealed that updating knowledge of subjects through embarking on industrial attachment was a major T&D need for teachers. Teachers indicated keenness in getting more involved in curriculum design activities and advocated improvement of their content knowledge to confidently engage in curriculum design. Results generated insights into the need for higher education teachers' T&D for effective curriculum design and implementation. Strengthening polytechnic-industry links and teachers' drawing on teamwork to plan and undertake industrial attachment were proposed.

2.1 INTRODUCTION

The development of new curricula as means to curriculum reform is a common event in countries across the globe. Commitment to successful curriculum reform, however, requires active involvement of teachers in the design of new curriculum. Despite the laudable curriculum intents, quite too often, attention and energies of policy makers are focused on ''what'' (enacting curricular

[2] A previous version of this chapter was presented at the annual conference of the *American Educational Research Association* (2011, New Orleans, Louisiana). A new version of this chapter has been accepted by IJTD as at March 2011and is in press as: Bakah, M. A. B., Voogt, J. M., & Pieters, J. M. Curriculum reform and teachers' training needs: The case of higher education in Ghana. *International Journal of Training and Development.*

policy/legislation) of desired educational change neglecting the ''how'' (bringing a new curriculum into practice) (Rogan & Aldous, 2005). This study is about assessing the knowledge needs of teachers in order to design curriculum in Ghana's polytechnics due to curriculum reform. To realize a successful curriculum reform ("what"), teachers need to be appropriately prepared ("how") since they are the most influential factor in the change process (Fullan, 2007). Teachers have a crucial role in efforts to enact the new curricula which are under development. Therefore it is of most importance for the polytechnics to have teachers with up-to-date knowledge and skills to design, implement, and enact new curricula. Ingvarson, Meiers and Beavis (2005) indicate that teacher professional development (PD) is recognised as a vital component of policies to enhance the quality of teaching and learning in our educational institutions. Training and development (T&D) directly linked to curriculum design is considered to more effectively prepare teachers to enact curricula (Penuel, Fishman, Yamaguchi, & Gallagher, 2007) than conventional T&D programmes. On-going curriculum reform in Ghana's polytechnics has underscored the need to focus attention on teachers' PD.

As a result of the upgrade of Ghana's polytechnics to tertiary institutions (Nsiah-Gyabaah, 2005), the polytechnics started to develop and run Bachelor of Technology (B. Tech.) programmes. The Higher National Diploma (HND) programmes, which were already in existence, needed updating to ensure curricular quality and relevance (Owusu-Agyeman & Van den Oosterkamp, 2009). Although the curriculum of the polytechnics has been designed to cater for the needs of industries, there is the need for continuous update and evaluation of content to meet the challenges of industrial growth and expansion. In addition to this, studies have shown that polytechnics teachers in Ghana need to improve their knowledge and skills as they continue to practice their career (Nsiah-Gyabaah, 2005) and get involved in the design of HND and B. Tech curriculum (Owusu-Agyeman & Van den Oosterkamp, 2009). The success of curriculum reform is dependent on teacher's participation in the reform which is critical as content, instruction and curriculum development may largely fall within their purview. It is critical, therefore, that the management plans and provides consistent and on-going support to their teachers through T&D. The first step is to determine the specific needs of their teaching population. In order to support these polytechnic teachers it is necessary to proactively include their 'voices' in guiding decisions on how best to support them in the work that they need to do.

The purpose of this study is to investigate polytechnic teachers' T&D needs and challenges as they get involved in curriculum design in the reform process. It

further examines the perspectives of teachers on how they are involved in curriculum design as an effective way of implementing innovations.

2.2 PROFESSIONAL DEVELOPMENT OF TVET TEACHERS: NEEDS AND CHALLENGES

Industrial attachment (IA) is seen as an effective T&D activity for Technical and Vocational Education and Training (TVET) teachers. One of the most important features of TVET is its orientation towards the world of work and the inclusion of work-integrated learning in the curriculum (Choy & Haukka, 2009). In an ever-changing industrial environment, IA is a necessary T&D strategy for TVET teachers to ensure that they are equipped with the necessary workforce skills and capabilities for the near future (Choy & Haukka, 2009). There have been ways to develop and maintain TVET teachers' and instructors' professional competence globally through in-service training involving industrial attachment (Paleocrassas, Tsiantis, Dimitropoulos, Pagkalos, Pavlidis, Nikolopoulos, & Tsaliagou, 2009); exemplars of which are in India (Jain & Saxena, 2002) and Kenya (Kerre, 2009). Cort, Harkonen, and Volmari (2004) contend that practical training periods in companies allow teachers to update their skills and knowledge in the subject areas they teach, while encouraging them to experiment with new teaching methods and materials, giving them a realistic and holistic impression of the professions, and bringing elements of realism into their teaching.

This strategy for applying IA for T&D purposes is a systematic approach to learning and development in authentic environments to improve individual, team and organizational effectiveness (Kraiger & Ford, 2007). Teachers involved in this kind of on-the-job T&D activities increase their competencies critical for a successful teaching performance. This study analyses the T&D needs of a specific group of professionals in the TVET sector as pertains to a specific task they perform. Specifically, the analysis intends to investigate the PD needs of teachers in the polytechnic as they embark on designing new programmes. Putnam and Borko (1997) have indicated that for teachers to be empowered and treated as professionals, they should determine the focus and nature of their PD activities. This study provides an example of determining the needs of educators, the results of which can be used by management to guide their decisions when prioritizing areas for T&D.

Needs analysis in T&D has evolved as a research area that serves a vital role in shaping strategy and enabling organizations to take full advantage of emergent strategies. Inancevich (1992) asserted that a needs assessment should present the

following: (1) the analysis of the organization's needs; (2) the knowledge, skill and attitude needs to perform the job; and (3) the person or jobholder's needs. Robert (1999) studied the same concept and found that a needs analysis typically had a dual focus: organizational analysis and operational analysis. Both studies found that organizational analysis was used to analyse the needs of the entire organization now and in the future and operational analysis was used to analyse the needs of a specific group of jobs or positions (Inancevich, 1992; Robert, 1999). In this study operational analysis is used to identify the needs of polytechnics teachers. We will use the concept of a needs analysis to reveal the needs and challenges of TVET teachers and to justify a common ground for T&D activities. Krishnaveni and Sripirabaa (2008) proposed that perception-based, consensus-oriented assessment is a valuable tool for evaluating and improving T&D activity and that brainstorming sessions led to suggestions for enhancing capacity in identified lag areas. In this context employees identify their T&D needs to satisfy lifelong employability. Although literature has revealed that a number of studies have focused on employees' reactions to T&D (Arthur, Bennett, Edens, & Bell, 2003), there is lack of empirical evidence about employees' T&D needs in relation to particular task or tasks employees are to perform.

Active involvement of teachers in curriculum design is pertinent to successful implementation. As indicated earlier, teachers' increased level of professional knowledge and skills can create a firm basis for curriculum design and implementation in polytechnics. PD triggers the teacher's awareness of what the curriculum is about and what the former is doing. Teachers' assessment of training needs endeavours to start a process of reflection, critique, and refinement of the teacher's classroom practice. Thus training needs elicit change through the teacher's awareness while PD intervenes directly to bring about change. PD is a basic educating strategy with the purpose of achieving change in what the teacher does and why. Whereas the constituents of curriculum development are accessible through the knowledge and skills of teachers, attitude and awareness of teachers' training needs help to attract a PD experience to support curriculum development and achieve change.

2.3 TVET TEACHERS IN CURRICULUM DESIGN AND IMPLEMENTATION

Curriculum design (CD) is a process involved with devising, planning, and selecting elements, techniques, and procedures by which to communicate learning (Hansen, 1995). CD is generally an iterative and lengthy process, carried out by a broad range of participants and influenced by an even wider variety of

stakeholders (Akker van den, 2003). A major stakeholder is the teacher (Marsh & Willis, 2003) who participates from time to time in CD (Ben-Perez, 1990). Teachers' knowledge of subject matter and classroom as well as their concerns need to be the starting point of CD processes (Ben-Perez, 1990). Active involvement of teachers in CD leads to a sense of ownership and contributes to their PD through reflection on concrete experiences (Akker van den, 2003). Penuel, et al. (2007) reported from a large-scale survey that PD which is specific and linked to the curriculum influenced teachers' knowledge and practice and impacted implementation of curriculum reform. Teachers' knowledge of content and pedagogy enables them to reveal weaknesses, shortcomings and conditions of the curriculum. For this reason, teachers need to have a central role in the CD process that starts with locating curricular problems (Ben-Perez, 1990). An important focus of PD therefore is in curriculum design. The main research question for the study is: *What training and development needs of teachers exist in a curriculum reform scenario?* Cross-sectional survey (Gray, 2004) was used to acquire substantial data on CD activities and PD challenges and needs from polytechnic teachers and administrators.

2.4 METHODS

2.4.1 Sample

The mechanical engineering departments of four out of ten polytechnics in Ghana were engaged in the study. These four polytechnics were selected because they are the oldest and most well established. All mechanical engineering teachers (N=44) in those four polytechnics were involved in the study. Twenty teachers had a master's degree, nineteen were bachelor's degree holders and five had HND. Twenty persons in leadership positions were involved. All the teacher respondents were males whilst 3 of the 20 respondents in management position were female.

2.4.2 Instrumentation

Teachers responded to questionnaires and semi-structured interview (four teachers from each polytechnic, purposively sampled due to long service bringing total for the study to twelve). All the 20 persons in leadership positions were interviewed. Questions elicited participants' perceptions about T&D and CD in the polytechnic. Questionnaire items on T&D activities which comprised open and close-ended items were based on teachers' perception of their T&D needs.

2.4.3 Data analysis

Questionnaire data were analyzed using descriptive statistics. When appropriate, further analysis was conducted using the paired-sample t-test to compare the means of teachers in terms of their current status and desired state of involvement in curriculum design. To get an indication of the magnitude of an effect, effect sizes were calculated using Cohen's d (Cohen, 1988). Cohen provided tentative benchmarks for the interpretation of effect sizes. He considered *d*=0.2 a small, *d*=0.5 a medium and *d*=0.8 a large effect size. All interviews were transcribed and analysed. This process involved segmenting the information (Tesch, 1990) and developing coding categories (Bogdan & Biklen, 1992). Data were categorised into emerging themes and presented through a narrative report (Miles & Huberman, 1994).

2.5 RESULTS

2.5.1 Teachers' training and development needs

Teachers had the opportunity to indicate what kind of T&D they needed most. Teachers prioritized their T&D needs (Table 2.1) and results showed that majority of them (82%) indicated the most important T&D need as IA to update their practical skills. Only 2.3% of the teachers indicated that on-campus workshops in subject area were the preferred need.

Table 2.1 *Priority of training and development needs of teachers*

Professional development activities	**N**	**%**
Refresher courses organised by professional institutions	3	6.8
Pursuance of further academic studies	4	9.1
On-campus workshops in subject area	1	2.3
Industrial attachment to update practical skills	36	81.8

Interview data from teachers and leadership confirm the importance of IA for the T&D of polytechnic teachers. The ensuing comment by a teacher is an example of what the teachers observed about industrial visits.

> *"Here when you talk about staff professional development people are thinking of going abroad. But just within here I can be attached to an industry where I can work for about two to three hours then I come and teach. And that will make me efficient."*

The above comment affirms the notion of some teachers on PD. They are content with industries as a learning resource. Meanwhile another teacher was of the view that;

> *"We need to be going to industry and see what is coming on board now because technology is changing very fast so to be abreast with time, we need to be going to industry."*

The teacher acknowledges that industries are better equipped with modern technologies which the polytechnics may not afford to acquire. Thus to catch up with innovation they have to embark on industrial visits. This view is confirmed by a fellow teacher as he indicated that;

> *"In fact since we are producing students to feed industry through hands-on training, the departments will have to liaise with industry for their inputs such as equipping staff with relevant knowledge and skill in order to give off their best."*

While only 9.1% of the teachers indicated continuing further academic studies as a priority need for T&D needs, pursuance of further academic studies in terms of graduate and post graduate programmes was high on the agenda for leadership in terms of T&D. Comments that follow attest to this. A head of T&D asserts that;

> *"Teachers need to be provided with scholarships to embark on further studies. They need sponsorship as well to attend relevant seminars and training workshops. Yes, I think that is very much needed and has been spelt out in our strategic plan."*

Despite documentations to ensure that teachers pursue further academic studies, limited or unavailable scholarships are challenges that beset the polytechnics. A HoD intimated this challenge further in the following statement;

> *"All is not well with us teachers in this institution in terms of academic qualification, so our desire is to get the encouragement and support from the polytechnic management to get higher degrees, yes."*

It is observed from the results that apart from IA, teachers' attainment of high academic knowledge through post graduate programmes was considered necessary by polytechnic leadership as a component of a T&D programme.

2.5.2 Teachers' involvement in curriculum design

Results (Table 2.2) indicate that 50% or less of the teachers are currently involved in almost all CD tasks listed except deciding on learning materials and resources (54.5%). As to the curricular tasks that teachers desire to be engaged in, over 50% of them responded in the affirmative to all the CD components. Developing instructional/learning techniques scored the highest positive response from the respondents (68.2%). Deciding on learning venues scored the least percentage of 52.3% in relation to teachers' desired curriculum tasks.

Table 2.2 *Teachers' (N=44) involvement in curriculum design*

	Teachers' involvement			
Curriculum design tasks	*Current*	*Desired*	**P-Value**	**Effect size**
Deriving objectives	40.9	61.4	0.005*	0.40
Developing instructional/learning techniques	45.5	68.2	0.003*	0.47
Developing evaluation techniques/procedures	36.4	61.4	0.003*	0.51
Selecting course periods	40.9	54.5	0.083	0.28
Deciding on learning venues	31.8	52.3	0.005*	0.41
Determining student groups	40.9	61.4	0.018*	0.40
Deciding on teachers' tasks	50.0	56.8	0.445	0.14
Deciding on learning materials	54.5	54.5	1.00	0.00
Determining course content	45.5	61.4	0.033*	0.32
Overall	*43*	*60*	*0.001**	*0.44*

Note: Cronbach's Alpha=.89; *p<0.05.

Paired-sample t-test results (Table 2.2) reveals an overall significant difference (p<0.05) with a medium effect size of 0.44 between teachers' current and desired involvement in CD tasks. Four tasks being selecting course periods (p=0.083, d=0.28), deciding on teachers' tasks (p=0.445, d=0.14), and deciding on learning materials (p=1.00, d=0.00) were not significant. The largest effect size (d=0.51) recorded was on the task developing evaluation techniques/procedures. The teachers were asked if their involvement in CD will empower them as professionals. This was meant to know whether teachers see their performance of CD tasks as part of their professional duties. A total of 97.4% of them (43 of the 44 respondents) agreed to the statement.

To acquire detailed information on how teachers are involved in CD, the polytechnic leadership provided responses on CD activities of teachers. Their comments showed that a CD environment existed in the polytechnics. They gave several examples in their responses to confirm that new programmes were being developed and teachers' involvement in the design process. The

statement by a dean explained how teachers were involved in the development of the B. Tech. programmes;

> *"You know let me give you an example. We developed the B. Tech syllabus. What we did was that we got some of the teachers who formed committees for various programmes. We come together and then come up with the curriculum and we pass it over to industry for industry to put in their concerns. So it is more or less teamwork, let me put it that way."*

The dean's statement concerning the design of new B. Tech. programmes indicated that the committees are not made up of every teacher in the departments concerned, but rather a selected few. In contrast to that, all teachers are involved in the review of an existing programme which is the HND syllabus. A HoD declared that;

> *"At a departmental meeting where all the teachers are present, we come out with the core competencies in the syllabus for the three year HND curriculum. So based on the core competencies we came up with some modules, or blocks and we spread the competencies based on this block. Basically that is what we do."*

These comments from leadership indicate that teachers form the core of committees that design or review the curriculum which is a very important and prevalent feature at the polytechnics due to new B. Tech. programmes being mounted and the review of existing HND programmes. Information from the deans and HoDs indicated that there were usually no guidelines for the selection of teachers who form committees for CD at the department. A dean admitted that;

> *"Yes, I think there doesn't seem to be a coordinated programme, at least with my experiences here, that consciously aims at pulling all teachers on board to design or review that programmes."*

The study also sought to find out whether the curriculum components (Akker van den, 2003) were made manifest in the steps and decisions taken by teachers in designing curriculum at the polytechnics. Probing further in the interviews revealed that all the components were considered as has been captured in the comments of a head of academics below;

> *"The various aspects of the curriculum are taken into consideration when teachers meet to review or design a programme. Attention is paid to selection of content and their objectives, teaching technology to be adopted, delivery methods, teacher evaluation and assessment criteria for students. We also take into consideration teaching and learning materials and timetables among others."*

The results revealed teachers' interest in getting more involved in CD activities. Overall, teachers unanimously agreed that getting involved in CD empowered them as professionals. Ways in which teachers in the polytechnics are involved in CD are through the design and review of new and existing programmes respectively.

2.5.3 PD needs of teachers in relation to curriculum design

The study sought to find out whether teachers had PD challenges in relation to their encounter with CD activities that they participate. Data captured (Table 2.3) revealed that the majority (54.5%) of the teachers referred to inadequate exposure to new trends in industry. Only 25% of them were of the view that lack of higher academic knowledge in their subject area was a challenge while 4.5% referred to inadequate conduct of own research in subject area.

Table 2.3 Teachers' (N=44) professional development challenges in terms of curriculum design

Challenges in professional development	N	%
Inadequate workshops on subject area	7	15.9
Inadequate exposure to new trends in industry	24	54.5
Inadequate conduct of own research in subject area	2	4.5
Lack of higher academic knowledge in subject area	11	25

Data in Table 2.3 is corroborated by interview data as we capture a few comments in the following paragraphs beginning with teachers as in the case of one who indicated that;

> *"We need to undertake industrial visits but it is not working. Even if it is just one day and you come back, you see a lot of things. Before going on a visit to industry teachers can put down those things exactly they want to learn about. So it makes it possible for you to learn a lot even for just for one day but well it's hard to process the visits."*

The above comment reiterates teachers' willingness to acquaint themselves with industrial operations and equipment to bridge the industry teacher knowledge gap. It will be noted from the ensuing comment from another teacher that their desire is to train students who have industry relevant hands-on skills, thus calling for a balance between theoretical and practical training.

"I think we should think of a technical polytechnic producing people that can easily fit into the job market. A polytechnic teacher should not enter the classroom to offer only theoretical information. He should be going to industry to acquaint himself with the modern machinery being used and modern trends of production to impart to students."

The stance of leadership was clear about the need for teachers' knowledge of developments in industry. It will be noted that polytechnics may not purchase some major industrial machines since their operation can only be in industrial settings due to large-scale production. A HoD stated;

"As a matter of fact, improving the practical aspect of teacher's knowledge is a major setback which I must confess. Due to the fact that engineering in particular is capital intensive, we need to equip teachers to have strong practical grounding."

A dean as in his comments below stressed that teachers' IA will impact on the curriculum through its regular update by teachers who might encounter current information concerning their subject areas.

"In fact all the polytechnics are practical oriented and therefore teachers should be attached to industry for regular visits. Then with the change of industrial trends, we could make the necessary changes in the curriculum quickly. So the IA should not only be for the students but also for the polytechnic teachers."

The results reveal that IA is of prime importance to teachers for the performance of CD since it will keep them abreast with industrial trends and bring new information and skill needs of industry to bear on the curriculum and instructional practice.

2.6 DISCUSSION AND CONCLUSION

This study aimed at identifying T&D needs of teachers related to their involvement in CD in an era of curriculum reforms in Ghana's polytechnics. Despite the small sample size, there is little reason to think that the responses might be biased, especially because all respondents were contacted individually. Pursuing post-graduate programmes was the T&D priority of leadership due to polytechnics' policy to maintain master's degree as the minimum qualification for their teachers. IA was mostly deemed by teachers as a very important T&D programme. This confirms the studies of Jain and Saxena

(2002) and Kerre (2009) who were successful in their IA programmes for TVET teachers as a means for PD. IA usually refers to the formal placement of persons in the workplace to facilitate the achievement of specific learning outcomes (Choy & Haukka, 2009). IA is a necessary T&D programme for polytechnic teachers to ensure that they are equipped with updated knowledge and skills for curriculum design. Teachers were involved in the design and review of new curriculum and existing curriculum respectively through being members of curriculum development committees (cf. Marsh & Willis, 2003). Inadequate exposure to relevant new trends in the engineering industry was a concern for teachers regarding their knowledge base for the performance of curriculum tasks. Ben-Perez (1990) also found that challenges teachers face with curriculum development is related to subject matter content of curriculum. Teachers' up to date experience and knowledge about developments in industry is of utmost importance for an up-to-date curriculum.

Analysing present knowledge requirements is an essential starting point for T&D, just as it is for strategic planning. It appears in this study that the polytechnic teachers were aware of and understand what their needs are regarding curriculum development. This awareness is a precursor to the actual practice of designing and implementing the curriculum. Findings revealed teachers' desire and willingness to undertake IA. This study showed that teachers find it important to incorporate relevant and up to date information on developments in industry in their teaching. Findings from this study concerning IA were consistent with earlier researchers such as Okaka (2003) whose report on the status and needs of TVET teachers in southern Africa countries such as Botswana, Malawi and Mauritius revealed problems with IA arrangements and therefore recommended its review. Although regular IA is regarded critical for Australian TVET practitioners to keep up-to-date with changes and technologies, there was no consistent approach or formal co-ordination of such activities (Holland & Holland, 1998). Teachers in higher TVET education as in countries mentioned above either developed or developing recognize that they have T&D needs in updating their knowledge on developments in industry. However a structured approach to meet these needs seems lacking. Teachers in higher education are assumed to possess high level knowledge in their subject areas. They are often at the forefronts of designing programmes and courses to expand knowledge and make it more relevant to its consumers. Lessons drawn from this study, stimulates thinking about whether higher education teachers need to regularly assess their T&D needs, especially if they want to make relevant contribution to curriculum reform. We advance knowledge of the effectiveness of self-identified T&D needs of teachers in higher education since it forms the basis for the conduct of systematic and sustained in-service programmes to boost knowledge and skills for curriculum reform.

2.7 IMPLICATIONS FOR PRACTICE

One major channel through which polytechnics can achieve successful curriculum reform is to involve academically competent and professionally skilled teaching staff. Providing opportunities for teachers to pursue postgraduate programmes is a long-term strategy that does not address the current curriculum reform activities. A more feasible measure for teachers is to embark on IA, since up-to-date knowledge about practical components of subject matter is relevant for the polytechnic curriculum. Polytechnic departments could develop and sustain polytechnic-industry partnerships, through memorandum of understanding and workshops to address knowledge gaps between polytechnics and industries. Teamwork is a fertile ground to embed T&D among teachers with a view to enhancing their knowledge for curriculum reform. The use of teamwork to enhance T&D could be in the form of design teams, a PD approach which is collaborative in nature and useful for curriculum reform. According to Handelzalts (2009), a design team is a group of at least two teachers working together on a regular basis, with the goal to re-design and enact (a part of) their curriculum. In a design team, teachers can plan for and undertake IA as well as other useful PD activities which can meet their learning needs for curriculum reform.

CHAPTER 3
Updating polytechnic teachers' knowledge and skills through design teams in Ghana[3]

While teachers and administrators in polytechnics in Ghana have categorically expressed the growing need for the former's knowledge and skills update in the era of polytechnic transformation, little attention has been paid to the subject. In this chapter is a report on a professional development intervention organised for 16 engineering teachers divided among three design teams (DT) who planned and undertook industrial attachments to update their knowledge and skills in their subject areas. With relevant knowledge acquired, they updated their courses and subsequently conducted teaching try-outs. Data collected during the study through interviews, questionnaires and logbook sought teachers' learning experiences in DTs. The results indicated teachers' acquisition of relevant knowledge and skills during the DT activities. Furthermore, DT enabled active learning, collaboration as well as dialogue on subject matter among teachers and was a useful means for the professional development process.

3.1 INTRODUCTION

The era when Technical and Vocational Education and Training (TVET) teachers' knowledge and skills acquisition ended with their apprenticeship during their training, is fast fading due to permanent change in vocational jobs driven by developments in society and the economy (Harteis, 2009). While TVET sectors consider the necessity of workers' lifelong learning, less emphasis is given to the effects of this *change* for teachers in the TVET field. In an ever-changing industrial environment worldwide, the update of knowledge and skills is a necessary professional development strategy for TVET teachers to ensure that they are

[3] A previous version of this chapter was presented at the annual conference of the *American Educational Research Association* (2011, New Orleans, Louisiana). A new version of this chapter has been published as: Bakah, M. A. B., Voogt, J. M., Pieters, J. M., 2011. Updating polytechnic teachers' knowledge and skills through teacher design teams in Ghana. *Professional Development in Education*. doi:10.1080/19415257.2011.576265.

equipped with the necessary skills and capabilities for teaching (Choy & Haukka, 2009). There are 440 TVET providers in Ghana among which 188 are public and 252 are private. The types of TVET providers or institutions are varied upon the trade/subject for learning, qualification level and juridical agencies. Among them are the ten polytechnics in Ghana which provide TVET education at the tertiary level leading to the award of Higher National Diploma (HND) and Bachelor of Technology (B. Tech.) degrees. The aims and objectives of the polytechnics as tertiary institutions are to:

1. Provide tertiary education through full time courses in the field of manufacturing, commerce, science, technology, applied social sciences, applied arts and such other areas as may be determined by authority for the time being responsible for higher education
2. Encourage study in technical subjects at tertiary level, and
3. Provide opportunity for development, research and publication of research findings.

From the aims and objectives outlined above, the central focus of polytechnic education is to provide programmes that are career-oriented and practical in content. Among the key objectives of up-grading the polytechnics to tertiary institutions in 2007 was to improve the quality of teaching, to increase and improve output particularly in technical and vocational level training and to increase access to tertiary level education. In spite of this polytechnic education in Ghana has suffered major setbacks which could be linked to factors such as (1) weak linkages with industry in terms of curriculum development which have further led to a mismatch of supply and demand skills (Owusu-Agyeman & Van den Oosterkamp, 2009). The government has constituted the Council for Technical and Vocational Education and Training (COTVET) to co-ordinate and oversee all aspects of TVET in the country. However the impact of their formation is yet to be felt (Owusu-Agyeman & Van den Oosterkamp, 2009). The MoEYS (2003) reported that in 2002, the proportion of teaching staff and students of technical and vocational institutes on industrial attachment stood at 18%. In recognition of this, a TVET strategy document of the MEAU (2007) has suggested that employers provide opportunities for industrial attachment for trainees and for TVET teachers to regularly update their work experience. The MEAU acknowledges that the quality of TVET is dependent on the competence of the teacher which is partly measured by being abreast with new technologies in the workplace.

The problem researched in this study is related to the complex changes that polytechnics are undergoing in Ghana. Due to changes in government financing structures and the upgrade of polytechnics into tertiary institutions, polytechnics are starting to be managed much more like semi-autonomous

organizations. Managers of polytechnics are being required to look for new ways of ensuring that teachers are effectively facilitated in their learning in order to cope with the changes as well as to innovate. Professional development of teachers has been one major area of concern in polytechnic education in Ghana (Nsiah-Gyabaah, 2005; Gervedink Nijhuis, Bakah, & Akomaning, 2009). The upgrade of polytechnics into tertiary institutions has called for the maintenance of competent teachers (NCTE, 2001). One key area of concern for professional development as expressed by polytechnic teachers and management in Ghana is for the former to update their knowledge and skills in their subject areas through embarking on industrial attachment (Bakah, Voogt, & Pieters, in press). As technology is fast advancing, polytechnic teachers see the need to pursue relevant knowledge to improve on their professional competence and be able to update their courses (Bakah et al. In press). Acquisition of knowledge and skills in TVET does not only concern the learners but also the teachers who ought to develop their competence over time as circumstances change to better guide the learning process (Craig, 2003; Harteis, 2009). Thus, successful professional development arrangements are necessary for polytechnic teachers to enrich their knowledge and skills; improve their practical or professional qualifications and be abreast with permanent change driven by developments in society and the economy.

One major means by which knowledge and skills can be acquired by teachers in TVET education is through industrial attachment. Industrial attachment usually refers to the formal placement of trainees in the workplace to facilitate the achievement of specific learning outcomes that would potentially lead to their employability on completion of a training programme (Choy & Haukka, 2009). Industrial attachments typically involve training providers and industries (through employers) forming partnerships to offer situated learning opportunities in the workplace so that TVET students and teachers have access to authentic experiences that only the workplace can offer (Choy & Haukka, 2009). In the light of the foregoing, industrial attachment is worthy of consideration for TVET teachers. The term 'industrial attachment' for teachers is commonly used in Asian and African TVET systems to describe arrangements allowing them to replenish and update their skills. In other countries, it may be called on-the-job learning for teachers and trainers (e.g. Finland), return or back-to-industry programmes (e.g. Australia) and industry placements or secondments (e.g. United Kingdom).

Industrial attachment is seen as an effective professional development activity for TVET teachers to maintain the currency of their vocational knowledge and expertise, including their knowledge of technologies and practices commonly used in contemporary workplaces (Loveder, 2005). Cort et al. (2004) identified

up-to-date vocational skills and knowledge as one of the competencies needed by TVET practitioners who then incorporate 'what they learn into their own teaching programmes to ensure trainees leave the TVET system with immediately useful skills' (p. 22). Cort et al. contend that practical training periods in companies allow teachers to update their skills and knowledge in the subject areas they teach, while encouraging them to experiment with new teaching methods and materials, "giving them a realistic and holistic impression of the professions, and bringing elements of realism into their teaching" (p. 38–39). This study explores the impact of a professional development arrangement, in which industrial attachment is embedded, on polytechnic teachers' update of their knowledge and skills. This is aimed at equipping polytechnic teachers with contemporary developments in the industrial sector for classroom practice. The professional development arrangement makes use of the concept of design teams, which will be elaborated on in the next section.

3.2 DESIGN TEAMS

3.2.1 Concepts and approaches

According to Handelzalts (2009) a teacher design team is a group of at least two teachers, from the same or related subjects, working together on a regular basis, with the goal to redesign and enact (a part of) their common curriculum. The design team (DT) concept provides teachers with a creative space to reconsider the teaching of their subject, the intellectual stimulus of working together and the challenge to move the thinking forward (Simmie, 2007). DT is one means by which teachers can collectively participate in curriculum design, fulfil their learning, social and intellectual needs and are effective in bringing about teacher professional development (Ball & Cohen, 1996; Deketelaere & Kelchtermans, 1996; Mishra, Koehler, & Zhao, 2007; Parchmann et al., 2006; Penuel, Fishman, Yamaguchi, & Gallagher, 2007; Westbroek et al., submitted) and curriculum innovation (Mishra et al., 2007). Experienced teachers have varying personal and professional needs to develop their creativity, to share their experience, to leave the isolation of their classroom (Simmie, 2007) and according to Jarvis et al. (2003), to continue the intellectual challenge of the subject that may have attracted them to teaching in the first instance. Groups of teachers meeting to share and work together provide an opportunity to extend their professional boundaries (Carlgren, 1999). Professional activity embeds individuals' learning in the social context of the workplace and gives access to a community of practice (Wenger, 2003) and further offer individuals the opportunity of expanding a repertoire of experiences (Billett, 2006).

The more teachers are dependent on each other through collaboration, the more potential the interaction has for learning (Handelzalts, 2009). Evidence from a wide range of studies of schools suggests that those schools that make extensive use of teacher collaboration are particularly successful in promoting teacher learning (Erickson, Brandes, Mitchell, & Mitchell, 2005; McCotter, 2001; Putnam & Borko, 2000). Collaboration in networks can create opportunities for reflection on learning processes and new teaching experiences (Borko, 2004; Clement & Vanderberghe, 2000; Handelzalts, 2009; Lumpe, 2007). Collaborative learning adheres to a holistic perspective on teacher professional development (Bell & Gilbert, 1996). Teachers' being in a team that collaboratively articulates and recognizes a problem in daily educational practice enhances their motivation to redesign that daily practice. Teachers who get help from colleagues who are more expert than they are may also gain important new information from those interactions that extends what they learn from formal professional development experiences (Ball & Cohen, 1996). Having multiple participants in professional development from a single school helps to build trust and support relationships (Penuel, Riel, Krause, & Frank, 2009). Furthermore, teachers often report that participating as a group in professional development can give focus to collegial interactions and motivate working through problems of practice together (Little, 1993).

Exemplars of the DT concept and approach can be found in the research of Nieveen, Handelzalts, Akker van den and Homminga (2005) where they used DTs as part of the PIVOT programme: a school-based curriculum innovation to integrate curriculum development with teacher development. The project sought to identify ways to generate more ownership and commitment and to create mechanisms for schools and teachers to come to the forefront of curriculum improvement. Parchmann et al. (2006) studied teams of science education researchers and teachers who jointly designed curriculum to support teachers in changing their teaching towards a more context-based and student-oriented teaching. Millar, Leach, Osborne and Ratcliffe (2006) worked with DTs composed of both teachers and researchers (in a school - university partnership) to develop research-based classroom materials for the teaching of physics and biology. These classroom materials were then transferred to other classrooms with good transferability rates and increased student motivation recorded. Simmie (2007) conducted a study where biology associates worked with one hundred biology teachers in DTs and together they produced eighteen innovative classroom resources, which have now been made available for the teaching of biology in Ireland. His study considered the merits of the DT approach as a means to contribute to curriculum implementation and continuing professional development. This study sets forth to maximise the worthwhile opportunities that

DT offers for the update of polytechnic teachers' knowledge and skills as it addresses the question: *What is the impact of design teams, as a professional development arrangement, on teachers' knowledge and skills?* In this study we operationally define polytechnic teachers' knowledge and skills as subject matter based technical knowledge and skills, curriculum design knowledge and skills and collaboration skills.

The following sub-research questions informed the study:

1. What knowledge and skills do teachers acquire by participating in a design team?
2. What is the effect of teachers' learning in a design team on their classroom practices?
3. What are teachers' perceptions of design teams as a professional development arrangement?

3.3 PROFESSIONAL DEVELOPMENT ARRANGEMENT

The twelve-week programme composed of six main activities and was conducted through three DTs, namely Automobile (ADT), Production (PDT) and Electrical (EDT. The activities included an introductory workshop, meetings, industrial visits, course update, teaching try-outs and a dissemination workshop. The introductory workshop, which was held in the first week, oriented teachers on the concept of DTs. Plenary sessions were held on the issue of industrial attachment for teachers and its potential for teacher learning and course update. The workshop opened up the opportunity to secure teachers' acceptance of the need to update their knowledge and skills. The first author as researcher was the main facilitator at the workshop which comprised presentations and discussions.

Meetings of three DTs commenced in the second week and continued through the third week for teachers to engage in identifying parts of the courses to be updated and a plan of action for the update of knowledge and skills in those areas identified. Each DT chose two on-going HND core courses (for year one and two). Teachers collectively examined the contents of the course syllabus and identified topics for update and improvement in terms of classroom practices. Accompanying the decision on the areas for update was the consideration of the feasibility of fulfilling acquisition of the needed information within a day's visit to industry. The courses chosen and areas updated by each DT are in Table 3.1. DTs worked out an action plan to visit industry for more information to support the update of the courses. They then decided on

industries to visit and embarked on industrial attachment during the fourth, fifth and sixth weeks. Each DT industrial visit, which lasted a day, took teachers more than 200 kilometres away from their polytechnic. The Automobile DT visited Japan Motors Company Limited and Toyota Ghana Company Limited at Accra while the Production DT visited Gratis Foundation in Tema and Kpeve Water Pumping Station at Kpeve. Electricity Company of Ghana in Tema was the industrial location visited by the Electrical DT.

Table 3.1 *Overview of courses chosen and areas updated by DTs*

Design team	**Courses**	**Class**	**Areas updated**
PDT	*Workshop Processes and Practice 2*	HND 1	to select a suitable material for making mould intended for sand casting, to produce a mould for a given simple engineering component, to produce a casting from the mould
	Installation and Maintenance (Pumps)	HND 2	procedure for the installation of pumps, process schedules for pumps, maintenance of pumps, trouble shooting and repairs of faults on pumps
ADT	*Workshop Process and Practice 2*	HND 1	the identification and use of instruments to implement quality control checks on modern vehicles
	Vehicle Engineering Science and Laboratory Work 1	HND 2	the use of high speed engine test indicators and hydraulic dynamometers for various engine tests such as: indicated power, break power, mean effective pressure, specific fuel consumption, heat balance test and thermal efficiency
EDT	*Electrical Machines 1*	HND 1	designing and rewinding single phase transformers
	Electrical Machines 3	HND 2	designing and rewinding single phase induction motors

Note: HND, higher national diploma, below bachelor level.

After the industrial visit, from the sixth to eighth week, series of meetings were held by the DTs to review industrial attachment and teachers' industry reports. Based on the knowledge and information acquired, courses were updated. During the ninth and tenth weeks, teachers conducted teaching try-outs of the parts of the updated courses which they collaboratively designed in their DTs, which were subsequently evaluated by the students who took the course. All the DT members witnessed the teaching try-out in their respective areas and subsequently evaluated it during the eleventh week. Participating teachers disseminated the activities of the DTs in a seminar in the twelfth week which was open to all teachers in the polytechnic and members of the polytechnic administration. The aim of the seminar was to propagate, reflect on and share experiences of the work of the DTs and to progress the professional dialogue with

regard to the future of DTs in the polytechnic. In all, six meetings were held per each DT. The first author as researcher acted mainly as a facilitator and participant observer at all the phases of the intervention.

3.4 METHODS

3.4.1 Design of the study

This study was designed to explore the potential of DTs for teachers' knowledge and skills update as the teachers embark on industrial attachment and subsequently update their courses by collaboratively redesigning curricular materials and teaching methods. This research employed mixed methods in data collection in a case study. A multicase study embedded design (Yin, 1993) was applied with three cases, the DTs and teachers and students as units of analysis. The study investigated teachers' experiences regarding their participation in DT, teachers' perception of what they have learned from DT, as well as changes in classroom practice that have occurred as a result of participation in DT: industrial attachments, course update and teaching try-outs. Students' experiences with teaching try-outs were also explored.

3.4.2 Participants

Teachers

Overall, 16 teachers (all males) from the faculty of engineering at Ho Polytechnic took part in the study based on their availability as fulltime teachers and upon recommendation by their heads of department. The teachers were grouped into the Automobile (ADT), Production (PDT) and Electrical (EDT) design teams. Background characteristics of the teachers are provided in Table 3.2. Ho Polytechnic is one of four polytechnics in Ghana where a needs analysis study was conducted to find out the professional development needs of teachers (Bakah *et al.*, in press). Ho Polytechnic was purposefully selected among the four polytechnics since it is situated in a low industrialised region of Ghana and is geographically isolated from industrialised locations.

Table 3.2 *Background characteristics of teachers*

Design team	Teacher (pseudonyms)	Age	Highest academic qualification	Years of teaching at polytechnic	Number of HND students
ADT (n=5)	*Kelvin*	53	Master's	16	Automobile Engineering *Year 1: 55* *Year 2: 65*
	Martin	52	Master's	27	
	Felix	42	Master's	7	
	Norbert	64	HND	11	
	Justice	29	HND	4	
PDT (n=6)	*William*	51	Master's	20	Production Engineering *Year 1: 57* *Year 2: 31*
	Patrick	45	Master's	15	
	Alfonse	29	Bachelor's	2	
	Henry	25	HND	2	
	John	55	HND	27	
	Donald	33	HND	6	
EDT (n=5)	*Larry*	50	Master's	13	Electrical Engineering *Year 1: 142* *Year 2: 128*
	Oliver	46	Bachelor's	16	
	Bill	33	Bachelor's	6	
	Roland	28	HND	2	
	Victor	30	HND	2	

Note: HND, higher national diploma, below bachelor level.

Students

A total of 478 HND Engineering students (average age 24 years) were involved in the study of which 212 experienced the post-industry teaching try-outs conducted by the teachers and subsequently evaluated the subject taught. The remaining 266 evaluated the same subject as it was taught prior to the commencement of DT activities.

3.4.3 Instruments

Teachers' interviews

There were six categories of semi-structured interview data collected from each teacher to find out their experiences during the following design team activities: workshops, industry visits, course update, teaching try-outs, perceptions of DTs and teacher learning in DTs. On average, each interview lasted 30 minutes and was audio taped.

Teachers' questionnaire

Teachers also responded to close-ended 5 point Likert-scale questionnaire items, with 1 is strongly disagree to 5 is strongly agree. Related to teachers' perception of industries visited, two constructs were distinguished; *acquisition of knowledge*

and skills (6 items) (α=0.72) and *usefulness of knowledge and skills (8 items)* (α=0.71). Teachers also provided responses on their *perception (12 items)* (α=0.70, α=0.84) of DTs before and after the professional development programme. According to Morgan, Leech, Gloeckner and Barrett (2004), the alpha values reported here (above 0.70) are reasonable for internal consistency.

Students' questionnaire
Questionnaires were administered to students after the teaching try-out of updated courses. The questionnaires consisted of 19 items on students' perceptions and experiences with the courses taught. Possible answers to all items were on a five point Likert-scale (1=strongly disagree to 5=strongly agree). The questionnaire was administered immediately after the teaching try-outs. After running factor analysis using SPSS, two constructs obtained were *presentation* (α=0.89) and *clarity* (α=0.83) for student responses. *Presentation* in this study refers to the practice of showing and explaining content of the topic to the students and *clarity* denotes the practice of making content of the topic clear for students' comprehension of the concepts.

Researcher's logbook
A logbook was kept by the first author in order to document the process of teachers working in the DTs.

3.4.4 Data analysis

Teachers' Questionnaires
Teachers' questionnaire responses were analyzed using SPSS to compute the means and standard deviations. Analysis of comparison of teachers' perceptions of DTs before and after the professional development programme employed the Wilcoxon non-parametric test (Corder & Foreman, 2009) on assumption that the population cannot be assumed to be normally distributed. Effect size was calculated using Cohen's *d* (Cohen, 1988). Cohen (1988) provided tentative benchmarks for the interpretation of effect sizes being *d*=0.2 a small, *d*=0.5 a medium and *d*=0.8 a large effect size.

Students' questionnaires
Means and standard deviations were calculated for students' responses and an independent sample T-test was computed to find out whether significant differences existed regarding the experiences of participants and non-participants in the teaching try-out in terms of the sub-scales *presentation* and *clarity*. Cohen's *d* (Cohen, 1988) was calculated to find out the extent of the differences. A one-way ANOVA test was conducted to evaluate the extent to

which differences exist between the participants (Automobile, Production and Electrical HND students) perceptions of the lesson they had in terms of *presentation* and *clarity*.

Teachers' interviews and logbook
All interviews were transcribed and coded using codes generated from the study. The coding schemes (Bogdan & Biklen, 1992; Miles & Huberman, 1994) were labelled: *industrial attachment evaluation, course update evaluation, teaching try-out appraisal, perceptions of DTs and teacher learning in DTs.* Atlas-ti software version 5.5 was used for the coding of all the interview data. Intercoder reliability (Lombard, Snyder-Duch, & Bracken, 2002; Neuendorf, 2002; Tinsley & Weiss, 2000) was calculated using a random sample of 8 interviews from 16 teachers. There were two coders including the first author of this article. The intercoder reliability using Cohen's kappa (*k*) was 0.93. Information recorded in the logbook was analysed qualitatively using data reduction technique. Major themes were identified and clustered (Miles & Huberman, 1994).

3.5 RESULTS

3.5.1 Teachers' knowledge and skills acquisition in design teams

At industries- subject matter based technical knowledge and skills
Teachers' (*n*=16) evaluation of the industrial attachment revealed that all the teams found the visit relevant. The overall means for acquisition of knowledge and skills (M=4.48, SD=.32) and usefulness of knowledge and skills acquired (M=4.60, SD=.35) were very high. Teachers' interviews further revealed how they found the industrial attachment very relevant in terms of knowledge and skills acquired and how useful it was for their professional development and classroom practices. Across all the DTs, every member was emphatic about how significant it was for them to visit industry as Donald (PDT) said;

> *"... I thought I knew so many things on pumps until I got to Kpeve Pumping Station ..."*

The PDT indicated their exposure to innovative processes of production and this was confirmed by William (PDT) that;

> *"...we were exposed to new processes of casting and varieties of sand ... it was a very good exercise we went through."*

The EDT were pleased with their skill acquisition as Roland (EDT) informed that;

> "*I acquired new skills in rewinding single phase induction motors and detecting faults...*"

The ADT were content with information acquired;

> "*We were introduced to new models of vehicles and how to conduct quality control checks on them ...; this is rich information for me and my course.*"(Kelvin, ADT)

In spite of the wide range of positive responses re-echoing the success of the industrial attachment, all except two teachers from the EDT and ADT as well as three teachers from PDT stated that too limited time was spent at the industry. Nonetheless, all of them admitted that the targets for the visits were achieved except for extra industrial operations that were of interest to them. Teachers showed keen interest in the industrial visit, took down notes and asked resource persons many questions. Furthermore, they were eager to try their hands on equipment whenever they were given the opportunity to.

During collaborative design- curriculum design knowledge and skills

During the course update, each DT unanimously chose two on-going HND core courses (see Table 3.1) and collectively re-examined the contents for areas to update. They worked out an action plan to visit industry, for additional information on contemporary industrial operations regarding the areas targeted for update, which they successfully accomplished. After regularly meetings for discussions and decision-making, the courses were finally updated in terms of content and pedagogy. In all teachers expressed the view that their course update was a meaningful exercise. To them DT allowed for a participatory approach in updating courses and gave grounds for extensive work in a short period. Teachers admitted acquiring some skills which were critical to curriculum design in the form of content selection and analysis. Teachers also acquired the skill of analysing goals and identifying objectives for the courses they selected. However the process was not exactly the same for all the DTs due to some internal team arrangements to enrich their decisions. The ADT invited the polytechnic Industrial Liaison Officer (liaises with industries on students' industrial attachment placements and feedback) of the polytechnic to be present to give advice on which industries could best be visited based on the areas to be updated. ADT found his contributions to the choice of industrial location useful. At some of the design sessions of the PDT the Chairman of the Faculty of Engineering Board (a board that among other things oversee and approve faculty curriculum design issues) who is a production engineering expert was

invited for his contributions on the identified need areas in the courses. The PDT found him a great resource in their deliberations. Unlike the ADT and PDT, the EDT did not involve any specialist in their course update meetings but rather through two meeting (one for HND year one and another for HND year two) students' views were solicited on the need areas identified for further information to augment ideas for the course update.

The Majority of the teachers observed that the course update resulted in the interchange between different ideas of people making it a mutually productive and beneficial process;

> "*... it helped in the integration and cross-fertilisation of ideas.*" (Felix, ADT)

Most of the teachers in each team admitted how the exercise made them more aware of the delicate balance between what they think they know and what ought to be taught. Every single teacher felt the sense of ownership for the updated courses as for instance Justice (ADT) indicated that;

> "*...in fact this is a decentralised way of handling curriculum design especially as long as skill development and practicals are concerned. This is what we need and we want to do. This is in a way encouraging grass root design of curriculum which is very supportive*".

It was observed that teachers exhibited clear understanding of the process of updating their courses and employed their subject matter and pedagogical knowhow in the discussion process. Oliver (EDT) simply said that;

> "*I am proud of the teamwork to build a relevant syllabus step by step.*"

Despite the show of common interest, it was observed that one teacher in PDT and two in ADT did not open up initially in team discussions about the courses but upon examining other colleagues' frankness, they begun to contribute and be actively involved in the group activity. Across all the DTs, it was obvious that arriving at a consensus in the selection of two core courses for update was difficult due to varying individual priorities but this challenge was surmounted by unanimous decisions at the end. Justice (ADT) confirmed this saying;

> "*... as in every consensus process, we emerged with different opinions, priorities and interest levels...but we reached a decision afterwards.*"

Teacher collaboration- collaborative skills

Teachers pointed out that their involvement in DT has had considerable impact on their learning. They pointed out that it gave them the opportunity to share knowledge and ideas with colleagues. Donald (PDT) informed that;

> "*... in DT I conferred with colleagues, discussed issues openly and learnt.*"

Most teachers indicated that in DTs they had the opportunity to reflect deeply on their courses in order to improve them. John (PDT) said:

> "*... we have a saying that two heads are better than one... working in a team has improved my knowledge and what to teach.*"

They learned from colleagues who were experienced, learned to work harmoniously in teams and acquired team working skills. As a result of working in the DT, teachers learned to tolerate diverse ideas from colleagues, cope with temperament, compromise and come to consensus on issues. They maintained that DT created and sustained dialogue in the academic corridor. According to Oliver (EDT);

> "*... working as a team, gave me the opportunity to share ideas, come out boldly... and was motivated to learn.*"

It was worthwhile to note the teachers found it interesting to learn together at the industry despite their varied qualifications, age and experiences. Kelvin (ADT) mentioned that;

> "*...no one is paragon of knowledge. It was a nice opportunity to improve my knowledge among colleagues in DT.*"

To them, taking time off duty to travel several kilometres from their polytechnic into an industrial environment was invigorating, refreshing and exciting. They admitted that being in DT sustained in them the zeal to achieve team targets as they planned for and visited industry and got exposed to new equipment and technologies. Teachers learned by designing as Alphonse (PDT) states;

> "*I had new ideas from colleagues as we examined the syllabuses.*"

Bill (EDT) submits that;

> "*Preventing a static syllabus by delving into it and incorporating current changes from industry gave a boost to our knowledge and the teaching process.*"

Martin (ADT) acknowledged that;

> *"Once I want the students to learn certain things; I must have broad knowledge in that direction. We had this chance to assess ourselves alongside the curriculum."*

3.5.2 Effect on teachers' classroom practices

Teaching try-outs

Teaching try-outs by the EDT involved rewinding single phase transformers and single phase induction motors. They indicated that their department acquired the transformers and induction motors some months earlier but teachers did not have any training on their usage until their visit to industry. In effect, EDT teachers were of the opinion that students experienced real practical work on the transformer and saw for themselves how the windings are done. To them, new ideas from industry benefited the course except for unexpected power failure during teaching which happened twice lasting eight minutes and six minutes respectively. Another challenge encountered by the EDT was the large class-size. During the teaching try-out by the PDT, teachers made use of video recordings of the procedure for the installation and maintenance of pumps (recorded at industry) in addition to PowerPoint slides to teach the topic. Teachers informed that at first the topic was taught without students having any pictorial conception since such heavy duty machines cannot be procured by the polytechnic, however, the video helped in communicating a lot of information on varieties of pumps to the students thus expanding their knowledge. According to them, students found the class really interesting since they had a clear pictorial view of the installation, maintenance and operation of pumps in PowerPoint slides and videos. Students' responses to questions and contributions were very encouraging and showed their articulation. The identification and use of instruments to implement quality control checks on modern vehicles formed the core of ADT teaching try-outs. The ADT teachers also stated that teaching what was existent in industry was interesting since students watched a detailed video recording on the conduct of quality control checks on modern vehicles instead of the usual outmoded automobile engines in the workshops. They indicated that students showed very keen interest in the lesson.

Students' experiences

There were questionnaire responses of students who were participants (n=212) in the teaching try-out and students who were non-participants (n=266). The overall means of aspects of the lesson reported by all the Automobile, Production and Electrical students who participated in the lessons were higher; *Presentation* (M=3.88, SD=.66) and *Clarity* (M=3.37, SD=.63) than students who did not

participate; *Presentation* (M=3.35, SD=.87) and *Clarity* (M=2.75, SD=.79). There was a significant difference (*p*=.0001) in terms of both subscales *presentation* and *clarity* between participants and non-participants with a large effect size of .70 and .86 respectively.

A one-way ANOVA test was conducted to evaluate the extent to which differences exist between the participant perceptions for the course they took. It was revealed that no significant difference (*F*=2.41, *p*=.092) was found across lessons for Automobile, Production and Electrical student groups in terms of the subscale *presentation*. Concerning the subscale *clarity*, a significant difference (*F*=6.91, *p*=.001) existed across lessons. Using the Tukey HSD procedure, multiple comparisons between the three programmes were made to evaluate the pairwise differences among the means for the subscale *clarity*. With respect to the lesson for Production and Automobile students, pairwise significant differences (*p*<0.05) did not exist in terms of *clarity* (difference in means=.08, *p*=.777). However, pairwise significant differences existed among Production and Electrical students' lessons (difference in means=.35, *p*=.002) and Automobile and Electrical students' lessons (difference in means=.27, *p*=.025) regarding *clarity*. The relatively low means in terms of *clarity* for Electrical students may be attributed to challenges during the teaching try-out explained by the teachers as very large class size for a relatively small laboratory and the persistent power failure during the lesson where the transformer (which depends on electricity for operation) was being used.

3.5.3 Teachers' perceptions of design team as a professional development arrangement

Survey data from teachers (*n*=16) showed their perceptions of DTs before and after engaging in its activities. Overall results indicated that a significant difference (*p*=.0001) existed between teachers' perceptions before (M=2.50, SD=.37) and after (M=4.22, SD=.37) the professional development activities. Extremely large effect sizes ranging from 1.20 to 3.90 were recorded for all the items.

Teachers articulated their experiences with working in a DT and were unanimous that some specific elements of DTs had considerable impact on them. They discovered that working in DTs was interesting. Specifically teachers liked collaborations, discussions and teamwork in DTs. According to most of them, teamwork allowed for variety of views to enrich decisions. Teachers agreed that being in a DT boosted their confidence in the courses they teach as they managed to update them with relevant information from industry. They admitted that it was difficult for an individual to gain attention at the industry, thus with DT,

industries opened up and invested time. They were also of the view that workload and bureaucracy uninspired individual moves to visit industry however;

> "*... in DTs we have collectively planned and visited industry... to me, it is a great awakening.*" Roland (EDT)

It was interesting to know that being in a team, colleagues benefited from responses to each other's questions by industry resource persons. Teachers discovered that collaboration and DT were indistinguishable; enabling crossbreeding of ideas, interacting, sharing information and brainstorming on issues. Norbert (ADT) stated that;

> "*...actually DTs brought us together, it has taken us a step higher in our career and enhanced unity of purpose.*"

Larry (EDT) said;

> "*... DT fostered good relationships among staff.*"

With the actual designing of the courses, teachers found it practical and of use in DTs as Justice (ADT) said;

> "*As we probed the syllabus in DTs, it shaped my paradigm on the practical training of my students; it was interesting to hear colleagues' contributions on it.*"

William (PDT) was of the view that;

> "*In the design process was the painstaking effort by numerous brains to improve our system of teaching. So DT is useful.*"

Victor (EDT) indicated that;

> "*Pooling ideas for a holistic course was rewarding, some teaching challenges were highlighted and we factored in students' concerns about the course.*"

Challenges of working in design team

In spite of the numerous positive remarks from the teachers on their DT experiences, they encountered certain challenges, some of which are generally inherent in teamwork while some concern DTs in this study. EDT had the most challenges since the only five teachers at post all joined the DT. In Table 3.3, we find DT challenges in this study.

Table 3.3 *Challenges of working in design team*

Challenge	DT	Solution
▪ Deciding on time for DT meetings	*All*	Met before or after teaching periods
▪ Workload	*EDT*	Adjustment of schedules
▪ Consensus building *(only initial)*	*All*	Harmony and compromises overtime
▪ Dominance by older or more experienced teacher *(only initial)*	*PDT*	Prompted by colleagues amicably
▪ Department standstill for DT meetings	*EDT*	Met before or after teaching periods
▪ Some teachers' having their teaching period(s) coinciding with times for DT industry trips	*All*	Teachers concerned gave group assignment to their students within the period when the former were visiting industry

Suggestions

At the seminar to disseminate the DT activities, teachers made various suggestions. They suggested that DT activities should be maintained in their departments and initiated in other departments in the polytechnic that were not involved in this study. On the whole, they want it integrated into the polytechnic structure to enable teacher learning and collaboration. An idea which was widespread among teachers was the need to involve industry representatives in the course update process for their contributions. Another common suggestion was that teachers' industrial visit should be undertaken during vacation periods to avoid the obvious absence of a whole group of teachers from a department when school is in session. Teachers recommended that their industrial visits should be done on a yearly basis to keep up the momentum of their knowledge and skill update.

3.6 DISCUSSION AND CONCLUSION

Exploring the impact of design teams, as a professional development arrangement, on polytechnic teachers' knowledge and skills has been the focus of this study. The DT concept, in this initiative, aimed to provide a secure space where teachers' creativity could flourish and where dialogue on teacher learning and curriculum design could be reconsidered and reflected upon. The teachers' enumeration of their experiences with working in DTs has informed this research. Notable was the commitment and enthusiasm teachers showed during DT activities and tasks. They benefited from collaboration in DTs as it stimulated their learning and confirms the findings of Billett (2006) and Wenger (2003) that individual learning in the social context gives them the opportunity to expand their repertoire of experience. Teacher learning and professional development

was impressive during collaborative curriculum design as similarly was the case in the studies of Ball & Cohen (1996), Deketelaere & Kelchtermans (1996), Mishra et al. (2007) and Penuel, at al. (2007). Teachers were able to enrich their courses which impacted positively on their knowledge of subject matter and teaching which is akin to the findings of Nieveen et al. (2005) who used DTs as part of school-based curriculum innovation which brought teachers to the forefront of curriculum improvement and generated teacher ownership, commitment and professional development. Embarking on industrial attachment as planned and executed in DT culminated in teachers updating their knowledge and skills by getting abreast with some technological advancement in industry as likewise identified by Cort et al., (2004) that up-to-date vocational skills and knowledge is one of the competencies needed by TVET teachers.

The results of this case study were limited to data gathered and analysed from one polytechnic. The relatively small sample size needs to be taken into consideration and limit the simple generalization of the results. More research, within polytechnics and other TVET institutions is needed to validate these findings. In addition, this study described how teachers learned through their experiences with DT to enhance their knowledge and skills; it did not intend to determine the degree of its effect on students' achievement. For a TVET institution in a developing country, it appears that the number of master's degree holders as in this study is quite high; the reason being that degree programmes (B. Tech.) are now being offered in the polytechnics. Thus a post graduate degree is the minimum academic qualification for teaching undergraduate programmes. Furthermore, teachers with post-graduate qualifications are promoted to the professional rank of lecturer and are better remunerated than those without post-graduate qualifications. These two reasons outlined could be contributing factors to motivate the polytechnic teachers to acquire postgraduate degrees.

Collaboration among teachers in DTs was enhanced and opened up the opportunity for dialogue on their subject matter, discussions on what should be taught, brainstorming on relevant information from industry and brought teachers with varied experiences and ages to a level of thinking and cohesion. Collaboration thus enabled teacher interdependency and interaction. Likewise in the study of Handelzalts (2009), it was found out that the more teachers depended on each other through collaboration, the more potential the interaction had for teacher learning. Similar to the findings of this study are evidences from a wide range of research (Borko, 2004; Clement & Vanderberghe, 2000; Erickson et al., 2005; Handelzalts, 2009; Lumpe, 2007; McCotter, 2001; Putnam & Borko, 2000) suggesting that professional development interventions that make extensive use of

teacher collaboration are particularly successful in supporting teacher learning. The cohesion found among team members in this study confirms the findings of Penuel et al. (2009) that multiple participants in professional development from a single school helps to build trust and support relationships. Teacher learning impacted positively in their classroom practices as a result of redressing particular challenges in their courses. This was evident in the teaching try-out where students appreciated the knowledge they acquired, a finding similar to that of Millar et al. (2006) whose studies with DTs to develop research-based classroom materials resulted in increased students' motivation. While the sense of ownership in a relevant course swelled up confidence in individual teachers, their working in a DT throughout the intervention noticeably appeared to be a worthwhile approach to teamwork for them to update their knowledge and skills and update their courses as found in the studies of Millar et al. (2006), Nieveen et al. (2005) and Simmie (2007). Despite the few initial challenges that teachers encountered in DTs such as consensus building and combining DT activities with already heavy teaching workloads, their teamwork to advance ideas had enormous returns making it a promising strategy for their knowledge update.

In conclusion, findings suggest that DT is a useful venture for the update of teachers' knowledge and skills in polytechnics. Findings from this study provided evidence that DT approach in professional development can foster teacher learning and collaboration. The study provided new lenses for professional development activities which employ teamwork for teacher learning and change. The findings on the DT approach to change teacher practices and beliefs with regard to improving their knowledge and skills have important implications for teacher professional development. It becomes evident that in professional development, it is worthwhile to engage teachers in teamwork to rigorously plan and implement their own learning. In the light of this, it can be concluded that teachers' knowledge and skills update through industrial attachment is a sine qua non for professional competence in the TVET sector and can be said to be better approached through teamwork as in DTs.

From the findings reported in this chapter, it is recommended that for DTs to be more robust to carry out their activities, teachers must see themselves and each other as learners in the team, this may to a large extent encourage tolerance and mutual understanding and reduce dominance. Also, in order not to evade the goal of learning by design, it is necessary for teachers to understand the principles of developing themselves and their courses. Furthermore, meeting regularly and varying DT activities is likely to prevent boredom, eschew passive behaviours and encourage participation.

CHAPTER 4
Determining teacher development and curricular quality through collaborative curriculum design[4]

In this chapter, collaborative curriculum design is addressed as an effective method for the continuing professional development of teachers in a polytechnic in Ghana during curriculum reform. Three design teams have been working to update engineering syllabuses to commensurate contemporary industrial skill demands as well as update their own knowledge in their subject areas for fourteen weeks. They embarked on industrial visits, incorporated relevant information in their courses and conducted teaching try-outs. Mixed methods were employed for data collection during design activities. Results indicated that teachers updated their domain knowledge and skills, design teams improved teacher collaboration while teacher ownership of and commitment to quality curriculum increased. Furthermore, teaching try-outs of updated courses were a success from both teachers and students perspectives. It was concluded that the relational nature of the interdependencies between the social and individual contributions to curriculum design illuminates the fabric of teachers' continuing professional development.

4.1 INTRODUCTION

Curriculum renewal is a complex undertaking which requires the quality of two related processes: curriculum development and teacher professional development (PD) for it to be successful (Fullan, 2007). Recent insights in curriculum reform point to the need to increase the active involvement of teachers to promote ownership, commitment and successful implementation (Borko, 2004). The curriculum reform situation in Ghana's polytechnics, which have transformed over the past 20 or more years has called, as from these recent insights, for the involvement of teachers in curriculum design; updating

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Higher National Diploma (HND) programmes and designing Bachelor of Technology (B. Tech.) programmes. Having been upgraded to higher education institutions, polytechnics in Ghana provide higher technical and vocational education and training leading to the award of HND and B. Tech. in business and management, applied arts and sciences and engineering. The problem researched in this study is related to polytechnic teachers' PD as they embark on rigorous curriculum design due to the polytechnics' upgrading (Gervedink Nijhuis, Bakah, & Akomaning 2009; Nsiah-Gyabaah, 2005). The upgrade of polytechnics into tertiary institutions has called for a curriculum reform and the maintenance of competent teachers (Owusu-Agyeman & Osterkamp van den 2009). One key area of concern for PD as expressed by polytechnic teachers and management in Ghana is for the former to update their knowledge and skills in their subject areas through embarking on industrial attachment (Bakah, Voogt, & Pieters, in press) to effectively contribute to curriculum design. Furthermore, as technology is fast advancing, polytechnic teachers see the need to continuously pursue relevant knowledge to improve on their professional competence and be able to update their courses (Bakah et al., in press). As wide-reaching change takes place in society new kinds of work are emerging and new kinds of vocational curricula are needed to prepare citizens for employment in these contexts. When teachers are co-designers of new curricula, the curriculum development and teacher PD processes become intertwined: curriculum development activities can lead to increased professional development. On the contrary, increasing professional expertise can lead to further improving curriculum development as was revealed in a study by Bakah, Voogt and Pieters (2011) that showed that collaborative curriculum design (CCD) through design teams (DT) enabled active learning, collaboration as well as dialogue on subject matter among teachers, and was a useful means for the PD process. In this study we explore the impact of CCD in DTs on curriculum quality and teachers' continuing professional development (CPD) in the polytechnics. Studies have revealed the benefits of CCD in DTs (Nieveen, Handelzalts, Akker van den, & Homminga, 2005; Millar, Leach, Osborne, & Ratcliffe, 2006; Simmie, 2007).

4.2 THEORETICAL UNDERPINNINGS

4.2.1 Collaborative curriculum design

CCD is gradually gaining ground in education as a promising way to create teacher ownership by involving them in curriculum innovation (Borko, 2004; Desimone, 2002; Villegas-Reimers, 2003). CCD processes have the potential to contribute to the PD of the teachers involved as well (Borko, 2004). By

collaboratively designing, subject matter interactions occur which can be used as learning opportunities and the combination of doing and reflecting can enhance PD (Penuel, Fishman, Yamaguchi, & Gallagher, 2007).Though CCD could bring along certain difficulties it certainly offers rich opportunities to benefit from the "complementing competence" of the different collaborating professionals (Jarvis, Holford, & Griffin 2003). In the past few years much has been written on teacher collaboration in schools. According to Supovits (2002) much of the attention and widespread use of research on teams in order to improve practice and instruction comes from the organizational theories on group practice and communities in the workplace. Collaboration in teams or communities is presented as an effective response to increasing change and a knowledge based workforce (Handelzalts, 2009). By collaborating, professionals pool their knowledge and can together create new knowledge.

4.2.2 Communities of practice

In the educational research literature communities are seen mainly as settings for on-going teacher learning (Grossman, Wineburg, & Woolworth, 2001; Hord, 2004). Communities of practice are best understood in terms of a wider social learning theory that centres on shared attempts to build meaning and which describes a community of practice as an activity system about which participants share understandings concerning what they are doing and what that means in their lives and for the community. DuFour (2005) identified the following three ideas that characterize the basis of all professional learning communities: ensuring that students learn, building a culture of collaboration, and focusing on results. Communities of practice may be established with a particular developmental purpose in mind, such as networks for improvement of professional practice. These may be explicit and framed approaches to CPD or alternatively may be informal and implicit networks which frame the day to day experience of colleagues working in the same educational domain.

Cordingley (2003) explores the knowledge creation/knowledge use interface in discussing the Networked Learning Communities Programme in England and indicates the importance of the self-conscious development of a professional learning community for teachers to gain increasing control of their own learning. Bolam, McMahon, Stoll, Thomas, Wallace, Greenwood, Hawkey, Ingram, Atkinson and Smith (2005) describe creating and sustaining effective professional learning communities. Effective professional learning communities exhibit eight key characteristics. These are shared values and vision; collective responsibility for pupils' learning; collaboration focused on learning; individual and collective professional learning; reflective professional inquiry; openness, networks and

partnerships; inclusive membership; mutual trust, respect and support. These are, indeed, likely to be desirable characteristics in the climate in which DTs operate. In effect, Wenger et al., (2002) state that communities of practice are a set of socially defined ways of doing things in a specific domain: a set of common approaches and shared standards that create a basis for action, communication, problem solving, performance and accountability. Thus the effect of social learning perspective on teachers' CPD is a powerful new element that provides a useful corrective to overly individualistic approaches to teacher development (McArdle & Coutts, 2010). Well-structured and implemented CPD is likely to improve teacher motivation and morale; can have a positive impact on teachers' attitudes, knowledge and skills; can lead to successful changes in teachers' practice, to school improvement; can improve pupils' learning and achievement. A systematic review of literature on sustained, collaborative CPD and its effect on teaching and learning (Cordingley, Bell, Rundell, & Evans, 2003) concluded that CCD could have a positive impact on teachers and pupils. The reported changes in teacher behaviour included: greater confidence; enhanced beliefs among teachers of their power to make a difference to pupils' learning; development of enthusiasm for collaborative working, despite initial anxiety about classroom observation; and greater commitment to changing practice and willingness to try new things (Stoll, McMahon, & Thomas, 2006). Andrews and Lewis (2007) found that where teachers work collaboratively, it not only enhanced their knowledge base, but also had a significant impact on their classroom work. Teachers' teams usually described in literature (i.e. professional learning communities, communities of practice) mostly focus on improving the teaching process through the professional development of the teachers. In the case of DTs the goals of professional development or building of cohesion in the staff are seen as secondary to the main design goal (see Handlezalts, 2009). Teacher collaboration and development in the work of DTs are seen as contributing factors to realizing a better curricular product. The defining characteristic of a DT in this respect, emphasizes the fact that, aside working on related subjects, teachers need to have some common ground on which they collaborate.

4.2.3 Design teams

Teachers' teams usually described in literature (i.e. professional learning communities, communities of practice) mostly focus on improving the teaching process through the PD of the teachers (Handelzalts, 2009). In the case of the DTs, PD or building of cohesion among teachers are seen as outcomes in a

design process. The theoretical basis for the formation of DTs lies in the findings of a number of studies (e.g., Giroux, 1992; Lieberman & Miller, 2005) in which teaching is viewed as a complex intellectual activity with the inherent drive of experienced teachers to fulfil their learning, social and intellectual needs as part of the process to realise their full potential. The DT concept provides teachers with a creative space to reconsider the teaching of their subject, the intellectual stimulus of working together and the challenge to move the thinking forward. In this way, teachers are invited to become curriculum makers (Simmie, 2007). According to Handelzalts (2009) a DT is a group of at least two teachers, from the same or related subjects, working together on a regular basis, with the goal to redesign and enact (a part of) their common curriculum. It is one means by which teachers can collectively participate in curriculum design, fulfil their learning, social and intellectual needs and are effective in bringing about teacher PD (Mishra, Koehler, & Zhao, 2007; Parchmann et al., 2006; Penuel et al., 2007) and curriculum innovation (Mishra, Koehler, & Zhao 2007). There are a myriad of contexts for PD and as Borko (2004) puts it;

> *"For teachers, learning occurs in many different aspects of practice, including their classrooms, their school communities, and professional development courses or workshops. It can occur in a brief hallway conversation with a colleague, or after school when counselling a troubled child. To understand teacher learning, we must study it within these multiple contexts, taking into account both the individual teacher-learners and the social systems in which they are participants." (p. 4)*

An embedded professional development, directly related to the work of teaching, can take the form of co-teaching, mentoring and reflecting on actual lessons, group discussions or in curriculum design.

4.3 METHODS

Mixed methods in a multicase study embedded design (Yin, 1993) was applied with the DTs as the three cases, and teachers and students as units of analysis. The study investigated teachers' perceptions regarding their participation in DTs and what they have learned from co-design activities (the industrial attachments, course redesign process and the teaching try-outs) as well as changes in classroom practice that have occurred as a result of participation in DTs. Students' evaluation of the teaching try-outs helped to assess the impact of the updated courses.

4.3.1 Collaborative curriculum design in this study: Structure and activities

The collaborative curriculum design activities took fourteen-weeks and included an introductory workshop, CCD activities, industrial visits and teaching try-outs. The introductory workshop, which was held in the first week, oriented teachers on CCD in teacher DTs. The first author as researcher was the main facilitator at the workshop and throughout the study. Starting from the second week, teachers in three teams, based on commonality in subject areas, worked collaboratively to update their courses to suit current technological practices in industry. Accompanying the decision on the areas for update was the consideration of the feasibility of fulfilling acquisition of the needed information within a day's visit to industry. The selected courses and areas updated by each DT are in Table 4.1. The teachers visited industry in teams to acquire relevant information to make their courses more practical and relevant in content. The Automobile team visited Caterpillars and Quansah Motors (Branch of Toyota Ghana Company) in Takoradi and Mechanical Lloyd in Accra, the Production team visited Gratis Foundation and Westing Castings in Takoradi. Ghana Grid Company Limited (GRIDCo) and Takoradi International Company at Takoradi and Aboadze respectively were the industrial locations visited by the Electrical team. They were exposed to several technologies regarding their area of study. In many ways, this course redesign was a typical team experience for the teachers; for the most part, the teams worked at their own pace to complete the redesign of the courses. During the thirteenth and fourteenth weeks, teachers conducted teaching try-outs of the updated courses which were subsequently evaluated by the students. To understand how DTs impact on the curriculum and teacher professional development, the following research questions are addressed in this study: *What is the impact of DTs on teacher professional learning and curriculum reform practices?*

The following sub-research questions informed the study:

1. How do teachers perceive the contribution of DTs to their professional learning?
2. How do teachers' perceive the contribution of DTs to the quality of the updated courses?
3. How do students perceive the quality of the updated courses?
4. What are the perceptions of DTs as a PD arrangement?

Table 4.1 *Overview of courses chosen and areas updated by DTs*

Design Team	Course	Class	Areas updated
PDT	*Engineering Processes 2*	HND 1	hydraulic systems; operation and maintenance of hydraulic systems
	Manufacturing Technology 2	HND 2	joinery methods: contemporary welding operations in Fusion weld and Resistance Weld gas and arc welding repair of defective casting by arc welding
ADT	*Workshop Process and Practice 1*	HND 1	the use of automotive electronic diagnostic equipment for fault finding. the use of immobilizers and key programming the use of automotive scanners the use of oscilloscope
	Hydraulics 2	HND 2	hydraulic systems; to identify the hydraulic systems of machine tools identify components which make up typical machine tools for hydraulic systems the operation of the hydraulic system maintenance schedule for hydraulic system procedure for making minor repair on hydraulic system
EDT	*Electrical Machines 1*	HND 1	the following on transformers: voltage Regulation no-load and short-circuit operation tap changing (on-off load)
	Electrical Machines 3	HND 2	the following on synchronization: synchronisation System (Mark V) synchronizing Torque load characteristics of an isolated generator that on an infinite busbars voltage Regulation

Note: HND, higher national diploma, below bachelor level.

4.3.2 Participants

Teachers

Overall, 16 teachers (all males), addressed in this study by pseudonyms, from the faculty of engineering at Takoradi Polytechnic took part in the study based on their availability as fulltime teachers and upon recommendation by their heads of department. The teachers were grouped into three teams which are Automobile, Production and Electrical DTs. Background characteristics of the teachers are provided in Table 4.2. Takoradi Polytechnic was purposefully selected since it is situated in a relatively industrialised region of Ghana.

Table 4.2 *Background characteristics of teachers*

Design team	Teacher *(pseudonyms)*	Age	Highest academic qualification	Years of teaching at polytechnic	Number of HND students
Automobile *(n=5)*	*Edem*	46	Master's	1	Automobile Engineering *Year 1: 144* *Year 2: 38*
	Atsu	54	HND	15	
	Kwame	28	HND	3	
	Wesley	32	HND	6	
	Sage	51	Bachelor's	7	
Production *(n=5)*	*Douglas*	69	Bachelor's	21	Production Engineering *Year 1: 104* *Year 2: 106*
	Michael	63	Master's	3	
	Robert	55	Master's	6	
	Archi	52	Master's	3	
	Tony	48	HND	23	
Electrical *(n=6)*	*George*	64	HND	17	Electrical Engineering *Year 1: 151* *Year 2:120*
	Ben	26	Bachelor's	2	
	Cephas	39	Master's	3	
	Angelinos	32	HND	3	
	David	27	Master's	3	
	Antoine	26	HND	2	

Note: HND, higher national diploma, below bachelor level.

Students

A total of 663 HND Engineering students (average age 24 years) were involved in the study of which 370 experienced the post-industry teaching try-outs conducted by the teachers and subsequently evaluated the subject taught. The remaining 293 evaluated the same subject as it was taught prior to the commencement of DT activities.

4.3.3 Instruments

Teachers' questionnaire

Teachers also responded to close-ended 5 point Likert-scale questionnaire items, with 1 is strongly disagree to 5 is strongly agree on their perceptions of industrial attachment (13 items; α=0.89), CCD (10 items; α=0.79), teaching try-out (17 items; α=0.74), collaborative course design (9 items; α=0.91 and their learning in DTs (10 items; α=0.82). They also provided responses on their perception (12 items; α=0.95, α=0.92) of DTs before and after the PD programme. According to Morgan, Leech, Gloeckner and Barrett (2004), the alpha values as reported here are considered high.

Teachers' interviews

There were five categories of semi-structured interview data collected from each teacher to find out their experiences during the following DT activities: industry visits, course update, teaching try-outs, perceptions of DTs and teacher learning in DTs. On average, each interview lasted 45 minutes and was audio taped. A logbook was kept by the first author in order to document the process of teachers working in the DTs.

Students' questionnaire

Questionnaires were administered to students after the teaching try-out of updated courses. The questionnaires consisted of 17 items on students' perceptions and experiences with the courses taught. Possible answers to all items were on a five point Likert-scale (1=strongly disagree to 5=strongly agree). The questionnaire was administered immediately after the teaching try-outs. After running factor analysis using PASW Statistics, two constructs obtained were *presentation* (α=0.95) and *clarity* (α=0.93) for student responses. *Presentation* in this study refers to the practice of showing and explaining content of the topic to the students and *clarity* denotes the practice of making content of the topic clear for students' comprehension of the concepts.

4.3.4 Data analysis

Teachers' questionnaires

Teachers' questionnaire responses were analysed using PASW Statistics to compute the means and standard deviations. Analysis of comparison of teachers' perceptions of DTs before and after the PD programme employed the Mann-Whitney U non-parametric test (Fay & Proschan, 2010) on assumption that the population cannot be assumed to be normally distributed. Effect size was calculated using Cohen's *d* (Cohen, 1988). Cohen (1988) provided tentative benchmarks for the interpretation of effect sizes being *d*=0.2 a small, *d*=0.5 a medium and *d*=0.8 a large effect size.

Students' questionnaires

Means and standard deviations were calculated for students' responses and an independent sample T-test was computed to find out whether significant differences existed regarding the experiences of participants and non-participants in the teaching try-out in terms of the sub-scales *presentation* and *clarity*. Cohen's *d* (Cohen, 1988) was calculated to find out the extent of the differences. A one-way ANOVA test was conducted to evaluate the extent to which differences exist between the participants (Automobile, Production and

Electrical HND students) perceptions of the lesson they had in terms of *presentation* and *clarity*.

Teachers' interviews and logbook
All interviews were transcribed and coded using codes generated from the study. The coding schemes (Miles & Huberman, 1994) were labelled: *industrial attachment evaluation, course update evaluation, teaching try-out appraisal, perceptions of DTs and teacher learning in DTs.* Atlas-ti software version 6.2 was used for the coding of all the interview data. Intercoder reliability (Lombard, Snyder-Duch, & Bracken, 2002; Neuendorf, 2002) was calculated using a random sample of 8 interviews from 16 teachers. There were two coders including the first author of this article. The intercoder reliability using Cohen's kappa (*k*) was 0.91. Information recorded in the logbook was analysed qualitatively using data reduction technique. Major themes were identified and clustered (Miles & Huberman, 1994).

4.4 RESULTS

4.4.1 Teachers' professional learning in DTs

Acquisition of knowledge and skills during visits to industry
Teachers' evaluation of the industrial attachment as shown in Table 4.3 revealed that all the teams found the visit relevant. The overall means for acquisition of knowledge and skills (mean=4.37, SD=0.30) was high with Automobile team having the highest mean of 4.58 and SD 0.25. Among the items to which teachers responded to are: I acquired new practical skills in my area of study; I got acquainted to new technologies and I operated machines and equipment to my satisfaction.

Table 4.3 *Teachers' perception of acquisition of knowledge and skills at industry (n=16)*

Design team	**M**	**SD**
Automobile	4.58	0.25
Production	4.23	0.22
Electrical	4.31	0.32
Total	*4.37*	*0.30*

Note: M, means; SD, standard deviation; 1, strongly disagree to 5, strongly agree.

Further details were provided by the teachers regarding the knowledge and skills they acquired at the industry. Michael in the Production team confessed that he

personally had not encountered foundry work at the industry so it was a new experience for him. Antoine (Electrical team) expressed his excitement at some observations he made for the first time;

> *"It was really interesting to see for the first time that the optical wire actually gets through the optical ground wire and from there it goes through the all diametric self-supporting system ... to avoid any interference, that is, disturbance of carrier signals."*

Atsu (Automobile team) also stated that;

> *"It was the first time we saw the torque convertor and its components even though we have always been mentioning it in teaching."*

Most of the Automobile teachers appreciated the tremendous progress being made at the industry: eschewing trial and error process, precision in their work, ability to relate to them technically and their knowledge about the systems. Apart from the vehicle engines, the changes taking place in the cars mostly had to do with the electronic system which they were introduced to. The Electrical team found it very interesting to learn about the new communication system using the optical fibre. In some cases they indicated how certain principles became clearer and more practical onsite as in the ensuing statement of George who is in the Electrical team;

> *"At GRICO there was a question about the Ferranti effect on their transmission lines ... In books we learn that to get away with this effect, you normally have to widen the gap between pylons and bolts but at the industry we realize that these pylons have already been constructed so how do you do that bearing in mind the cost? It was an eye opener to be told that they wash the lines. So we realized that in books certain instructions are given which we teach the students but practically, that isn't what is being done."*

Some of the teachers realised that even the very simple maintenance procedures that they taught students had a shortfall and so were pleased to learn what the real industrial practices are. For instance Edem of the Automobile team indicated that;

> *"...I discovered that most of the components of the tractor are frozen before being used. Also detergents are used to clean machinery after it is disassembled so that exact portions for wear and tear are detected. Meanwhile what we teach is for a part to be replaced when they are not working but did not realize that dirt could be the problem."*

According to Cephas (Electrical team) he taught that tap changing allows the transformer turns ratio to be varied to allow for the supply deviations but on the field his knowledge got expanded further that;

> *"...there is actually a resistor in there that does that. We even had an opportunity to witness it but earlier on we knew that it is just for allowing the correct deviation in supply voltages. So we can come out confidently when teaching ... It also doesn't make teaching so abstract."*

Archi (Automobile team) talked about the fact that there are some of the machines he spoke of in class but had never seen till the visit to the industries;

> *"... like the radial drilling machine and vertical boring machine."*

After going through the sessions, there was question time where so many things were explained to the teachers. For example a question on corona discharge (dealing with electrical lines) in the Electrical group received a lengthy discussion and explanations; conductors were at the end of the lines to deal with corona effect. In some cases certain features and operations were not seen by the teachers since of these steps are done at the design stage, for instance the no-load transformer.

Having observed teachers' admissions concerning their experiences at the industry, the knowledge they acquired on contemporary industrial operations was detailed and extensive as certain principles became clearer and for others some operations, machines and maintenance procedures were seen for the first time. Apart from resource persons' briefings, the teachers acquired some practical skills at the industry as a result of learning about machines and equipment and in some cases practicing their use or operating them through a hands-on training. In effect, teachers became more enthusiastic about expanding their knowledge, resulting in their acquisition of subject matter knowledge and practical skills which impacted on their courses and teaching as reported in the following sections.

Co-design in DTs

During the course update, each DT unanimously selected two on-going HND core courses (see Table 4.1) and collectively re-examined the contents for areas to update. Certain areas and topics were selected for update based on team discussions regarding challenges of teaching the courses: unavailability of certain equipment for practical lesson demonstrations, obsolete equipment, limited knowhow on operations, verification on certain maintenance procedures, upgraded equipment not incorporated, teachers' and students' challenges with the course, current technological advancements and so on. The industries were

contacted personally by team representatives to verify whether the areas identified for further knowledge were in practice. Thus, industry operations managers and other industry resource persons were very helpful in providing the needed information for DTs to make informed decisions on industries to visit. Subject matter experts also provided support in identifying areas for update. They worked out an action plan to visit industry, for additional information on contemporary industrial operations regarding the areas targeted for update. After regularly meeting for discussions and decision-making, the courses were finally updated in terms of content and pedagogy. Table 4.4 shows results of teachers' perception of the CCD activities with a generally high means and standard deviations for all the DTs.

Table 4.4 *Teachers' perception of CCD (n=16)*

Design team	**M**	**SD**
Automobile	4.53	0.14
Production	4.35	0.21
Electrical	4.26	0.23
Total	*4.37*	*0.22*

Note M, means; SD, standard deviation; 1, strongly disagree to 5, strongly agree.

All the teams engaged in identifying need areas for the courses they selected for update. With the syllabus, they were able to identify the areas of interest as confirmed by Douglas (Production team) that;

> *"... we identified need areas in the syllabus ... where in my opinion knowledge was weakest."*

Ensuring curriculum relevance and quality was the target of the teams as Wesley (Automobile team) informed that;

> *"We are rejuvenating the practical component of our courses and I find it very relevant."*

Teachers found the industrial visit a healthy one to being abreast with the current systems so as incorporate relevant topics in the syllabus. Angelinos (Electrical team) was of the view that the design activities compelled him to be responsible for quality of the curriculum. It was necessary for the teams to align their syllabus to what is existent in the industries since employers need graduates with readily available useful skills. By going to the industry, teachers have been able ascertain when is expected of to be taught in order to produce graduates with relevant knowledge and skills as Tony in the Production team remarked;

> *"It helps us to know what we should actually teach the students."*

Apart from enhancements to existing curriculum, teachers gained some basic (curriculum) design skills. They developed the expertise in analysing the various components of the course, including theory and practicals, verify/authenticate information and incorporating relevant knowledge in syllabus. Teachers developed the skill of working together in a team which corresponds to particular understanding and skills required for subject matter interaction.

New approaches to teaching in teaching try-outs

During the teaching try-out by the Automobile team pictures in PowerPoint slides were used to explain the maintenance of hydraulic systems and board diagnostics. The Electrical team took their students through the lesson on synchronisation and tap changing using video as well as pictures (in PowerPoint slides), whilst hydraulics and joinery methods were taught by the Production team using PowerPoint slides. The teachers evaluated the teaching try-outs with responses to items such as: The lesson was generally interesting; Students understood the topic and explanation on equipment better; I explained concepts better than previously; Students had a clear and vivid picture of equipment; Students liked the mode of presentation; I applied skills acquired in industry and so on. According to Table 4.5, overall means showed that teachers appreciated the teaching try-out of their courses (mean=4.71, SD=0.20) in terms of imparting useful information to students in their lessons. The means for all the teams were very high indicating the success of the teaching try-outs.

Table 4.5 *Teacher evaluation of teaching try-out (n=16)*

Design team	**M**	**SD**
Automobile	4.73	0.14
Production	4.72	0.13
Electrical	4.70	0.30
Total	*4.71*	*0.20*

Note: M, means; SD, standard deviation; 1, strongly disagree to 5, strongly agree.

The teaching try-outs were opportunities for teachers to teach the upgraded course during which they communicated what they had learned from the industry. It sharpened teachers' skill of imparting knowledge obtained from industry. They had gained confidence in the teaching of the updated courses due to knowledge they acquired and shared in DTs. Furthermore, teaching what is on-going at the industry instead of working on the same old laboratory equipment in the polytechnic made the teaching livelier. The mode of presentation sustained students' interests in the lesson and was a practical way of teaching certain industrial procedures found only during mass production.

4.4.2 Updated curriculum and its quality

Teacher perspectives

During the teaching try-out, teachers revealed their experiences with teaching the updated courses. Having added new content to improve the quality of their courses was satisfying for the teachers. Revealing his teaching try-out experiences, Ben (Electrical team) indicated that;

> *"Earlier, we used only the small types of transformers meant for power distribution purposes but they (students) haven't seen a transmission transformer which is also called the power transformer so having seen it; students were very keen and interested in the lesson."*

Teaching students what is existents at the industries gave a sense of meaning to the curriculum while teachers had the satisfaction that students learnt something more relevant. According to Sage (Automobile team), showing students components of the torque converter was a new thing in class because he always talked about it but did not have samples to show. This boosted his confidence compared to earlier lesson. Students also found the lesson interesting, and easy to understand. Robert (Production team) was confident about imparting relevant knowledge to students on how blow holes which are casting defects are detected using ultrasonic sound detectors. Robert said that;

> *"These are transformations that we have not included in our earlier teaching."*

Student perspectives

Students were generally fascinated by the lessons and stated that viewing clear and vivid images of equipment and industrial operations gave them a very broad knowledge of the topic and was a very good idea. The mode of delivery sustained their interest throughout the lessons. They were generally of the view that concepts became clearer and things they had to imagine or view as diagrams in books were seen real, thus such *presentation* should be extended to other topics. The students evaluated the lessons and further confirmed their experiences which can be found in the results listed in Table 4.6. The overall means of aspects of the lesson reported by the students were very high; *presentation* (Mean = 4.21, SD = 0.47) and *clarity* (Mean = 4.04, SD = 0.56).

Table 4.6 *Overall means for students' experiences*

Students' Experiences	Non-Participant (n=293)		Participant (n=370)		Sig.	Effect Size
	M	*SD*	*M*	*SD*		
Presentation	2.96	1.08	4.21	0.47	.0001*	1.50
Clarity	2.85	1.00	4.04	0.56	.0001*	1.47

Note: M, means; SD, standard deviation; 1, strongly disagree to 5, strongly agree; * p <0.05.

A one-way ANOVA test was conducted to evaluate the extent to which differences exist between the participant perceptions for the course they took. It was revealed that significant differences existed across lessons for Automobile, Production and Electrical student groups in terms of both subscales *presentation* (F=9.05, p=0.0001) and *clarity* (F=13.18, p=0.0001). Using the Tukey HSD procedure, multiple comparisons between the three programmes were made to evaluate the pairwise differences among the means for the subscales. With respect to the lesson for Production and Automobile students, pairwise significant differences (difference in means=0.26, p=0.0001) were present. Also, pairwise significant differences (difference in means=0.17, p=0.007) were there regarding the lessons for Production and Electrical students. Apparently the relatively low rating of *presentation* for the Production lesson could be attributed to the somewhat poor images on the PowerPoint slides used in class due to inadequate illumination of the workshops in Westing Castings (an industry). Furthermore the extra high lights produced through welding affected visibility. Regarding *clarity*, pairwise differences existed between showed in terms of the Electrical and Automobile/ Production lessons (resp. difference in means=0.24, p=0.001; difference in means=0.33, p=0.0001). The higher appreciation of the Electrical lesson regarding *clarity* could be attributed to the seemingly abstract nature of the topic which was taught previously without illustrations. As a result the intervention might have brought a great distinction between the way the topic 'synchronisation' was taught and therefore liked by the students.

4.4.3 Teachers' perceptions of DTs as a PD arrangement

Survey data from teachers showed their perceptions of DTs before and after engaging in its activities. In Table 4.7, the results indicate that a significant difference (p<0.05) existed between teachers' perceptions before and after the PD activities with a corresponding extremely large effect sizes ranging from 2.25 to 3.54. The overall significance (p=0.0001) and effect size (3.28) as found in Table 7 were both very high.

Table 4.7 *Teachers' perceptions of DTs (n=16)*

	Before		After			Effect
Design team perceptions	*M*	*SD*	*M*	*SD*	**Sig.**	**Size**
Improve my content knowledge	2.75	0.93	4.56	0.51	0.0001*	2.41
Obtain new ideas in my subject area	2.75	0.93	4.44	0.51	0.001*	2.25
Not difficult to make time for DT	2.56	0.96	4.50	0.63	0.001*	2.39
Easy to discuss my learning needs	2.56	0.81	4.50	0.51	0.0001*	2.87
Beneficial to update my knowledge	2.50	0.73	4.69	0.48	0.0001*	3.54
Helps integrate new ideas in teaching	2.56	0.96	4.56	0.51	0.0001*	2.60
Not difficult to conduct focused DT	2.50	1.16	4.62	0.50	0.001*	2.37
Useful for professional development	2.56	0.96	4.56	0.63	0.001*	2.46
Solves problems in my subject area	2.56	1.09	4.62	0.62	0.001*	2.32
Useful in my course update	2.81	0.98	4.75	0.45	0.0001*	2.54
Want to continue always to be in DT	2.62	0.96	4.75	0.45	0.0001*	2.84
Will recommend DT to colleagues	2.75	0.78	4.69	0.48	0.0001*	3.00
Overall	*2.63*	*0.76*	*4.60*	*0.38*	*0.0001**	*3.28*

Note: M, means; SD, standard deviation; 1, strongly disagree to 5, strongly agree; * p <0.05.

DTs were a useful means of bringing teachers together and a learning ground for many. Kwame (automobile team) was of the view that;

> *"Participating in DTs been a real eye-opener. There were ideas that never crossed my mind until my being in this team."*

Through contributions from team members, a lot of ideas flowed for course update and teacher professional development. Ben (Electrical team) confirmed this saying;

> *"Being in a group also promotes strength than being single."*

While Douglas (Production team) also indicated that;

> *"Design team is all about group work which is also all about being tolerant and accepting each other's views and politely rejecting each other's views. Design teams are a good step to assist us to reach the heights we want to in knowledge. We tapped into the experiences of one another."*

According to David (Electrical team), DT was very useful because whenever teamwork takes place there is always a brainstorm and something useful comes out of it due to the various experiences everyone has, therefore, he maximised the chance to learn from others. Teamwork has given the opportunity for lecturers to speak with themselves, talk about issues that concern them, teaching

and industry work. DT was a learning ground for teachers during CCD as evidenced in Table 4.8 in their responses to items such: DT was interesting for my learning, collaborative course redesign was a learning opportunity; DT engaged me in conversations with colleagues and DT contributes significantly to my growth. Results (Table 4.8) from the survey indicated that across all the teams, teacher learning occurred.

Table 4.8 *Teacher learning through collaboration (n=16)*

Design team	**M**	**SD**
Automobile	4.78	0.14
Production	4.29	0.44
Electrical	4.39	0.27
Total	*4.48*	*0.36*

Note: M, means; SD, standard deviation; 1, strongly disagree to 5, strongly agree; * p <0.05.

In spite of the positive results from the teachers on their DT experiences, they encountered certain challenges during teamwork which include conflicting time tables affecting meeting times and managing students' time during teacher absence during industry visit. However, it was suggested by the teachers that DT activities should be maintained in their departments and initiated in other departments in the polytechnic for curriculum design and teacher professional development. On the whole, they want it integrated into the polytechnic structure to enable teacher learning and collaboration.

4.5 DISCUSSION AND CONCLUSION

This study sought to examine the impact of collaborative design activities on teacher PD and curricular quality among polytechnic teachers. The DT concept aimed to strengthen teamwork among colleagues in the same subject area as they embark on updating their knowledge and courses. The teachers' account of their experiences with working collaboratively in DTs has informed this study. To a very large extent, teachers showed dedication during all aspects of the design process and developed their knowledge and skills in the process. The discovery of current information on content in DTs improved their practical skills as supported by the social learning perspective on teachers' CPD that teamwork is a powerful new element that provides a useful corrective to overly individualistic approaches to teacher development (McArdle & Coutts, 2010). By collaboratively designing, the teachers gained the skill of interacting with each other on content as is the view of Penuel et al. (2007) that interactions through doing and reflecting can enhance PD. The teaching try-outs generated changes

in teacher behaviour which included: greater confidence; enhanced beliefs among teachers of their power to make a difference to students' learning; development of enthusiasm for collaborative working, greater commitment to changing practice and willingness to try new things. These outcomes were identical to the findings of Stoll et al. (2006).

Collaboration in DTs enhanced teacher learning and increased subject matter dialogue which confirms the findings of Borko (2004) that CCD processes have the potential to contribute to the PD of the teachers involved. Teacher learning and PD was impressive during CCD as was the case in the study of Mishra, Koehler, and Zhao (2007) and Penuel et al. (2007). The study of Borko (2004) suggests that PD interventions that make extensive use of teacher collaboration are particularly successful in supporting teacher learning. Teacher learning impacted positively on their classroom practices as a result of redressing particular challenges in their courses and improving curriculum quality. This is in support of the conclusion by Cordingley et al. (2003) that CCD could have a positive impact on teachers and pupils while Andrews and Lewis (2007) also found that where teachers work collaboratively, it not only enhanced their knowledge base, but also had a significant impact on their classroom work. This was evident in the teaching try-out where students appreciated the knowledge they acquired, a finding similar to that of Millar et al. (2006) whose studies with DTs to develop research-based classroom materials resulted in increased student's motivation. DT in this intervention clearly appeared to be a valuable approach to teamwork among polytechnic teachers for them to update their knowledge and skills and update their courses (cf. Millar et al., 2006; Nieveen et al., 2005; Simmie, 2007). Despite the few initial challenges that teachers encountered in DTs combining design activities with already heavy teaching workloads, their teamwork to advance ideas had enormous returns making it a promising strategy for their knowledge update. The result of this case study basically confirms the findings of a similar study conducted in another polytechnic in Ghana by the authors of this work (anonymous). Therefore, although generalising this study worldwide might not be possible, results from the two studies confirm that CCD is a useful means for teachers' CPD apart from ensuring curriculum quality. Consequently, the findings here have far reaching implications for polytechnic education in Ghana and sub-Saharan Africa.

In conclusion, findings suggest that teachers improved their knowledge during CCD. DT is a worthwhile undertaking for teachers' CPD during CCD. Findings from this study authenticate the valuable characteristics of collaboration among teachers as a useful means for teacher interaction and teacher learning and DTs served that purpose well. Thus this study provides insights into engaging teachers

in teamwork for their CPD. It also highlights the importance of engaging teachers in the update of their own courses as well as making them conscious of maintaining curriculum quality and relevance. CCD encourages grass root participation in making curricular decisions and instils a sense of ownership among teachers. It becomes evident from the implications of this study that it is worthwhile to connect teachers through teamwork and allow their reflections on current practices and promote creativity. This study provides evidence of some characteristics that learning communities exhibit as indicated by Bolam et al. (2005) such as shared values and vision; collective responsibility for pupils' learning; collaboration focused on learning; individual and collective professional learning; reflective professional inquiry; openness, networks and partnerships; inclusive membership; mutual trust, respect and support. Consequently, findings demonstrate teacher learning in their work environments and promotion of quality teaching and learning. The relational nature of the interdependencies between the social and individual contributions illuminates the fabric of teachers' CPD and subject matter discourse.

CHAPTER 5
Tracing the professional growth of teachers in a design process: An exploration of the interconnected model of professional growth[5]

Using Clarke and Hollingsworth's (2002) Interconnected Model of Professional Growth (IMPG), we trace the professional development of polytechnic teachers in a collaborative curriculum design scenario in a semester-long investigation. The teachers worked in teams during design meetings to update their syllabuses for various mechanical and electrical engineering courses. Syllabus updates were based on industrial visits of the teams. Fourteen weeks of field notes for six teachers in three design teams show participants' professional growth situated in their curriculum design and classroom implementation. Data analyses revealed that individual professional growth occurred among all six teachers and suggests that tracing teacher growth in an interconnected manner results in in-depth knowledge of teacher learning and change. The IMPG model helped to provide an analytical look into intertwined changes in individual teacher knowledge and their idiosyncratic sensitivity to the complex interactions with content and teaching and this could have implications for teacher development in higher education.

5.1 INTRODUCTION

Although an extensive body of research focuses on an array of topics in teachers professional development, we are only beginning to learn what and how teachers learn from professional development (Bredeson, 2000) and its impact on student outcomes (Borko, 2004; Guskey, 2000). While professional development programs vary widely in their content and format, most share a common purpose: 'to alter the professional practices, beliefs, and understanding of school persons toward an articulated end' (Griffin, 1983, p. 2). The issue of how

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teachers grow professionally as a result of their participation in a professional development programme has been the centre of intense debate in recent years (Darling-Hammond & Bransford, 2005; Desimone, Porter, Garet, Yoon, & Birman, 2002; Putnam & Borko, 2000). Guskey (2002) indicates that what attracts teachers to professional development is their belief that it will expand their knowledge and skills, contribute to their growth, and enhance their effectiveness with students. To advance studies of and designs for professional development we argue the importance of better understanding how teachers come to make sense of their learning in professional development programmes. In this study we documented the process of teacher professional growth and change that took place while teachers collaboratively designed updates of their courses. This study is part of an on-going research on teacher professional development and curriculum design in polytechnic institutions in Ghana.

5.2 CONTEXT OF THE STUDY

Polytechnic education in Ghana started in 1951 as technical institutions at the secondary level and by 1990 they were re-designated as polytechnics. From 1993 the ten state-owned vocational oriented polytechnics were brought to tertiary status to offer career-focused programmes in the field of manufacturing, commerce, science, technology, applied social sciences and applied arts leading to the award of Higher National Diploma (HND) accredited by the National Accreditation Board (NAB). In 2007 the polytechnics started to offer Bachelor of Technology (B. Tech.) degree programmes by government mandate. This was part of strategies to improve on the capabilities and capacities in the polytechnic to meet the manpower needs of the nation. The central focus of polytechnic education is that its programs are career-oriented and practical in content. In response to a Ghana Government mandate to develop comprehensive vocational and technical education and training, there have been questions about measures being put in by the polytechnics to ensure that existing human and material resources are commensurate with their new status as higher institutions of learning (Nsiah-Gyabaah, 2005). Although the original curriculum of the polytechnics has been designed to cater for the needs of industries, there is the need for continuous update and evaluation of content to meet the challenges of industrial growth and expansion. In addition to this, studies have shown that polytechnic teachers in Ghana need to improve their knowledge and skills as they continue to practice their career (Nsiah-Gyabaah, 2005; Gervedink Nijhuis, Bakah, & Akomaning, 2009) and get involved in the design of HND and B. Tech curriculum. The success of curriculum reforms, like the

ones indicated in this study, in the polytechnics is dependent on teachers' knowledge and skills to facilitate their participation in the reform. This is critical as content, instruction and curriculum development may largely fall within their purview. This study is part of efforts to step up teacher professional development among polytechnic teachers.

The fourteen-week programme discussed in this study included an introductory workshop, collaborative curriculum design activities, industrial visits and teaching try-outs. The introductory workshop, which was held in the first week, oriented teachers on collaborative curriculum design in design teams. The first author as researcher was the main facilitator at the workshop and throughout the study. Starting from the second week, teachers in three teams, based on commonality in subject areas, worked collaboratively to update their courses to suit current technological practices in industry. The teachers visited industry in teams to acquire relevant information to make their courses more practical and relevant in content. They were exposed to several technologies regarding their area of study. In many ways, this course redesign was a typical team experience for the teachers; for the most part, the teams worked at their own pace to complete the redesign of the courses. During the thirteenth and fourteenth weeks, teachers conducted teaching try-outs of the updated courses which were subsequently evaluated by the students.

5.3 TEACHER PROFESSIONAL GROWTH

For teachers, learning occurs in many situations of practice (Peressini, Borko, Romagnano, Knuth, & Willis, 2004). Situative perspectives argue that, to understand teacher learning, we must study it within multiple contexts, taking into account both the individual teacher-learners and the physical and social systems in which they are participants (Putnam & Borko, 2000). Whereas cognitive perspectives focus on knowledge that individuals acquire, situative perspectives focus on practices in which individuals have learned to participate and 'consider individuals' acquisition and use of knowledge as aspects of their participation in social practices' (Greeno, 2003, p. 315). To say learning is situated refers to how a person learns a particular set of knowledge and skills, and the situation in which a person learns, is a fundamental part of what is learned (Greeno, Collins, & Resnick, 1996). In this study, we assess teacher professional growth within both the situative and cognitive standpoints of teacher learning. The professional development programme provided teachers the opportunity to acquire knowledge in their respective subject domains which can be classified under the

cognitive perspective of teacher learning. We envisage the occurrence of situative learning among the teachers due to their collaborative curriculum design in teams and teaching try-outs; individual teachers are expected to learn from those practices especially as such practices relate to their career. Professional growth can be pervasive when learning is viewed as a collective enterprise, and stifled without continual interactions (Gallagher & Ford, 2002), where teachers share successful experiences and learn from each other. Through this approach, teachers continually utilize the instructional resources and skills of their peers to support mutual growth and attainment of shared instructional and curricular goals (Glazer & Hannafin, 2006) as is expected of teamwork in this study.

5.4 THE INTERCONNECTED MODEL OF PROFESSIONAL GROWTH

Clarke and Hollingsworth (2002, p. 948) propose that the central focus of professional development efforts aligns with ''change as growth or learning'' perspective where teachers change inevitably through professional activity. Within this perspective, growth is identified with learning. In addition, it is seen as a natural and expected component of the professional activity of teachers. In view of professional development where teachers are seeking fulfilment through reflection and professional development, change is realized as growth or learning and teachers themselves are learners in a learning community. Daloglu (2004) suggests among others that for professional development activities to lead to teacher growth, programmes need to be adequate to facilitate critical reflection and change. Apparently it is necessary to consider how the process of teacher growth is addressed in professional development programmes.

In facilitating the professional development of teachers, it is necessary to consider the process by which they grow professionally as well as the conditions that maintain and promote that growth. In particular, it requires the teacher to be embedded in a continuous process of learning and be sensitive to the demands of teaching and learning. The Interconnected Model of Professional Growth (IMPG - Clarke & Hollingsworth, 2002 – see Figure 1), an empirically grounded model that incorporates key features of contemporary learning theory is explored to investigate teacher learning in a professional development programme. The IMPG distinguishes four separate domains in the teacher's realm. The model suggests that growth in one domain is translated into growth in another through the mediating processes of ''reflection'' and ''enactment''. The four domains distinguished are the *Personal domain*, reflecting the teacher's knowledge, beliefs and attitudes; the *Domain of practice,* encompassing all

forms of professional experimentation (not exclusive to classroom experimentation); the *Domain of consequence, concerning* the salient outcomes of teacher enactment on students and the *External domain*, dealing with sources of information, stimulus or support.

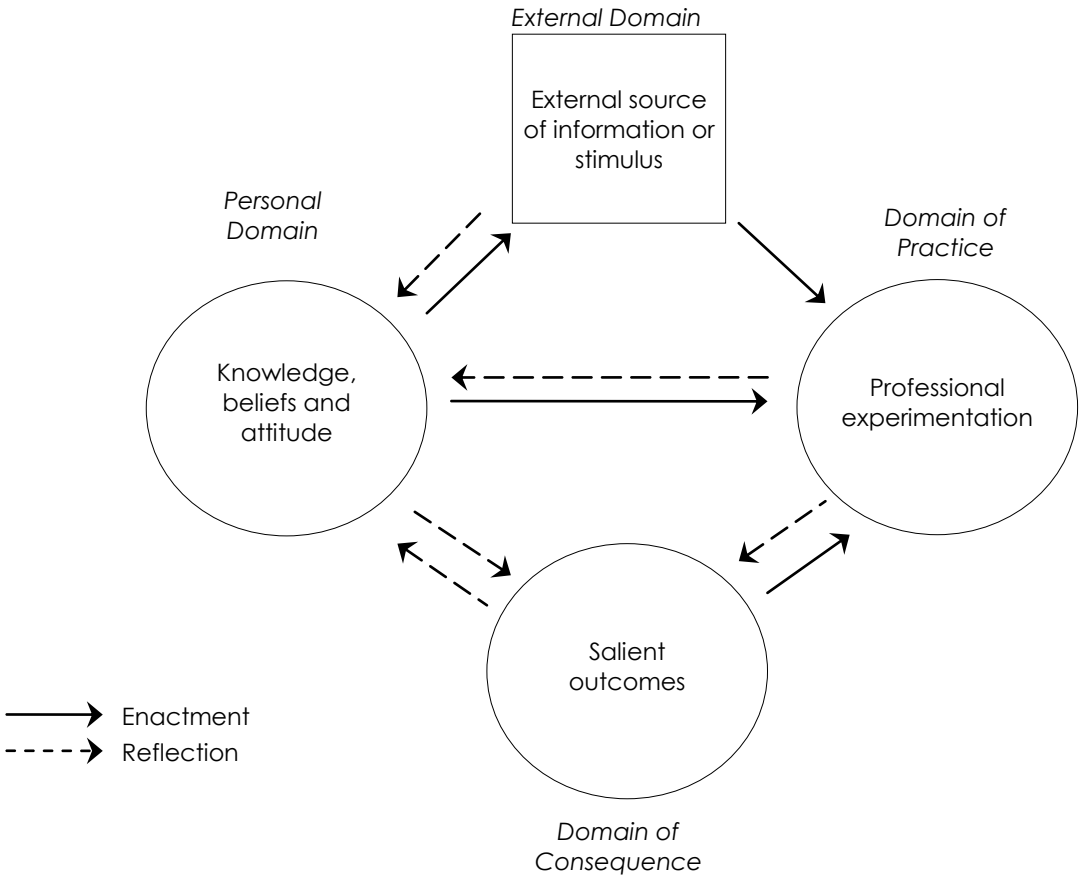

Figure 5.1 The Interconnected Model of Professional Growth (Clarke & Hollingsworth, 2002)

The mediating processes of reflection and enactment are represented in the model as arrows linking the domains. The IMPG recognizes the convolution of professional growth through the identification of multiple growth pathways between the domains. Unique to this model is its depiction of professional growth as an inevitable and continuing process of learning; recognizing the mediating processes of reflection and enactment as the mechanism by which change in one domain leads to change in another (Clarke & Hollingsworth, 2002). In the Interconnected Model the *external domain* is differentiated from the other domains due to its position outside the teacher's personal world while a combination of the *domain of practice*, the *personal domain* and the *domain of consequence* constitute the individual teacher's professional world of practice, encompassing the teacher's professional actions, the inferred consequences of

those actions, and the knowledge and beliefs that prompted and responded to those actions (Clarke & Hollingsworth, 2002). The interrelated nature of the four domains emphasises the complex nature of teacher professional growth and provides important consideration for teacher professional development. On the basis of the features of IMPG, we probe teacher professional growth in this study as guided by the following research question: *How does teacher participation in collaborative curriculum design activities impact on their professional growth?* In this work we define teacher professional growth as a proactive change taking place in teachers' knowledge, attitudes and skills.

The IMPG in this study is used to identify the growth that took place in polytechnic teachers while participating in design teams. The *external domain* consisted of information provided to teachers at the introductory workshop, which oriented teachers about collaborative curriculum design. In the design teams teachers visited industrial plants to familiarise themselves with modern ways of industry operations, modern machines and equipment and their handling. The *domain of practice* concerned teachers' professional experimentation during collaborative design in teams and their teaching of the updated courses. In the design teams teachers took major decisions regarding the update of the curriculum which offered them the opportunity to exhibit and exchange their expertise with their peers. In addition teachers also experimented professionally while teaching the updated courses. The *personal domain* reflected the new knowledge and skills acquired by teachers whether from industry, during collaborative curriculum design, from teamwork or from teaching their updated courses. Finally the *domain of consequence* consisted of students' experiences with the updated courses and teachers reactions on those experiences.

5.5 METHODS

5.5.1 Design

This study employed mixed methods in data collection in a case study (Yin, 1993). Teachers in three teams were units of analysis. The study investigated teachers' growth in the professional development programme.

5.5.2 Participants

Data for the study comes from three teams made up of male teachers from the faculty of engineering in Takoradi Polytechnic which was selected because of its long years of existence and proximity to some major industries. The teams were

Automobile (5 teachers), Electrical (6 teachers) and Production (5 teachers). For the purpose of reporting on individual teacher professional growth in this paper, we limited our focus on six teachers (two selected randomly from each team). Particulars of these teachers who are reported on in this study are in Table 5.1.

Table 5.1 *Particulars of teachers*

Design team	Teacher *(pseudonyms)*	Age	Highest academic standing	Years of teaching in polytechnic	Course	No. of HND Sts.
Automobile	*Melvin*	54	Diploma	15	Workshop Process and Practice 1	18
	Julian	46	Master's	1	Hydraulics 2	93
Electrical	*Steve*	64	Diploma	17	Electrical Machines 3	71
	Harry	26	Bachelor's	2	Electrical Machines 1	81
Production	*Ernest*	69	Bachelor's	21	Manufacturing Technology 2	49
	Leonard	38	Master's	3	Engineering Processes 2	58

5.5.3 Data collection

Three types of data were collected from teachers: notes taken from group discussions in design activities, individual industry reports and face-to-face interviews on self-progress periodically taken throughout the study. The first author observed and took detailed field notes (in logbook) of the groups when they were involved in design related discussions. There were five categories of semi-structured interview data collected from each teacher to find out their experiences during the following team activities: industry visits, collaborative design activities, teaching try-outs, perceptions of teamwork and teacher learning in teams. On average, each interview lasted 25 minutes and was audio taped.

5.5.4 Data analysis

All interviews were transcribed and coded using codes generated from the study. The coding schemes (Miles & Huberman, 1994) were categorised: *industrial attachment evaluation, course update evaluation, teaching try-out appraisal, perceptions of r design teams and teacher learning in design teams.* Atlas-ti software version 6.2 was used for the coding of all the interview data. Intercoder reliability (Neuendorf, 2002) of two coders was calculated using a random sample of 18 out of 30 interviews from 6 teachers making Cohen's kappa (k) 0.89.

Information recorded in the logbook was analyzed using data reduction technique. Major themes were identified and clustered (Miles & Huberman, 1994).

5.6 FINDINGS

5.6.1 Teachers' reflection and enactment processes

In the sections below, we present the reflection and enactment processes of the six teachers in the Automobile, Electrical and Production design teams. Although the design process is similar across the groups, there are also few important differences regarding the experiences of individual teachers. The process of teacher professional growth did not take place in isolation considering the four main components of the IMPG in Figure 1. Two mediating processes represent how change in one domain is translated into change in another. Within the context of teacher learning, the actions that teachers took to put a newly acquired idea or belief into practice constituted the first mediating process called enactment. The enactment process is discussed in relation to Figure 2 with reference to the solid arrows. The second mediating process is reflection which refers to thoughtfulness and considerations that constitute the development of teacher knowledge and are discussed based on Figure 2 indicated by the broken arrows. The enactment and reflection results from each of the respondents will be presented differently to address the research question. Even though Clarke and Hollingsworth (2002) indicated that the domain of practice (P) encompasses all forms of professional experimentation, we delineate P* in our study to mean all activities that teachers engaged in apart from classroom implementation. Such activities are the course redesign and design teamwork. Teachers' collaboration in design teams also constitutes their experiences which we categorise as P*. We find it important to exhibit such distinction between P and P* since our study also seeks to describe teacher learning during such facets.

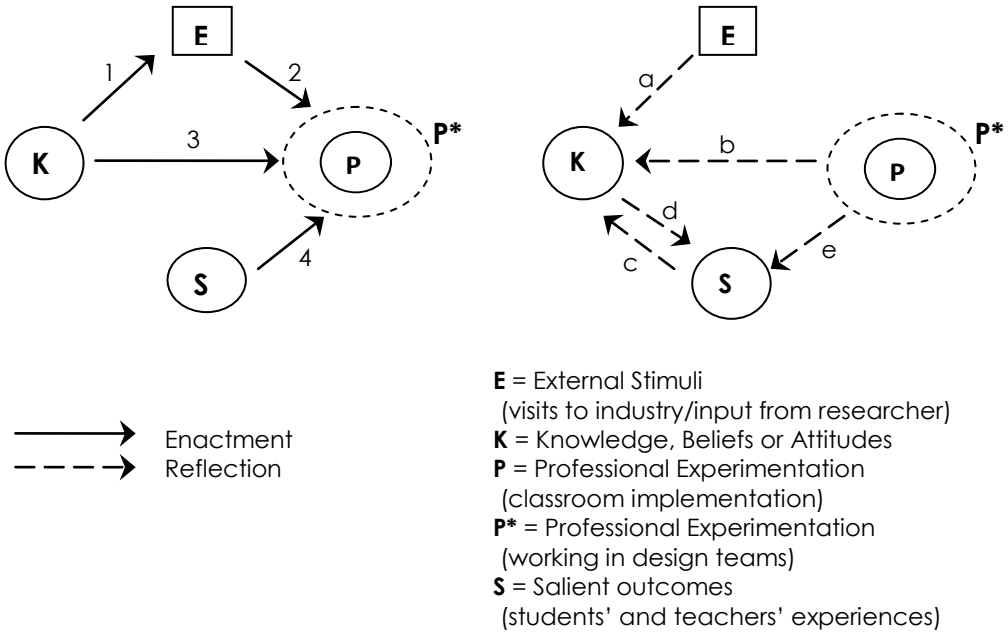

Figure 5.2 Teacher learning networks

Melvin

During the development process, Melvin expressed optimism at advancing in knowledge in his subject area *(1)*. He hoped to improve his course but had never thought that working in a team could be practical in achieving this purpose. Commenting on his knowledge of course design Melvin intimated;

> *"I learnt the technicalities involved such as analysing the course structure (b, P*). Collectively digesting the syllabus was so practical (e, P*)."*

Melvin practiced the procedures of course design in a communal effort *(3, P*)*. Having been equipped with information from industry, Melvin's knowledge had been enhanced *(a)*, as he stated that;

> *"At Mechanical Lloyd, I discovered their latest diagnostic tool for BMW vehicles and practiced it on a BMW 7-Series (a)."*

Such knowledge acquired by Melvin enabled him to update his course *(3, P*)* and conduct his teaching try-out *(3, P)*. Melvin taught *On Board Diagnostics;* commenting on the teaching, he said;

"There are a lot of things I read and teach in abstract but things I encountered at the industry have helped me (a; 2, P). It's going to enhance my teaching and make it easier to explain things to my students (a, 3, b). I understood the diagnostic system and was able to relay the information to my students better (a; 3, P; b, P). It was a lively class as students discussed fault finding in their groups (e, P)."

Reflecting on his involvement in teamwork, Melvin revealed that;

"I had the opportunity to interact with fellow teachers and learnt to tolerate diverse behaviours (e, P)... It has been a lot of learning experience to listen to colleagues ideas (b, P*)."*

Julian

Having spent a year in the polytechnic, Julian expressed enthusiasm about visiting industry with his colleagues *(1)*. He had high expectations of older and more experienced colleagues in terms of drawing from their experiences with their courses and their ideas for course design *(b, P*)*. Just as others in his team, he got involved in course update and said;

"We all came to agreement that there was a need for a particular type of students' practical training, which was an important activity (3, P). I learnt from my colleagues certain competencies that students need to possess as well as the need for a balance between technical and industry-specific skills (b, P*). It intensified my practical knowhow (a) and gave me ideas for the direction of my course update (3)."*

Julian in the company of other colleagues visited industry and stated that;

"After undergoing servicing, the amount of pressure for the machine to operate on is calibrated on the computer; this actually broadened my understanding about the latest way of testing hydraulics of heavy duties trucks (a)."

Due to knowledge acquired, he was able to update his course *(3, P*)*. During the teaching try-out by Julian, he used pictures in PowerPoint to explain the maintenance of *Hydraulic Systems.* Commenting on the teaching he admitted saying;

"As we haven't got the physical components of these off-road trucks, we can now show them pictures of those components (3, P) than allowing them to just imagine as in previous lessons. I could see their interest in the lesson (e, P)."

Julian recognised the influence of teamwork on his knowledge as in his statement;

> *"t is very beneficial to work in a team because we share ideas about what we do and what we need to do (b, P*; 3, P*). I discovered the mode of presenting the topic with colleagues' help (b, P*) and it was successful (e, P)."*

Steve

Steve had been involved in the development of courses at national level, but had no experience in developing courses using information from industry on current technologies and so was curious. Having paid a visit to industry, this is what Steve had to say;

> *"…I got to know that the voltages used for excitation at the turbo generators were far less than at the hydro-generating stations (a). In the hydro-generating stations, about 500VDC is being applied whereas turbo generators at thermal power stations have about 35VDC ... the range is very vast. All along, I thought they were injecting about 100VDC so 35V was shocking (a). Then the principle I knew came to the fore and makes me appreciate N*I as magnetomotive force, giving me a clearer picture of that mathematical expression (1; a). I got to know what excitations mean (a)."*

Pondering over the redesign of the course Steve pointed out that;

> *"We identified some learning needs to bridge the gap between our syllabus and industry competency standards (2, P*) and I discovered that as a technical and vocational teacher I cannot create situational learning experiences without an understanding of workplace contexts and changes (1; b, P*). Such understanding made me draw on some practical knowledge from the industry visit (b, P*; a; 2, P*)."*

These observations by Steve further reveal that his discoveries during course design imparted on his knowledge *(b, P*)*. Having taught *Synchronisation*, Steve reflected on the lesson and new additions to the courses and students' reactions to the classes they took. He articulated;

> *"If you should have a look at the course outline for Electrical Machines 3, it's really abstract and complex … for there are some things that one cannot appreciate until a field experience (2, P; 1). For instance when you talk about an exciter or armature reaction to students in class, they can't visualise it. But with that diagrammatic representation students were able to appreciate it (e, P)….. So today's teaching was successful in my opinion (e, P). Most of the students were happy (e, P). And one of the students said that; 'If we can do this every now and then, then it is going to make learning easier and more appreciable'(e, P)."*

Steve reflected on the increase in students' motivation which propelled confidence in the knowledge he attained *(c)*. Further alluding to the immediate past comment from Steve is his reflection on the changed knowledge and skills regarding the course content *(d; b, P)* and its presentation *(e, P; d)*. Concerning collaboration in the team, Steve said;

> *"Teamwork for a moment changed my state of isolation in my area to working hand in hand with others (3, P*). For me, it was not only an eye opener (b, P*) but was also refreshing (e, P*) because even though there were some things I knew, in the team, I got to know much about them in a greater dimension (b, P*; c), for instance ... I was more inclined towards developing teaching material but I learnt in the team about also developing equipment concept due to practical skill competencies (3, P*; 2, P*)."*

Steve got to improve his knowledge among colleagues in the team *(b, P*)* as he drew ideas from them *(b, P*)* and further contributed to improving teaching of the course *(3, P)*.

Harry
Harry found it important to continuously professionalize and added;

> *"... as the world constantly changes so I want to expose my students to current things so that when they get to the industry, they know what they are about (a)."*

Reminiscing on his industry encounter, Harry stated that;

> *"Although I know that GRIDCO uses SF6 circuit breakers, I had not seen one until we went there. I saw how the change-over switches and focus relays work, how to test oil and cool the transformers (a). The transformers I knew had separate cooling systems but with the modern ones I saw, they are incorporated (a). I knew tap changing the analogue way but I now discovered the new digitally operated transformers which save time and energy (a)."*

He was also quick to admit that;

> *"There is now a lot of software development which our students need to know and I am going to teach them these (3, P; 2, P)."*

The course design facets were learning grounds for Harry as he points out in the ensuing quote;

"Actually incorporating some new things in our pretty old syllabus builds a lot of confidence in me (b, P). I discovered in the syllabus that though the principles with the old systems are the same, the operations change (b, P*)."*

Harry taught his class *Tap Changing* and indicated;

"It is very revealing, because with tap changing, we have always been teaching about the analogue type but this was an opportunity for me to introduce the digital system types to my students (3, P; 2, P). It was a livelier class than usual (e, P) to see students making useful contributions in class (e, P). They worked in groups on the transformers and it became student-centred unlike before (e, P)."

According to Harry, teamwork offered *abundant learning opportunities (e, P*; b, P*)*. He explained his assertion as follows;

"I learnt to share my ideas with fellow teachers (b, P; e, P*) and collaborate with others to build a strong knowledge base for my course (b, P*) ... most of all I learnt to be creative (b, P*; e, P*), became humble (e, P*) and was open to change (e, P*; c) ... I thought I was an expert in handling the course until it came to me as a big surprise that others have wonderful ideas to offer to improve it (d; 4, P)."*

About collaboration in the team, Harry said;

"Individuals are doing their respective researches here and there, but collaboration in the team unearthed other teachers' research works (e, P; c)... It was interesting ... to tape information from each other (e, P*; c)."*

Ernest

Change was the utmost agenda for Ernest. His target was to bring something new into his course and into the classroom *(1),* thus about the industry visit he informed that;

"We learnt ... generally about foundry works and methods of joining metals which enhanced my knowledge (a). I learnt about how castings are repaired when they don't come out well (a)."

The following are Ernest's observations during course design;

"I found out how to come up with specific topics and aspects of the syllabus that we wanted to hammer on since they are core parts of the HND course (3, P). I had the idea not to teach students something which is antiquated (b, P*). I*

learnt to impart occupationally oriented contents of skilled work ... subjects, tools, methods, technology (b, P). Most of all delving the syllabus was a new learning experience for me (b, P*).''*

During the teaching try-out, Ernest took his students through *Joinery Methods* and remarked;

''Apart from an updated content (a; b, P) the delivery method was different (e, P; c) because I now had a lot of pictures from industry to support what I was saying (2, P); a lot of pictures and videos spoke for themselves (2). The students showed a lot of interest and asked relevant questions than previously (e, P; 3, P*). Indeed, my industry experience kept me at ease in our class discussion on the topic (b, P).''*

Ernest shared his thoughts about his lessons in the team saying;

''Teamwork paved the way for me to know from colleagues, things I never knew (b, P; e, P*). I found how to tolerate individual differences in the team (4, P*) and I learnt to be circumspect in communicating information to be discussed (4, P*). We collaborated to share ideas (3, P*) and worked hand in hand to achieve set targets (3, P*) ... that unity of purpose was there (e, P*).''*

Leonard

Leonard was interested in acquiring relevant knowledge from industry to update his knowledge and course and looked forward to getting some hands-on training *(1)*. He indicated the following about industry;

''I encountered machines which earlier on I had never had the opportunity to operate myself like the radial drilling machine and vertical boring machine (a) ... I liked the experience (a). My confidence was reinvigorated (a). My students are going to benefit from this (2, P; 3 P).''

The course design process also offered Leonard some learning experiences as follows;

''At the onset, I got to know how to identify need areas in the syllabus (b, P). I also expanded my knowledge on competencies for my course (a; b, P*). I now know competency standards are made up of units of competency (a; b, P*), which are themselves made up of elements of competency (a; b, P*).''*

Leonard taught *Hydraulics* during the teaching try-out and indicated that;

> *"I realized that most of the students appreciated the format (e, P) ... the pictorial representation (e, P) and the PowerPoint presentation on the maintenance of hydraulic systems in heavy duty off-road trucks (e, P). One student said; '...sir, things are a lot of clearer today' (e, P)."*

In his remarks on teamwork, Leonard said;

> *Teamwork can never be downplayed since knowledge gained from my follow teachers was valuable (b, P*; e, P*) … In the team I acquired the idea of developing occupationally oriented tasks for students and confront them with occupational problems (3, P*; 3, P). I tapped into the experience of others (b, P*) and developed in creativity (b, P*; e, P*). I also got to know that colleagues are always ready to help when you consult them (b, P*) and that it's not helpful to work in isolation ... especially in academia (e, P*). We all got involved and were ready to share ideas (c, 4; P*S).*

5.7 DISCUSSION AND CONCLUSION

We collected rich field notes over the 14 week journey of updating courses and subsequent class use for six teachers in three different groups. Data for this research was segmented and categorized based on Clarke and Hollingsworth's (2002) IMPG. Tracing teacher growth through the IPMG revealed how they developed in their thinking and design conversation about curriculum design and subject matter update in teams with enquiry into industry operations. Our analysis shows that teachers have more similarities than differences among them as individuals and between the three groups. The groups evolved with time, both in terms of collaboration and cohesion. The individuals took advantage of teamwork to maximise their learning potential and let it impact on their teaching. Thus, in this study, we showed that teachers changed with respect to their knowledge in their respective subject areas and their use of teamwork in curriculum design. There are of course some inherent limitations concerning the narrow focus of the design activities by the teachers which is due to the limited period of 14 weeks for the design activities. The teachers were convinced that the design activities carried out were a major step in the series of curriculum design activities on-going in the polytechnics. The groups worked on their own during the design process which is a gratifying sign of effective future attempt by teachers to update their courses. Next, we will discuss in detail teacher learning as diagnosed by the enactment and reflection processes of the IMPG.

5.7.1 Teacher professional growth as depicted by the enactment and reflection processes

Domain of practice and personal domain

Tracing teacher professional growth revealed that most significantly, individual teacher learning occurred between the *domain of practice* and the *personal domain* where their participation in curriculum design activities increased knowledge in curriculum design and content. Analysing the course structure, incorporating competencies that students need to possess, balancing technical and industry-specific skills and bridging the gap between the syllabus and industry competency standards were among the concrete practical tasks and learning experiences in enactment that brought teachers face to face with their subject matter, however these experiences also emanate from reflection on knowledge acquired. Additionally, teachers' reflections on subject matter, delivery and outcomes in the teams enhanced interaction and knowledge sharing. Their participation in design teams was enactment driven and improved collaboration making them discover how to share knowledge and ideas, communicate with others, be creative, broadminded and tolerant as well as learn how to find information on subject matter. Teachers' presentation of subject matter was enhanced when they conducted teaching try-outs of the updated courses, an upshot of enactment. The success of classroom implementation was also dependent on current knowledge teachers got from industry and skill to present subject matter to students which made them more confident in content, both of which were revealed in the enactment process.

External domain and personal domain

Teacher learning was notably existent between the *external domain* and the *personal domain* as all the teachers became involved in the industrial visit to learn about current industrial operations in place. In effect teachers' acquired knowledge in their subject matters from industry to augment their knowledge and beliefs about their subjects, which was a major consequence of reflection. Apart from getting to know about relevant industrial trends, teachers individually handled equipment in brief training sessions to improve their hands-on experience except Melvin and Julian because they visited hydro-generating stations and thermal plants where power is constantly flowing thus could not be shut down at the time of visit for their use. The introductory workshop on collaborative curriculum design was a forum where teachers obtained more knowledge on course design in design teams, also a development from reflection.

External domain and domain of practice

All the teachers except Julian expressed knowledge acquisition between the *external domain* and the *domain of practice*. The teaching try-outs were based on the updated courses and were also a learning ground for teachers and enabled them to practice what they had learned from the industries; being outcomes of enactment. In this light, certain equipment and practical operations from industry were taught students based on their field experiences. There were software developments and automated/digital systems which teachers encountered and introduced in the classroom. A derivative of enactment was revealed during collaborative curriculum design as teachers learnt to bridge the gap between the syllabus and industry competency standards and design situational learning experiences based on the understanding of workplace contexts and changes. They embarked on their design tasks which called for documenting their newly acquired knowledge from industry for curriculum design purposes, a process which had phenomenal effects on their knowledge through the intensive brain work to restructure their syllabuses to reflect current needs of industries.

Domain of practice and domain of consequence

Appreciable amounts of teacher growth took place between the *domain of practice* and the *domain of consequence*. This experience, mostly revealed through reflection, was recorded by all the teachers after the teaching try-out which they described as refreshing, revealing and an eye opener. Students showed a lot of interest in the topics; and classes were livelier as it encouraged students' discussion; a result of reflection. Clarity and presentation of topics were rated high as they were supported with pictures from industry. There were consequences of design teams which emanated from the reflection process such as tolerance of diverse characters and behaviours, seeking ideas from colleagues, unearthing of research ideas, learning to communicate with others, uniting with others to achieve set targets, humility, creativity and being open to change. Collaborative curriculum design brought to light certain salient outcomes among teachers which produced enactment including discovering competencies, industry skills in syllabus, ensuring hands-on technical skills, being able to analyse the course structure, knowing certain competencies that students need to possess, being able to bridge the gap between the syllabus and industry competency standards and imparting occupationally oriented contents of skilled work among others.

Domain of consequence and personal domain

Apart from Melvin and Julian, all other teachers displayed professional growth between the *domain of consequence* and the *personal domain* and was solely revealed through the reflection process. The outcome of the teaching try-out propelled confidence in the delivery method and knowledge they attained and intensified their practical knowhow. There was change in their knowledge and skills after modifying the course content and presenting it. Teacher collaboration gave them ideas for their knowledge and update courses.

In conclusion, teachers grew professionally during the cycle of collaborative curriculum design and its use in class as diagnosed in all four domains of the IMPG (Clarke & Hollingsworth, 2002). In particular, their knowledge, attitudes and skills increased during their participation in collaborative curriculum design. The focus of the design teams was on curriculum development; however as an offshoot the process served as a learning experience for the individual teachers themselves as was uncovered through the enactment and reflection processes. Enactment was a crucial factor that contributed to professional growth as revealed in classroom practice and in design teams while reflection was mainly a pondering and intermediary factor which helped to reinforce knowledge acquired. The IMPG unearthed rich details of teacher professional growth emanating from their own professional practices and the interdependence of multiple factors in diagnosing teacher change. Teacher professional growth was in the context of the situated and cognitive modes of teacher learning (Greeno, 2003; Greeno, et al., 1996; Putnam & Borko, 2000). The knowledge and skills acquired by the teachers was situated in their practices in the classroom and in collaborative curriculum design. Teamwork in design teams enhanced individual professional growth as confirmed by Gallagher and Ford (2002) that professional development can be pervasive when learning is viewed as a collective enterprise as in professional communities. Through team approach, teachers continually utilized the instructional resources and skills of their peers to support mutual growth and attainment of shared instructional and curricular goals (Glazer & Hannafin, 2006).

The findings in this study have some implications for teacher professional development in polytechnics and other higher institutions in Ghana as well as in developing countries. By employing the IMPG for an analytical look into components of design activities by teachers, we have offered empirical grounding for the intertwined changes in individual teacher knowledge and their sensitivity to the complex interactions with content and teaching. Similarly, higher education institutions in developing countries, especially in sub-Saharan Africa, need to consider assessing teacher change in teacher learning systems yet

unexplored. Designers of in-service programmes could consider using complex models to discover teacher idiosyncratic and personal development as well as anticipate and promote concrete tasks to penetrate all avenues of their profession and provide recognition of the situated and personal nature of teacher practice and growth. Such institutions may also require paying attention to teacher complex learning mechanisms in networks which could necessitate a corresponding sophisticated model to detect professional growth. While this study has provided valuable insights into individual teacher professional growth during design and implementation of an engineering curriculum, further research is needed to explore the sustainability of change in teacher professional practice.

CHAPTER 6
Advancing perspectives of sustainability and large-scale implementation of design teams in Ghana's polytechnics: Issues and opportunities[6]

The study reported in this chapter seeks perspectives of teachers and leaders on the sustainability and large-scale implementation of design teams, as a means for collaborative curriculum design and teacher professional development in Ghana's polytechnics, eight to eighteen months after implementation. Data indicates that teachers still collaborate in design teams for curriculum design and professional development. Leaders' activities and behaviours are identified as supporting the sustenance of design teams. However internal policies are needed for its official recognition and use. Some identified inherent opportunities are outlined for sustenance and conclusions drawn based on the characteristics of the programme, contextual features and polytechnic climate.

6.1 INTRODUCTION

The development of new curricula is a common event in countries across the globe and was the case of polytechnics in Ghana from 2007. The Polytechnic Law 745 was promulgated to give legal backing to the running of degree programmes called Bachelor of Technology (B. Tech.) in addition to Higher National Diploma (HND) programmes. After acquiring the status of higher education institutions of vocational learning by law, the polytechnics embarked on rigorous curriculum reform. One of the major internal challenges faced by the polytechnics in meeting the demands of relevant curriculum and quality teaching and learning was the professional development of teachers (Nsiah-Gyabaah, 2005; Gervedink Nijhuis, Bakah, & Akomaning, 2009) as curriculum design became their responsibility. A study conducted by Bakah, Voogt and

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Pieters (in press) among the polytechnic staff to find out professional development needs of teachers revealed that the teachers wanted to improve on their knowledge and skills through industrial attachment so as to confidently engage in curriculum design. Based on the findings of Bakah et al. (in press) an intervention was designed which employed a collaborative approach to curriculum design in design teams to support lecturers in redesigning the HND programmes. The use of collaborative curriculum design was considered due to its workable, cohesive and interactive nature and as an effective professional development strategy among teachers (Mishra, Koehler, & Zhao, 2007; Millar, Leach, Osborne, & Ratcliffe, 2006; Nieveen, Handelzalts, Akker van den, & Homminga, 2005; Parchmann et al., 2006; Penuel, Fishman, Yamaguchi, & Gallagher, 2007; Simmie, 2007). A design team is a group of at least two teachers, from the same or related subjects, working together on a regular basis, with the goal to redesign and enact (a part of) their common curriculum (Handelzalts, 2009). The design team concept provides teachers with a creative space to reconsider the teaching of their subject, the intellectual stimulus of working together and the challenge to move the thinking forward; in this way, teachers are invited to become curriculum makers (Simmie, 2007). Designing by teams is one current popular means by which teachers can collectively participate in curriculum design, fulfil their learning, social and intellectual needs and are effective in bringing about teacher professional development (Borko, 2004; Deketelaere & Kelchtermans, 1996; Nieveen et al., 2005; Penuel, Riel, Krause, & Frank, 2009).

Two iterative studies using design teams in collaborative curriculum design among engineering teachers were conducted in two polytechnics. Findings from the first intervention showed that participants acquired relevant knowledge and skills during the intervention (Bakah, Voogt, & Pieters, 2011). Furthermore, collaborative curriculum design enabled active learning and improved cooperation, and dialogue on subject matter among teachers, and was a useful means for their professional development (Bakah et al., 2011). The results of the second intervention also revealed that teachers successfully redesigned their courses in design teams which impacted positively on their professional knowledge and on their classroom practices (Bakah, Voogt, & Pieters, submitted a). Still in the second intervention, Clarke and Hollingsworth's (2002) Interconnected Model for Professional Growth was used to trace individual teachers' professional growth during collaborative curriculum design activities. Results revealed that group discussions of subject matter in the design process as well as teachers' industrial visit in teams improved individual knowledge with an exhibition of idiosyncratic sensitivity to the complex interactions with content and teaching (Bakah, Voogt, & Pieters, submitted b). The success of the interventions

gives credence to the elements of collaborative curriculum design as a useful means of bringing polytechnic teachers together to decide on the curriculum while in the process, updating their knowledge in their domains. Eighteen and eight months after the first and second interventions respectively, curriculum design is still an on-going process in the polytechnics and largely the responsibility of teachers. Thus the aim of this present study is to examine to what extent the intervention has proven to be sustainable and what the potentials and conditions are for large-scale implementation in Ghana's polytechnics.

6.2 THEORETICAL UNDERPINNINGS

Programme sustainability

The term sustainability implies the continuation of a programme in some way. Stoll, Bolam, Mcmahon, Wallace and Thomas (2006) used sustainability to represent elements of continuous growth that is necessary for change where emphases of meaning have been noted to include whether the focus is on continuation of the benefits of the programme to the stakeholders/participants; the perseverance of the new initiative itself; or the process of developing local capacity to enable a programme to be maintained at the stakeholder/institution level. Sustainability may constitute a distinct stage of programme development in recognition of particular requirements for sustained use in the areas of, for example, training (Elias, Zins, Graczyk, & Weissberg, 2003; Osganian et al., 2003). It has also been suggested that the process of programme development (including sustainability) cannot be understood in isolation from the context in which the programme is operating (Goodson, Murphy-Smith, Evans, Meyer, & Gottlieb, 2001; Harvey & Hurworth, 2006). From this position, actions undertaken to initiate sustained use are mediated through the different structures and practices within individual settings and so create a unique set of factors for establishing sustainability. Further, it has been indicated that the necessary conditions required for sustainability need to be planned for at the early stages of programme development (Paine-Andrews, Fisher, Campuzano, Fawcett, & Berkley-Patton 2000). Therefore, these understandings tend to suggest that sustainability may develop from a more interactive relationship between the different stages of programme development and may not be based on a simple linear process (Harvey & Hurworth, 2006).

From a more general perspective, sustainability in educational change involves maintaining improvement over time, learning gains for everyone, and not only a few, support by attainable or available resources and opportunities for diverse

solutions and flexibility (Hargreaves & Fink, 2000). On system level sustainability of a professional development programme is demonstrated by the extent to which the professional development concept is accepted and implemented by different schools in an administrative region persistently (Todorova & Osburg, 2009). Necessary conditions for sustainability are the participation in the programme of a large proportion of the teachers in schools, teachers' positive attitudes and satisfaction with the course, availability of support and transfer of the goals, content and methodology of the programme (Todorova & Osburg, 2009).

Leadership

The factors which influence the sustainability of a professional development initiative are specific in every case and actions for improvement and can be taken when the stakeholders in the school system appreciate its value. Hipp, Huffman, Pankake and Olivier (2008) in a study on sustaining learning communities showed that teachers and leaders exhibited determination to build and sustain the culture of a professional learning community. Thus, how the school visions become reality through what the staffs do is critical to achieving school reform (Fullan, 2000; Mitchell & Sackney, 2001). Successful reform requires purposeful action based on commitment to change. In this regard, the central importance to school-based programme implementation is the support of leadership through the provision of structures, strategies and supports on the path to change (Elias et al., 2003; Kam, Greenberg, & Walls, 2003; Supovitz & Christman, 2003). Continuous improvement in schools is directly related to the breadth and depth of leadership in the school as Hargreaves and Fink (2006) state. Sustainable leadership acts urgently, learns from the past and from diversity, is resilient under pressure, waits patiently for results, and does not burn people out. In fact, leaders in schools that maintain learning and growth over time embrace change and provide supports for staff and students throughout the change process.

Up scaling

After decades of intense educational reform, educators, policymakers, and researchers still grapple with the question of how pockets of successful reform efforts might be "scaled up." Most research on scale tends to define what it means to "scale up" an external reform in quantitative terms, focusing on increasing the number of teachers, schools, or districts involved (Coburn, 2003; Datnow, Hubbard, & Mehan, 2002; Hargreaves & Fink, 2000; Legters, Balfanz, Jordan, & McPartland, 2002). Stringfield and Datnow (1998) define scaling up as 'the deliberate expansion to many settings of an externally developed school restructuring design that previously has been used successfully in one or a small number of school settings' (p. 271). Despite this simple definition, Coburn (2003)

states that it says nothing about the nature of the change envisioned or enacted or the degree to which it is sustained, or the degree to which schools and teachers have the knowledge and authority to continue to grow the reform over time. While the idea of sustainability is fundamental to scale-up, few conceptualizations address it explicitly. It only rarely appears in theoretical and empirical pieces (McLaughlin & Mitra, 2001). Most discussions address issues of sustainability and scale separately, obscuring the way that scale, in fact, depends upon sustainability (Coburn, 2003). While there is ample evidence that sustainability may be the central challenge of bringing reforms to scale. Schools that successfully implement reforms find it difficult to sustain them in the face of competing priorities, changing demands, and teacher and administrator turnover (Berends, Bodilly, & Kirby, 2002; Hargreaves & Fink, 2000; Hatch, 2000; McLaughlin & Mitra, 2001). Scaling up involves adapting an innovation successful in a local setting to effective usage in a wide range of contexts (Dede, 2006). In contrast to experiences in other sectors of society, scaling up successful programmes is very difficult in education (Dede, Honan, & Peters, 2005). Scalable designs for educational transformation must avoid what Wiske and Perkins (2005) term the 'replica trap': the erroneous strategy of trying to repeat everywhere what worked locally, without taking account of local variations in needs and environments. For example, the one-size-fits-all model, does not fit when scaling up in education, because a pedagogical strategy that is successful in one particular classroom setting, with one particular group of students frequently, will not succeed in a different classroom with different students. This suggests the need for a renewed and vigorous dialogue, not just about the challenges of sustainability, but about strategies for providing schools with the tools they will need to sustain the reform (Coburn, 2003). Dede and Honan (2005) identify four key themes in adapting an educational innovation successfully in some local setting to effective usage in wide range of contexts:

1. *Coping with change:* context, leadership, and funding
2. *Promoting ownership:* building constituent support; institutionalizing innovations
3. *Building human capacity:* working with collaborators and partners; providing professional development
4. *Effective decision making:* interpreting data; creating and applying usable knowledge

In the context of innovations in teaching/curriculum, Coburn (2003) describes scale as encompassing four interrelated dimensions: depth, sustainability, spread, and shift in reform ownership. "Depth" refers to deep and consequential change in classroom practice, altering teachers' beliefs, norms of social interaction, and pedagogical principles as enacted in the curriculum. "Sustainability" involves

maintaining these consequential changes over substantial periods of time, and "spread" is based on the diffusion of the innovation to large numbers of classrooms and schools. "Shift" requires districts, schools, and teachers to assume ownership of the innovation, deepening, sustaining, and spreading its impacts. A fifth possible dimension to extend Coburn's framework is "evolution," in which the innovation as revised by its adapters is influential in reshaping the thinking of its designers, creating a community of practice that evolves the innovation (Dede, 2006). The explicit focus on sustainability as a key element of scale also has implications for research design (Coburn, 2003). Other studies in the literature on scale employ designs that sample schools with a range of years of experience participating in the reform (Datnow, Borman, & Stringfield, 2000). In particular, design for sustainability centres on the issue of contextual variation and involves designing educational innovations to function effectively across a range of relatively inhospitable settings (Dede, 2006). Placing reform ownership as a central element of scale raises the priority for directing reform attention and resources to strategies that have the potential for enabling schools and districts to assume ownership for the reform over time (Coburn, 2003).

Educational change

The use of change theory to embed effective change practices into a programme and its implementation process is critical (Harvey & Hurworth, 2006). These structures are linked with a number of the noted sustainability factors such as mutual adaptability, establishing programme champions and assisting school ownership. Of interest these change elements appear to be most effective where schools themselves demonstrated an overt understanding of the process of school change (Harvey & Hurworth, 2006). Teachers are better able to sustain change when there are mechanisms in place at multiple levels of the system to support their efforts. This includes the presence of a supportive professional community of colleagues in the school that reinforces normative changes and provides continuing opportunities to learn (McLaughlin & Mitra, 2001; Stokes, Sato, McLaughlin, & Talbert, 1997), knowledgeable and supportive school leadership (Berends et al., 2002; Datnow et al., 2002; Hargreaves & Fink, 2000; Legters et al., 2002; Murphy & Datnow, 2003), connections with other schools or teachers engaged in similar reform and normative coherence. Fullan (2007) has indicated that collegial relationships facilitated change because change involves learning to do something new, and interaction is the primary basis for social learning. He emphasized that new meanings, new behaviours, new skills, and new beliefs are highly dependent on whether teachers are working as isolated individuals or are exchanging ideas, support and positive feelings about their work. As revealed in a secondary school study by Andrews and Lewis (2002), change in teachers' classroom practices grew out of shared purpose, shared

experience and professional dialogue. In this study, we investigate the sustainability and up-scale of design teams in Ghana's polytechnics, a means by which teachers can continuously engage in collaborative curriculum design and learn from it. Up scaling in this regard is expected to occur in terms of spreading of design teams to other departments and among teachers, increasing teachers' beliefs about social interaction and professional development, maintaining design teams and assuming ownership. Even though teachers have been the target in this collaborative initiative, its sustainability is considered the concern of both teachers and leadership.

The main research question which guided the study was: *What is the potential for sustainability and large-scale implementation of design teams in the polytechnic?* The following sub-research questions were formulated to answer the main research question:

1. Have design teams been sustained in Ho and Takoradi polytechnics?
2. What are teachers' (with and without design team experience) perceptions of design teams as a means for their professional development and to attain curriculum reform?
3. What are the conditions and necessary support for a sustainable and large-scale implementation of design teams according to teachers and leadership?

6.3 METHODS

As indicated earlier, this study is a sustainability study which grew out of a larger programme of research where the investigative site is polytechnics in Ghana. Thus, the cross-sectional survey method (Gray, 2004) is employed in which qualitative and quantitative data collection techniques (Yin, 1993) were used to find out teachers' and leaders' perceptions of the sustainability and large-scale implementation of design teams in the polytechnics.

6.3.1 Participants

The 29 teachers (13 and 16 from Ho and Takoradi Polytechnics respectively) in the design teams described in the introduction above were involved in this study. They were all from the faculty of engineering. Furthermore, 34 teachers (16 from Ho and 18 from Takoradi Polytechnics) who were not members of the design teams also were randomly selected for the study. Persons in leadership at the same polytechnics were also involved. These were vice-rectors (2), registrars for human resource (2), faculty deans (2) and heads of department (4). The faculty

deans and heads of department were directly involved in facilitating the design teams' activities during the intervention.

6.3.2 Instruments

Questionnaires, interviews and focus group interviews were employed to gather data and find out teachers' and leaders' perspectives of the sustainability and up-scale of design teams in the polytechnics. Teachers' responded to close-ended five-point Likert-scale questionnaire items, with one being strongly disagree to five being strongly agree. The scores are interpreted as follows: one is the lowest possible score, which represents a very strong negative attitude, while five is the highest possible score which represents a very strong positive attitude. Teachers who were participants in the design teams were engaged in a focus group interview of between four and six teachers lasting for a minimum of two hours per session. Leadership responded to a semi-structured interview guide in a face-to-face interview lasting about 45 minutes per session.

6.3.3 Data analysis

Thirty items were used to explore the perceptions of teachers who were participants and non-participants in design teams. After a factor analysis using PASW Statistics, twenty out of the thirty items were selected as high loadings on the extracted factors after an exploratory factor analysis. In all, 3 sub-scales were used: professional development (the value of design teams for teacher learning). Collaboration (the act of cooperating, working jointly and group effort in design teams) and curriculum design (the importance of design teams for collaborative curriculum design). Means and standard deviations (SD) were computed for the sub-scales. Table 6.1 shows the internal consistency reliabilities for the design team perceptions sub-scales and the factor loadings for the selected items as reported by the teachers.

T-test was computed to find out whether significant differences existed regarding the perceptions of participants and non-participants in the intervention. Analysis of comparison of data among teachers who participated in the intervention (total 29) employed the Mann-Whitney U non-parametric test (Fay & Proschan, 2010) on assumption that the population cannot be assumed to be normally distributed. Where significant differences were found, effect size was calculated using Cohen's *d* (Cohen, 1988) to find out the extent of the differences. Cohen (1988) provided tentative benchmarks for the interpretation of effect sizes being d=0.2 a small, d=0.5 a medium and d=0.8 a large effect size.

Table 6.1 *Internal consistency reliability for three sub-scales of the teachers' design team perceptions*

Sub-scale	Cronbach's alpha (α)	Items (*n*=63)	Factor loading
Professional development	0.91	*I can improve my content knowledge in a DT*	0.74
		I can obtain new ideas for my course in a DT	0.71
		I like the idea of visiting industry in DT	0.65
		I find it important to share knowledge in DT	0.63
		I learnt from colleagues in DT	0.63
		DT is a useful tool for teacher professional growth	0.58
		I wish to always be part of DT to visit industry	0.53
		DT is recommendable for teacher learning	0.52
Collaboration	0.80	*DT is a source for teacher collaboration*	0.80
		DT engages me in subject matter discussions	0.67
		I like collaboration with fellow teachers in DT	0.59
		It's easy to discuss subject matter challenges in DT	0.59
		We cooperate with each other in DT	0.58
		I like teamwork in DT	0.57
		I open up to my colleagues on challenges I face in my course	0.51
Curriculum design	0.81	*Using DT to identify learning needs interesting*	0.84
		Using DT to evaluate course content is useful	0.71
		I like curriculum design in DT	0.63
		DT is useful for solutions to challenges in my subject	0.59
		DT helped to integrate new knowledge into my teaching	0.59

Note: DT, design team

All interviews were transcribed and coded using codes generated from the study. The coding schemes (Miles & Huberman, 1994) were labelled: *implementation, perceptions, sustainability and up-scaling.* Atlas-ti software version 6.2 was used for the coding of all the interview data. Intercoder reliability (Lombard, Snyder-Duch, & Bracken, 2002; Tinsley & Weiss, 2000) was calculated using a random sample of 5 interviews from 10 leaders and 3 focus group interviews out of 6. There were two coders including the first author of this article. The intercoder reliability using Cohen's kappa (*k*) was 0.87 (interviews) and 0.81 (focus group interviews).

6.4 RESULTS

6.4.1 Sustaining design teams

Teachers' disclosures

All teachers' displayed a level of attachment to design teams several months after the collaborative curriculum design activities. Some of the features of their continuous use of teamwork were part of the original activities that formed design team work earlier on. In Table 6.2, very high means (above Mean=4.06, SD=0.57) were recorded from the teachers' responses in the two polytechnics. Collaborative curriculum design was still a feature among them as shown by items two, five and six while items one, three and four are proofs that teachers engage in design teams for their professional development. Other items such as seven and eight portray the furtherance of design teams. Teachers confirmed that new members joined their design teams as well as the expansion of design teams to other departments within their polytechnic (see items nine and ten). Interestingly, no significant differences ($p>0.05$) existed between the two polytechnics on teachers' outlooks as presented in Table 2.

Table 6.2 *Current use and state of design teams*

	Polytechnic				
	Ho *(n=13)*		**Takoradi *(n=16)***		**Sig.**
Activities and experiences	*M*	*SD*	*M*	*SD*	
Original teams					
1. I still visit industry in a DT	4.08	0.76	4.06	0.57	0.921
2.We share information about our courses in DTs	4.46	0.52	4.44	0.51	0.899
3. We visit industries in DTs to update our knowledge	4.38	0.51	4.50	0.52	0.541
4. DTs still use industry information from previous visits	4.23	0.73	4.19	0.66	0.827
5. We still work in DTs for curriculum design	4.15	0.56	4.38	0.81	0.270
6. DTs evaluate teaching of updated courses	4.46	0.51	4.50	0.52	0.839
7. DT meetings are held regularly	4.62	0.51	4.25	0.78	0.204
8. I engage in all DT activities	4.62	0.51	4.63	0.50	0.958
Expanded/new teams					
9. Other teachers have joined DT s	4.15	0.56	4.00	0.82	0.597
10. DTs have expanded to other departments	4.38	0.51	4.56	0.51	0.349

Note: M, Mean; SD, Standard Deviation; DT, design team.

Aside being members of recognised design teams in their departments, teachers formed their own teams of three or four due to a core subject they teach in order to share ideas on the content and maintain consistency in the information they transmit to their students. The aforementioned was especially among automobile

and electrical teachers in Takoradi Polytechnic (T'Poly) and the electrical teachers in Ho Polytechnic (H'Poly) as in the following statement from a teacher in H'Poly;

> *"The students are in groups for practical lessons handled by three of us. Initially we did not coordinate but after the design team experience, we decided to team up and harmonize what we do and even plan lessons ... we undertook an industry trip to Akosombo hydroelectric plant for information to supplement what we teach. We are even meeting in the next two hours on fluid mechanics."*

Another teacher at T'Poly said that the components in the course is shared among four of them in the areas of welding, theory and practice, manufacturing technology and workshop practice so they formed a team to share knowledge on the course. That teacher concluded by saying;

> *"So far knowledge shared has promoted the course."*

All the teachers except those in H'Poly automobile and T'Poly production, with no tangible reason, have sustained the momentum of undertaking industry trips in their design teams. For instance, the automobile teachers in T'Poly visited the Volta Lake Transport to study transport management, likewise the electrical teachers in T'Poly confirmed that they undertook an interesting trip to the Kpong Hydro Generation Station for a study on turbines, generators and grid-energy storage. Another major activity of design teams which teachers to a large extent held on to was curriculum design. The production teachers in H'Poly informed that they made certain major recommendations for the syllabus in their team which have been approved. This was an encouragement to them as one of them remarked;

> *"Design team has come to stay."*

At H'Poly, two of the original design teams (Automobile and Production) had new members joining while at T'Poly, three original design teams (Automobile, Electrical, Production) also had new membership. Despite the efforts at maintaining the existence of design teams, some challenges have been encountered. The teachers pointed out that long term sabbatical or study leave of teachers affect their design team participation while meeting times were in some cases difficult to locate due to conflicting timetables.

Leadership observations

All persons in leadership position in this study were fully aware of the existence of design teams in some departments in their polytechnics and were generally in favour of its existence. A registrar at T'Poly revealed;

"Management is aware of the teamwork among the electrical, civil and mechanical engineering department teachers and sees it as a relevant measure of teacher cohesion, development and curriculum design."

An engineering faculty dean in T'Poly informed that he was personally involved in forming design teams of three teachers who design students' laboratory lessons in the electrical and production departments and have pre-practical lesson meetings and hopes it will spread to other departments. In H'Poly the engineering faculty dean was aware of design teams and their activities in the faculty. The dean stated that the teams have been planning and undertaking industrial visits. According to T'Poly vice-rector, most of the departments are adopting competency-based teaching and learning which takes the collective effort of all the staff to really groom students to become competent. Thus the dean continued that;

"... To eschew teaching along parallel lines the civil engineering teachers, for instance, are currently working in teams to design and teach the competency-based courses. In fact, these teachers in teams of two and three, make follow-up on students undergoing industrial attachment."

This teamwork under competency-based training is also on-going in teams in the agriculture engineering department of H'Poly as confirmed by their vice-rector who indicated that teachers came together in design teams to update their courses. A registrar at H'Poly pointed out that;

"You know, it is a requirement that as a teacher, you update knowledge and also do research. Therefore by taking advantage of design teams to visit industry, develop the curriculum and so on, the result is knowledge update which is a form of motivation ... so most teachers are interested doing such activities. The teachers meet in teams without hesitation."

Most of the leaders were of the view that the on-going operation of design teams among teachers in some departments in the faculty of engineering has yielded results in terms of teachers' professional development, collegial interaction and syllabus reviews. They acknowledged that it was time to set up design teams as part of the polytechnic system.

6.4.2 Teachers' perceptions of design teams

Table 6.3 shows that teachers who participated in design team activities highly rated it with means above 4.00. However, its usefulness for their professional development was rated highest by all the teachers in both H'Poly and T'Poly

followed by collaboration and then curriculum design. Notable in the results is the similarity in sequence of teachers' perception of design teams from different polytechnics. Meanwhile no significant difference (p>0.05) existed between the two polytechnics in terms of all the variables listed in Table 6.3.

Table 6.3 *Teachers' perceptions of design teams by polytechnic*

	Polytechnic				
	Ho *(n=13)*		**Takoradi *(n=16)***		**Sig.**
Design team perception	*M*	*SD*	*M*	*SD*	
Professional development	4.46	0.19	4.57	0.26	0.199
Collaboration	4.42	0.32	4.34	0.34	0.278
Curriculum design	4.36	0.33	4.03	0.62	0.164

Note: M, Mean; SD, Standard Deviation.

The results as in Table 6.3 indicate that professional growth, teacher cohesion and curriculum design are important for teachers as that is needed for their continuous effectiveness in content and teaching. This is further buttressed by the teachers during focus group interviews as one of them in T'Poly indicated that;

> *"The motivating factor to be in design team is that we are likely to gain more knowledge, acquire new ideas and improve our teaching … by way of delivery, by way of content and so on."*

Table 6.4 *Teachers' perceptions of design team by participation*

	Participation in design team					
	Participants *(n=29)*		**Non-participants *(n=34)***		**Sig.**	**Effect size**
Design team perception	*M*	*SD*	*M*	*SD*		
Professional development	4.52	0.24	3.95	0.50	0.0001*	1.45
Collaboration	4.37	0.33	4.10	0.54	0.021*	0.60
Curriculum design	4.18	0.53	3.67	0.55	0.0001*	0.94

Note: M, Mean; SD, Standard Deviation; * p <0.05.

In Table 6.4, results establish the magnitude of design team impact on teachers who experienced it as against those who are not yet members. Significant differences (p<0.05) existed among participants and non-participants in terms of professional development, collaboration and curriculum design with participants appreciating design teams more than non-participants. There were high effect sizes for all three components as in Table 6.4. Nevertheless, it is worth noting that the means and standard deviations of the non-participants were quite high and thus show that they have high regard for design teams.

6.4.3 Conditions and support necessary to up-scale design teams

All teachers, whether participant or non-participants in the intervention, responded to items on means by which design teams can be sustained and up scaled in the polytechnics. The items were categorised according to the interrelated dimensions of scale by Coburn (2003) which are depth, sustainability, spread, shift and evolution in reform ownership. The occurrence of these dimensions (see Table 6.5) is relatively equal. In Table 6.5, a comparison is made between all teachers who are design team members and those who are not (using independent samples t-test), regarding their responses to conditions and support needed to scale-up design teams. Results show that significant differences (p<0.05) were present between participant and non-participant teachers for 16 out of the 18 items. All the teachers see the need for design teams to spread across the polytechnic and should be done through creating its awareness and formal recognition in the polytechnics. Generally medium (item 5, d=0.65) to large (item 15, d=1.07) effect sizes were found for the 16 items in Table 6.5 which indicates that the intervention had positive effects on teachers who participated in it and thus they agree more to conditions and support necessary to scale-up design teams.

The results of only design team participant teachers (29) were compared by polytechnic, regarding the conditions and support necessary to scale-up design teams. Using the output of a non-parametric Mann-Whitney U test revealed high means (above 4.00) and standard deviations for all the items among the teachers in the two polytechnics. However, significant differences (p<0.05) with large effect sizes existed between teachers in the two polytechnics related to 4 out of the 18 items in favour of T'Poly teachers which is much larger and older among the two polytechnics. The effect sizes for the 4 items are: there should be a design team coordination team (d=0.83); leadership should organise design team awareness seminars (d=0.85); design team should have representation on curriculum committees (d=0.96) and record keeping should be done at design teams (d=1.01).

Table 6.5 *Conditions and support necessary to up-scale design teams by teacher participation*

		Participation in intervention					
		Participant (*n*=29)		Non-participant (*n*=34)		Sig.	Effect Size
Measures (*α*=0.91)	**Dimensions of scale**	*M*	*SD*	*M*	*SD*		
1. DT team meetings should be made part of school schedule	*SH*	4.38	0.56	3.59	0.89	0.000*	1.06
2. Teacher development needs should be accessed through DTs	*EV & SU*	4.41	0.50	3.88	0.81	0.003*	0.79
3. DT activities should be recognized by the academic board	*SU & SP*	4.62	0.49	4.09	0.80	0.003*	0.80
4. DT activities should be reviewed at faculty board meetings	*SP & SH*	4.24	0.44	3.94	0.78	0.069	n/a
5. DT activities should be given attention at departments	*SP & SH*	4.41	0.50	4.00	0.74	0.013*	0.65
6. DT activities should be publicised regularly in polytechnic	*SU & SP*	4.38	0.49	3.79	0.88	0.002*	0.83
7. Leadership should occasionally interact with DTs	*SP & EV*	4.52	0.57	3.85	0.70	0.000*	1.05
8. There should be a design team coordination team	*SU, SP & SH*	4.34	0.61	3.79	0.81	0.004*	0.77
9. Every teacher should be design team member	*SP*	4.28	0.53	3.82	0.58	0.002*	0.83
10. Leadership should organise design team awareness seminars	*SU & SP*	4.34	0.48	4.18	0.63	0.243	n/a
11. DTs should have representation on curriculum committees	*DP & EV*	4.69	0.47	4.15	0.93	0.006*	0.73
12. Leadership should encourage curriculum design in DTs	*DP, EV & SH*	4.55	0.57	3.91	0.79	0.001*	0.93
13. Teachers in DTs should be motivated	*SP*	4.52	0.51	4.12	0.69	0.012*	0.66
14. DTs should advice leadership on teacher development	*DP, EV & SH*	4.34	0.61	3.88	0.73	0.009*	0.68
15. DTs should conduct regular scrutiny of the syllabus	*DP, EV, SH & SU*	4.69	0.47	4.12	0.59	0.000*	1.07
16. Sharing of ideas should be encouraged in DTs	*DP, EV, SH. SU & SP*	4.59	0.50	4.18	0.72	0.012*	0.66
17. Record keeping should be done at DT meetings	*SU & SH*	4.31	0.47	3.79	0.88	0.006*	0.74
18. DT should engage in professional development activities	*DP, EV, SH & SU*	4.66	0.48	3.94	0.85	0.000*	1.04

Note: M, Mean; SD, Standard Deviation; * p <0.05; DT, design team; DP, Depth; SU, Sustainability; SP, Spread; SH, Shift; EV, Evolution (Coburn, 2003); n/a, Not Applicable.

During the teacher group interviews, a number of issues were raised for the sustainability and large-scale implementation of design teams in the polytechnics. Some factors identified were common to the two polytechnics as for example most of teachers were generally of the view that much depends on them to build effective and workable design teams in the polytechnic: through being cooperative and appreciating the value of teamwork in design teams for their professional development and curriculum design. The sensitive issue of financial motivation for design team members generated interesting but lengthy discussions and even nearly arguments. Two schools of thought emerged, being those who were for or against design team allowances. In the minority were teachers who advocated for financial motivation for design team members. A greater number of teachers were of the view that teachers in design teams should not receive monetary rewards with reasons as follows:

1. some teachers will end up in design teams because of the financial benefits
2. the meaning and purpose of curriculum design and professional development might be lost
3. the polytechnic may be unable to pay teachers if all of them decide to be design team members
4. design teams may seem like working polytechnic committees that receive sitting allowances
5. lack of finance may be an excuse for leadership not to push the design team agenda or delay its large-scale implementation
6. monetary affairs can easily aggravate tension and derail design team activities

The general unacceptability of financial motivation for design teams among teachers may be a partial contradiction of results in Table 6.5 where item 13 (teachers in design teams should be motivated) had high means from both participant (mean=4.52, SD=0.51) and non-participant (mean=4.12, SD=0.69) teachers. Motivation in Table 6.5 is partly non-monetary since other support (listed in Table 6.5) needed to sustain design teams have on the whole been advocated by the teachers. Other suggestions from teachers and leadership to facilitate the sustainability and large-scale implementation of design teams in the polytechnics were that: There should be a policy for mandatory design team membership, orientation should be organised for new design teams members, teachers' letter of appointment should oblige design team membership, criteria for teachers' promotion should include design team accomplishment and design team should be spelt out in the polytechnics strategic plan.

6.5 DISCUSSION

This research was conducted in an effort to gain insight into the sustainability and large-scale implementation of design teams in polytechnics in Ghana. This study was conducted 8 to18 months after an intervention in two polytechnics where teachers in design teams collaboratively designed their courses based on knowledge updated from industry. Data from the two polytechnics generated an interesting cross-section of findings that provide useful insights into the design team sustainability efforts of the teachers and leadership as well as design team up-scaling in the polytechnic system. The findings show that teachers adopted strategies and methods consistent with their own knowledge and experiences with design team activities in the polytechnics within the months under review through maintaining collaborative curriculum design activities, industry visits to strengthen practical knowledge and keep abreast with industrial innovation as well as promoting effective teaching among others. This is akin to the findings of Hipp et al. (2008) in a study on sustaining professional learning communities which revealed that staff sustained professional learning communities through maintaining a collaborative and professional culture, teamwork and shared responsibility among others. As in the findings of Fullan (2000) and Mitchell and Sackney (2001) visions becoming reality through what staff do is critical to achieving school reform. The task of sustaining design teams may be challenging and difficult but worth tackling because of the potential benefits in terms of professional and curriculum development. The practices of design teams in this study is comparable to the finding of Todorova and Osburg (2009) that sustainability of a professional development programme is demonstrated by the extent to which the professional development concept is accepted and implemented persistently.

The formation of new design teams in other departments is an indication of its spread which is an aspect of scaling up (Coburn, 2003) and an indication of diffusion of design teams to other departments. A further indication of spread was the finding that new members joined most of the design teams that were formed during the intervention. These are evidences of scalability of a design in education which is in contrast to Dede et al.'s (2005) assertion that scaling up successful programmes is very difficult in education. Though the design teams have not been formally instituted by policy, they are being maintained in some departments and the awareness and benefits of design teams for professional development, collaboration and course design is valued by teachers and leadership and its enormous returns for teaching and learning are respected. To sustain design teams in the polytechnics, teachers want leadership to recognise and encourage design team activities. Teachers' concern for leadership support as identified in this study

confirms studies of Supovitz and Christman (2003) and Hargreaves and Fink (2006) that the role of educational leaders through the provision of structures, strategies and supports are critical on the path to change. Teachers highly advocated the making of design team part of the polytechnic system but admit that it will require time, effort and commitment from themselves and leadership as is the view of Harvey and Hurworth (2006), Paine-Andrews et al. (2000) and Hipp et al. (2008). It is encouraging to discover that leadership is aware and allows the operation of design teams in the polytechnics. Meanwhile even though design teams' teacher motivation in general is acceptable among teachers, it is feared by both teachers and leadership that financial incentives in particular for design team members might hinder its smooth upscale and sustainability and therefore should not be encouraged. Suggestions by both teachers and leaders to facilitate design team sustainability and large-scale implementation weighed heavily on leadership in the two polytechnics to officially establish policies to encourage teachers and guide design team existence as indicated by Elias et al. (2003), Kam et al. (2003), Supovitz and Christman (2003) and Hargreaves and Fink (2006) that of central importance to school-based programme implementation is the support and leadership of the school leader through the provision of structures, strategies and supports on the path to change.

Design team challenges enumerated by teachers included heavy teacher workload as well as difficulty in locating meeting times. Thus challenges are common occurrences in sustaining programmes as Berends et al., (2002), Hargreaves and Fink (2000) and McLaughlin and Mitra (2001) state that competing priorities, changing demands and teacher and administrator turnover are some of the challenges in the sustainability of educational programme. Despite the challenges, there are some opportunities which offer fertile ground for design team sustainability in polytechnics. Perhaps the most significant opportunity being that both teachers and leadership do not perceive the sustenance and scaling up of design teams as an arduous task. Such positive stance confirms the finding of Todorova and Osburg (2009) that positive attitudes of teachers and leadership are a necessary condition for sustainability. Teachers and leadership are basically aware of the usefulness of and value design teams due to their past experiences with it. Furthermore, leadership see the worth of design teams and show commitment to its course and also the polytechnics are autonomous institutions which can easily make their internal decisions without outside interference. Design teams encourage collegial relationships and provide continuing opportunities to learn which is in itself a catalyst for change and is similar to Andrews and Lewis's (2002) finding that change among teachers grew out of shared purpose, shared experience and professional dialogue. There is the potential of sustainability however, for design teams to be incorporated in

the polytechnic structure it needs to be better managed by polytechnic regulation. At length, promoting factors revealed in this study make us conclude that design team sustainability is more likely to continue.

6.6 CONCLUSION

This study illuminates some characteristics of sustainability of design teams in educational institutions particularly higher education contexts and challenges on the path to change. Large-scale implementation and sustainability of design teams seem promising due to supportive factors such as the maintenance and expansion of original design teams and staff awareness and commitment. It can be said that design team is a recognised part of the on-going system in some departments in the two polytechnics and has opportunities for teachers to learn and practice innovative approaches over a prolonged period of time, to work collaboratively on authentic design tasks and to influence the choice of activities toward addressing their learning needs. There are visible advantageous conditions, such as appreciation of collaboration by teachers and leaders, to sustain teamwork in design teams in the polytechnics. Teachers adopted strategies and methods consistent with their own knowledge and experiences with design teams, such as course update and industry visits. Teachers and leadership in educational institutions have found themselves battling with change especially initiated by national, state or local authorities to raise standards of achievement. However in this case, the teachers and leaders find themselves in higher institutions that are autonomous thus can take priority over their own vision of desirable improvements; especially as the study has shown an environment of promising opportunities. As circumstances in the polytechnics have so far permitted, it makes sense for polytechnic leaders to aim to promote design teams based on the institutional strength, that is, a clear articulation of goals and objectives and internal guidelines for operation.

6.7 REFLECTION ON OUTCOMES

Studying adaptability and scalability and then examining their validity and value is an important frontier for sustainable reform which will measure the degree to which the educational effectiveness of a design is robust despite attenuation of its conditions for success. Through identifying factors within the intervention's context that represent important conditions for success and summarizing the extent to which the effect of the intervention is sensitive to variation in each, we

could provide prospective adopters of the intervention a better sense of what its likely effectiveness could be in their own particular circumstances. The detailed programme design and supporting implementation strategy helped to sustain use of design teams at the polytechnics. The underlying design of design teams emphasised teacher and leadership involvement and ownership, identification of learning needs, links with existing policies and structures regarding curriculum design and an already pending need for teacher development to support the polytechnic reform process. An additional feature that also appeared to assist with the continuous use of design teams was the use of evidence-informed research in the development of the programme. Understandings of best practice in teamwork among teachers were combined with current knowledge about design team usage for collaborative curriculum design. The use of this broad theoretical underpinning appeared to strengthen the specific design of the strategies for planning and implementing collaborative curriculum design through design teams. The components of collaborative curriculum design were set in a purposeful and tangible process of curriculum reform in Ghana's polytechnics. Another essential component of the strategy was the formation of a group of design teams by committed teachers, particularly in the older polytechnics. These were teachers who became dedicated to the initiative and made sure that knowledge learnt in the industries was applied to other areas of the curriculum. In addition, design team is genuinely a 'living place' within the polytechnic with teachers working on improving knowledge, curriculum, teaching and learning. The already collegial relationship which characterises design teams is supportive and a mechanism to reinforce normative change and provide continuing opportunities to learn. The most important supportive contextual feature for sustained design team use was generally based on the leaders' support of especially heads of department and faculty deans. This boosted teachers' enthusiasm since some of these heads encouraged the formation of new design teams. Most teachers had a clear commitment to continuous improvement and saw the design teams as useful means for this process. We are however conscious of the fact that the process of re-culturing the polytechnic teachers as professional learning teams is a journey as evidenced by the time, energy and resources being exerted to move from implementation to sustainability.

CHAPTER 7
Reflection

This design-based research sought to provide professional development support for teachers through collaborative curriculum design in design teams. The curriculum reform scenario in polytechnics in Ghana offered enough grounding to embed teacher development in curriculum development, with the ripple effect of teacher professional development on their classroom practices. The purpose of this chapter is to reflect on the outcomes of the professional development approach as was intended for teachers in the faculty of engineering in two polytechnics in Ghana. In particular, this chapter entails a summary of the previous chapters. Thereafter is a reflection on the outcomes of the entire study and design-based research approach. The chapter ends with recommendations for practice and directions for future research.

7.1 DISSERTATION OVERVIEW

7.1.1 Introduction

Polytechnic education in Ghana has advanced considerably over the past 60 years and more. Recent developments in polytechnic education in Ghana which are government and polytechnic policies towards the provision of relevant technical and vocational education raise hopes of a bright future for the changing student and workforce needs. Today's polytechnic teacher has a mission to prepare students for the ever increasing workplace requirements. Consequently, teachers, who create and manage the curriculum to prepare students for success in their workplace, require up-to-date knowledge and skills. The realization of world-class education is a dream of every researcher, higher education institutions and governments. However, their creation and the maintenance of their status are not easy even in developed countries. This research was an attempt to provide professional development support for teachers in design teams to collaboratively update their courses. It was conducted in polytechnics in Ghana. Polytechnic development, curricular reform, updating teachers' knowledge-base and improving the quality of teaching

prompted this research. This research helped to gain a better understanding of issues related to collaborative curriculum development and teacher learning in the context of curriculum reform. The work of design teams was at the core of the process and was the focus of the research venture. In all, two polytechnics, six design teams were followed during their collaborative course design.

7.1.2 Aim and research questions

In this research, teacher professional development during collaborative design of their courses was investigated in two polytechnics in Ghana. Teachers' collaborative course update was facilitated through design teams during which they undertook industry visits to strengthen their knowledge-base for their effective contribution to a relevant curriculum and to classroom practices. Specifically, the professional development support for teachers in design teams was for them to (1) update their courses through collaborative course design; (2) effectively engage in curriculum design to ensure curriculum relevance; (3) update their knowledge and skills in their respective domains; (4) apply relevant knowledge in their classroom practices, and (5) enhance collegial interaction and collaboration. The main question that guided the conduct of this research was; *what is the impact of collaborative curriculum design on teacher professional development and curriculum reform practices?* In order to find answers to the main question, the following sub-questions informed the research:

1. What training and development needs of teachers exist in a curriculum reform scenario?
2. What is the impact of design teams, as a professional development arrangement, on teachers' knowledge and skills?
3. What is the impact of design teams on teacher professional learning and curriculum reform practice?
4. How does teacher participation in collaborative curriculum design activities impact on their professional growth?
5. What is the potential for sustainability and large-scale implementation of design teams in the polytechnic?

This research afforded teachers in Ghana's polytechnics the dual opportunity to improve their knowledge and skills in design teams and collaboratively design their courses in light of current technological advancements at the industrial sector. Design teams were not only helpful for updating teachers' knowledge and skills in their respective subject areas but also offered them the opportunity to strengthen their curriculum design skills and improve collaboration among them. The already existing curricular reform situation in the polytechnics offered fertile grounds for collaborative design. Furthermore this research enhanced teacher professionalism and knowledge as polytechnics embark on boosting

teachers' professional development to commensurate polytechnic academic standing in a curriculum reform situation.

7.1.3 Recapping research phases and results

Teachers' training and development needs in a curriculum reform scenario
At the initial stage of the research, a context and needs analysis study was conducted among teachers and leadership in four polytechnics, the report of which is detailed in Chapter 2. The research question for study was; *what training and development needs of teachers exist in a curriculum reform scenario?* The study revealed the training and development needs of teachers during the polytechnic reforms. Results showed that updating teachers' knowledge in their subject areas through embarking on industrial attachment was their major training and development need. The teachers preferred to visit industrial settings of their subject domains in order to update their knowledge and skills concerning current technologies being used. Teachers indicated keenness in getting more involved in curriculum design activities and advocated improvement of their content knowledge to confidently engage in curriculum design. Lessons drawn from this study kindled thinking about whether higher education teachers need to regularly assess their professional development needs, especially if they want to make relevant contribution to curriculum reform. This study advanced knowledge of the effectiveness of self-identified training and development needs of teachers in higher education since it forms the basis for the conduct of systematic and sustained in-service programmes to boost knowledge and skills for curriculum reform. Accessing teachers' knowledge needs towards effective curriculum design helped to provide useful insights into the depth of teacher knowledge for their curriculum design roles. Teachers' assessment of professional development needs was an attempt to reflect, analyse and improve course content and classroom practices and bring forth change. Whereas the constituents of curriculum development were accessible through the knowledge and skills of teachers, attitude and awareness of teachers' training needs helped to attract a professional development experience to support curriculum development. The conclusion was that the potential of a collaborative approach by teachers can update their knowledge and skills through industrial attachment, with a view to get effectively involved in curriculum design, was necessary.

Updating polytechnic teachers' knowledge and skills through design teams
Based on the outcomes of the context and needs analysis study, an intervention was conducted in which teachers in three design teams in the faculty of engineering in one polytechnic updated their HND courses. This stage of the research was guided by the question; *what is the impact of design teams, as a professional development arrangement, on teachers' knowledge and skills?* To

improve the teachers' knowledge-base, they visited industrial settings to obtain information on current technological advancements in industrial operations, machines and equipment. The teachers conducted teaching try-outs of the updated courses which were subsequently evaluated by their students. Findings, as reported in Chapter 3, were that teachers successfully redesigned their courses in design teams which impacted positively on their knowledge and classroom practices. They acquired subject matter knowledge and skills, curriculum design skills and collaborated effectively to enhance subject matter dialogue and interaction. Furthermore, design teams enabled active learning and dialogue on subject matter among teachers and were a useful means for the professional development process. It becomes evident from this study that in professional development, it is worthwhile to engage teachers in teamwork to rigorously plan and implement their own learning. It was recommended that for design teams to be more robust to carry out their activities, teachers must see themselves and each other as learners in the team, this may to a large extent encourage tolerance and mutual understanding and reduce dominance. Also, in order not to evade the goal of learning by design, it is necessary for teachers to understand the principles of developing themselves and their courses. In addition, meeting regularly and varying design team activities is likely to prevent boredom, eschew passive behaviours and encourage participation.

Determining teacher development and curricular quality through collaborative curriculum design

The purpose of the third study as detailed in Chapter 4 was not only to confirm the findings from the previous study that working in design teams enhanced courses and is a promising means of teacher professional development but to assess collaborative curriculum design as a method for the continuing professional development of teachers. The research question posed for the second intervention was; *what is the impact of design teams on teacher professional learning and curriculum reform practice?* Engineering teacher design teams in another polytechnic updated their courses to commensurate contemporary industrial skill demands as well as update their own knowledge in their subject areas. They also embarked on industrial visits, incorporated relevant information in their courses and conducted teaching try-outs. Results indicated that teachers updated their domain knowledge and skills, design teams improved teacher collaboration while teacher ownership of and commitment to quality curriculum increased. Teamwork gave way for varied ideas to enrich their courses. Findings from this study authenticate the valuable characteristics of collaboration among teachers as a useful means for teacher interaction and teacher learning and design teams served that purpose well. It also highlights the importance of engaging teachers in the update of their own courses as well as making them conscious of maintaining curriculum quality and relevance. More so, it became

clear from the implications of the study that it is worthwhile to connect teachers through teamwork and allow their reflections on current practices and promote creativity. It was concluded that the relational nature of the interdependencies between the social and individual contributions to curriculum design illuminates the fabric of teachers' continuing professional development.

Tracing the professional growth of individual teachers in a design process
This aspect of the research as expanded in Chapter 5 was investigated during the second intervention and extended the research beyond the group case studies and broad surveys. In particular, the Clarke and Hollingsworth's (2002) Interconnected Model of Professional Growth (IMPG) was used to meticulously trace individual teacher professional growth as it occurred during teamwork in collaborative curriculum design. The research question for this study was; *how does teacher participation in collaborative curriculum design activities impact on their professional growth?* The results indicated that individual professional growth occurred in an interconnected manner and with an exhibition of idiosyncratic sensitivity to the complex interactions with content and teaching. Collaborative curriculum design enabled individuals' active learning. The findings suggest that tracing teacher growth in an interconnected manner results in in-depth knowledge of teacher learning and change. The IMPG unearthed rich details through an analytical look into teacher professional growth emanating from their own professional practices and the interdependence of multiple factors in diagnosing teacher change. It was recommended that higher education institutions in developing countries need to consider assessing teacher change in teacher learning systems yet unexplored as designers of in-service programmes could consider using complex models to discover teacher idiosyncratic and personal development; anticipate and promote concrete tasks to penetrate all avenues of their profession; and provide recognition of the situated and personal nature of teacher practice and growth.

Issues and opportunities in advancing perspectives of sustainability and large-scale implementation of design teams
This final stage of the research (as presented in Chapter 6) was an impact study on the sustainability and the potential for large-scale implementation of design teams in the two polytechnics studied. This sustainability study was conducted eighteen months after implementation of the first intervention study and eight months after implementation of the second intervention study. The research question for this study was; *what is the potential for sustainability and large-scale implementation of design teams in the polytechnic?* Teachers and management shared their insights and reflections on the programme and the way ahead for teacher learning in the polytechnic. The results showed that teachers still collaborated in design teams for curriculum design and professional

development. Leaders' activities and behaviours were identified as supporting the sustenance of design teams. The findings showed that large-scale implementation of design teams seem promising due to supportive factors such as the maintenance and expansion of original design teams and staff awareness and commitment. There is the potential for sustainability however, for design teams to be incorporated in the polytechnic structure, it needs to be better managed by polytechnic regulation. Some identified inherent opportunities are outlined for sustenance and conclusions drawn based on the characteristics of the programme, contextual features and polytechnic climate. Opportunities are that collaboratively, working on authentic design tasks holds prospects for teachers to address their learning needs. The characteristics of the programme also contributed to the continuous use of design teams. For instance, the underlying design of design teams emphasised teacher and leadership involvement and ownership, identification of learning needs, links with existing policies and structures regarding curriculum design and an already pending need for teacher development to support the polytechnic reform process. Using evidence-based research promoted the understanding of best practices in teamwork among teachers together with current knowledge about design team usage for collaborative curriculum design. The already collegial relationship which characterises design teams enhanced a normative change and provided continuing opportunities to learn.

7.1.4 Reflections on outcomes

In this research teachers' professional development was supported during collaborative design of their courses in a curriculum reform context in polytechnics in Ghana. Teachers in the mechanical and electrical departments of the engineering faculty in two polytechnics received support through design team introductory workshops, teamwork in design team and industry visitations. The professional development of teachers took place in several forms during the collaborative course design process facilitated through design teams. Outcomes in this dissertation have shown that collaborative curriculum design in design teams did not only improve the relevance and quality of curriculum but was a valuable means of teacher professional development and had positive impact on their teaching.

Domain knowledge

Teachers acquired subject matter knowledge during collaborative curriculum design activities in design teams. They discovered central concepts, facts and principles relating to their courses. Teachers had a broader and deeper understanding of certain topics in the courses they teach. Due to the importance of practical lessons teachers teach, they learnt about tools, the functioning of

some equipment, the maintenance procedure for certain machines and certain production processes. (1)Teachers developed their knowledge further through interacting with colleagues on subject matter. Both experienced and less experienced teachers within the teams learned from each other's contributions on subject matter. (2) Delving into the syllabus to identify need areas for update and the process of reshaping content were learning grounds for teachers as they immersed themselves in their domains to ensure curriculum quality. (3) Teachers learned as individuals since they personally discovered certain information, knowledge and skills from others; their idiosyncratic sensitivity to the complex interactions with content, teaching and fellow teachers improved their knowledge-base. (4) For the group, interactions on team assignments were pervasive. They also viewed their learning as a collective venture due to the continual interactions for a relevant curriculum. (5) In addition, teachers' industry visits strengthened their knowledge-base for effective contribution to a relevant curriculum. They discovered relevant knowledge at the industries concerning contemporary industrial operations, services and servicing, machines and equipment as well as procedures in production. This direct contact and interaction at the industries constituted firsthand knowledge acquisition in subject matter domains and was useful and handy for teacher professional development, course update and teaching. Apart from getting to know about relevant industrial trends, teachers individually handled equipment in brief training sessions to improve their hands-on experience. The personal handling of equipment through training at the industry boosted the practical skills of teachers and was a relevant experience for their practical lessons in particular. In effect, teachers acquired domain knowledge during collaborative curriculum design of the syllabus in this research.

Curriculum design knowledge

During collaborative curriculum design, teachers shared experiences and learned from each other since the target for them was mutual growth and attainment of shared instructional and curricular goals. Their participation in curriculum design activities increased knowledge in curriculum design and content. Teachers became more skilled in discussing and describing content on the basis of curriculum components (Akker van den, 2003). They became more familiar with the structure of the syllabuses and stated objectives. Additionally, teachers' reflections on subject matter, delivery and outcomes in the teams enhanced interaction and knowledge sharing. (2) Involvement in collaborative curriculum design granted teachers the opportunity to reflect on realistic challenges they encountered with their courses both in theory and practical lessons. The examination of course structure and its update impacted positively on teachers' skills and competence for course redesign and teaching. Analysing the course structure, incorporating competencies that students need to possess,

balancing technical and industry-specific skills and bridging the gap between the syllabus and industry competency standards were among the concrete practical tasks and learning experiences for teachers. (3) Through collaborative curriculum design, teachers learned to bridge the gap between the syllabus and industry competency standards, and they designed situational learning experiences based on the understanding of workplace contexts and changes. They embarked on their design tasks which called for documenting their newly acquired knowledge from industry for curriculum design purposes, a process which had phenomenal effects on their knowledge through the intensive brain work to restructure their syllabuses to reflect current needs of industries. (4) Teachers received pedagogical support from the team for the teaching of updated courses after the course redesign. Discussions on delivery were useful since teachers needed pedagogical support to present certain fresh industry information to students. (5) The teaching try-outs were based on the updated courses and were also a learning ground for teachers and enabled them to practice what they had learned from the industries. Teachers therefore gained knowledge in curriculum design during the collaborative curriculum design process in this research.

Knowledge through collaboration

Teachers acquired knowledge through interacting with each other during collaborative curriculum design in design teams to improve their instruction. (1) Collaboration among teachers in design teams enhanced their knowledge in content and curriculum design. It opened up the opportunity for dialogue on their subject matter, discussions on what should be taught, and brainstorming on relevant information from industry and brought teachers with varied experiences and ages to a level of thinking and cohesion. Their collaboration enabled them to converse knowledgably about the curriculum to achieve the objectives of the programmes. (2) Collaboration thus enabled teacher interdependency and interaction. Their participation in design teams for course design improved collaboration making them discover how to share knowledge and ideas, to communicate with others, be resourceful, broadminded and tolerant as well as to learn how to find information on subject matter. (3) There were consequences of design teams during the design process such as tolerance of diverse characters and behaviours, seeking ideas from colleagues, unearthing of research ideas, learning to communicate with others, uniting with others to achieve set targets and being open to criticisms. In this research therefore, teachers' collaboration in design teams during collaborative curriculum design resulted in knowledge acquired in diverse ways on content, designing the curriculum and teaching.

Usefulness of design teams

The foray into design teams helped to understand how teachers negotiated their environments in relation to their own learning. The design team concept in this research aimed at providing an environment for teachers to engage in collaborative curriculum design, and where teacher professional development can take place. (1) Teachers benefited from collaboration in design teams as it stimulated their learning from one another and from group initiatives. Individuals had the opportunity to expand their experiences; therefore teacher collaboration in design teams was particularly successful in promoting teacher learning. (2) Teacher learning and professional development was impressive during collaborative curriculum design in design teams. The approach changed teacher practices and beliefs with regard to improving their knowledge and skills and had important implications for teacher professional development in higher education. (3) Groups of teachers meeting to share and work together provided an opportunity to extend their professional boundaries which they found very interesting. Their professional activities which included curriculum design embedded individuals' learning in the social environment of the design teams. (4) It became evident that in professional development, it is worthwhile to engage teachers in teamwork to rigorously plan and implement their own learning and deliberate on the curriculum. Findings from this research provided evidence that design team approach in collaborative curriculum design can foster teacher professional development and collaboration. The research provided new insights for professional development activities which employ teamwork for teacher learning and change. Design teams in this intervention clearly appeared to be a worthwhile approach to teamwork among polytechnic teachers for them to update their knowledge and skills, update their courses and improve teaching. It becomes evident from the implications of this research that it is useful to connect teachers through teamwork and allow their reflections on current practices and promote creativity. Given promising findings, it is worthwhile considering the application of this research in other polytechnics in Ghana and in sub-Saharan African due to its far reaching implications.

7.1.5 Reflections on methodology

Design-based research was a suitable approach to this research in the polytechnic context in Ghana. The manifestation of a great proportion of its characteristics in this research enabled the successful implementation of collaborative curriculum design in design teams in the polytechnics studied. From the initial stages of the research to the end, it empowered teachers to take responsibility and ownership regarding curriculum design and their own learning. According to McKenney, Nieveen and Akker van den (2006), when research

methods are creatively and carefully designed, they can contribute to the tertiary output of design research which is the professional development of the participants. In this research, the intervention in itself was a professional development programme which had an output of teacher professional development.

Preliminary investigation sought information from a cross-section of polytechnic staff including teachers and leadership on curriculum tasks, problems and context in order to define the problems. It allowed for the problem being addressed to be situated in educational practice. Despite the depth of stakeholder involvement, the teachers seemed unsure whether the results will be taken serious. To them, it appeared as another research headed for the shelf, however, the return of the researcher for the implementation stage helped to win the cooperation and trust of the polytechnics staff. Teachers had confidence in the approach to support them in their curriculum activities and professional development. As a result of collaboration between the researcher and practitioners, teachers became convinced that action was being taken for their professional development and content development based on their own recommendation. This again won their trust and confidence since their "voices" had been heard and considered. At the implementation stage, they became certain of the practical nature of the intervention and its relevance for the polytechnic context. Due to a diversion from the traditional form of research educational research, teachers became interested in the outcome and hence showed commitment to it. The participation of teachers was an important form of professional development and created awareness of how research can contribute to improving their professional context.

The sustainability and upscale study was a means to assess the practicality, effectiveness and large-scale implementation of the programme. The researcher acted as the facilitator in the development of solutions that were viable both theoretically and practically, together with teachers. Despite the researcher's influence in the integration of collaborative curriculum design in design teams among teachers, it did not affect the sustainability of the programme because teachers found design teams practical in the departments due to the already existing committee activities in the polytechnic system. Furthermore, teachers found design teams to be suitable for addressing challenges with content and curriculum. The variety of data sources used in the research guaranteed triangulation to increase the quality of data and eschew researcher biases.

The two iterations in this research strengthened the aims and sharpened the contextual perception of the collaborative curriculum design situation. Collaborative curriculum design in design teams was successful since curriculum

design was the order of the day as a result of curriculum reform in the polytechnic. Design-based research approach provided opportunities to improve the curriculum and generate knowledge as well as to contribute to a curriculum perspective. Curriculum products were improved and opportunities for professional development created.

7.1.6 Recommendations for practice

The use of collaborative curriculum design in design teams employed in this research emerged as a useful venture for the update of teachers' knowledge and skills. The concept of design team has made considerable progress in defining what counts as professional development among the polytechnic teachers in this research as well as in delineating conceptualizations of how professional development works. As revealed earlier, the approach enhanced teacher knowledge, course design and teaching in two polytechnics in Ghana. At the final stage of this research was a study to find out the sustainability and large-scale implementation of design teams in the polytechnics. Findings revealed important leads to sustaining collaborative curriculum design in design teams in the polytechnics. Contextual features and polytechnic climate seem to be major supporting factors for sustainability. Despite the current level of awareness of design teams in the two polytechnics, it is still important for management to encourage design teams in the polytechnics as curriculum design and professional development continue to fall within the boundaries of teachers' profession.

The maintenance of a professional learning culture in the polytechnics will require leaders to support institutional change. A clear articulation of policies within the framework of the polytechnics' academic milieu could ensure better grounding for design teams and make it permeate all the departments in the polytechnics. Leadership support is essential to the sustainability of design teams since they can be helpful in providing teachers with positive incentives such as verbal encouragement, allocate time for meeting and liaisons in promoting a positive attitude towards design teams. There is the need for departments to assign curricular responsibilities to design teams and maintain it by allocating meeting times to fall within the polytechnic schedule. The importance of effective teamwork during participation in the programme can also be capitalized on by leadership, through improving the conditions and support for collaborative work within design teams. That effectiveness depends in part on unified commitment from members: loyalty to and identification with the team, fostered through a balance between respecting individual differences and requiring unity.

Teachers' attitude and satisfaction with a design team can have a strong influence on the interest of teachers who have not participated in this professional development offering. In effect, communicating the character and outcomes of design teams to a broader audience of teachers and leadership can have a significant positive effect. In this research, teachers who formed original design teams showed a lot of commitment and thus should continue to adopted strategies and methods consistent with their own knowledge and experiences with design teams, such as course update and industry visits. Thus, those teachers who are still design team members could advocate its sustained use through encouraging other teachers within the polytechnics to join. Teachers should understand the importance of their professional development and its effect on their practice and hence develop ownership towards design teams and its products. They should take on the role of providing more information to polytechnic leadership about the positive findings and successes of design teams about improved teacher competencies, increased use of industry relevant information in teaching, collaborative course update and enhanced teacher cohesion. A lot depends on polytechnic staff to ensure that the implementation of design teams reaches fruition by taking ownership of the intervention.

The characteristics of the professional development programme for teachers in design teams may be useful for future attempts at implementing a similar research in other polytechnics in Ghana and sub-Saharan Africa. Design teams are important means to stimulate and support teacher learning, increase their involvement in design activities and encourage local ownership. In design teams, teachers are inspired to learn and collaborate better. There is a procedure that contributed to the effectiveness of the programme. Therefore, to successfully implement collaborative curriculum design in design teams, the following guidelines are proposed for use in polytechnics in Ghana and other sub-Saharan African countries. These guidelines are based on proven success of this research and literature.

1. Form design teams (preferably voluntary) composed of a maximum of six full-time teachers in the same subject matter domain.
2. For more effective collaboration during course design and working in design teams, orientation is important. Organise orientation for the design teams to prepare teachers by giving them the theoretical foundation/concepts of design team. Expose them to collaborative strategies they need to work successfully in teams. Describe clearly the activities teams will undertake including the curriculum design tasks based on the five general stages of curriculum development; analysis, design, construction, implementation and evaluation (Verhagen, Kuiper & Plomp (1999).

3. Commence design team meetings soon after the introductory workshop or orientation.
4. Schedule weekly meeting times and venues at the initial stage of design team meetings. Decide on a minimum of one meeting a week in order to keep track of design activities.
5. Set deadline for design team tasks.
6. All members' contribute effectively in teamwork and discussions whether young or old, experienced or inexperienced and share responsibility for each other's work. State clearly and discuss formal and informal roles of participants in the team. Major teacher collaboration levels possible through storytelling, assisting each other, sharing documents and joint work (Little, 1990).
7. Identify courses to be updated. Choose contents or topics that are to be taught in the immediate semester/term. Discuss and describe different activities on content on the basis of ten curriculum components; rationale, objective, content, learning activities, teachers' role, materials, grouping, location, time and assessment (Akker van den, 2003).
8. Plan to explore additional information on current technological advancements (and industry relevant skills) in industry to augment ideas for course update in terms of identified areas in the syllabus.
9. Identify industries to be visited. Seek expert advice on industries to visit in light of selected areas. Make contacts, schedule visiting dates in partnership with industry representatives and embark on industrial visits in teams. Undertake industry trips during vacation if possible, since it is the most suitable period to avoid missing lesson. Where industry trips take place during school session, keep students busy with assignments and group work at laboratories/ workshops while teachers are away
10. Equip design teams on industry trips with picture and video taking devices in order to capture motion and still pictures of certain procedures and equipment to aid in giving explanations to students in their lessons. Teachers take individual notes at the industries as much as possible for ease of reference in discussions at team meetings.
11. Each team member provides an industry visit report which will be discussed at post industry design team meetings during industry visit review.
12. Design teams update courses during post industry meetings, based on the knowledge and information acquired from industry.
13. Lessons are designed based on updated courses. Individuals teach courses in the presence of at least three team members.
14. Students' evaluate the lesson taught using designed evaluation forms.
15. Design teams evaluate lessons taught in light of updated course and students' responses on evaluation forms.

7.1.7 Directions for future research

This dissertation was on the analysis of the professional development of polytechnic teachers during collaborative curriculum design in design teams in the framework of polytechnic curriculum reforms. The dissertation contributed to knowledge on the effect of collaborative curriculum design on teacher knowledge and practice. The design teams played a significant role in the implementation of collaborative curriculum design through improving teacher cohesion and subject matter interaction. In particular, subject matter knowledge and skills, curriculum design knowledge and collaborative skills were enhanced. The two iterations in this research further confirm that collaborative curriculum design in design teams is a useful means for teachers' professional development apart from ensuring curriculum quality. Nevertheless, further research for additional knowledge on design teams is recommended in this section.

Although the two cases studied are representative of all technical and practical oriented programmes in the country's polytechnics, collaborative curriculum design activities in design teams may vary among teachers in various disciplines such as applied sciences, applied arts, engineering and business. Therefore further investigation in other disciplines in the polytechnics would offer new data and present an opportunity to study professional development in design teams. Such a study could yield insights into the learning experiences of other teacher groups and the manner in which they approach curriculum development and collaborative processes. Though the teachers and leadership were convinced that the design activities carried out were a major step in the series of curriculum design activities on-going in the polytechnics and created a leeway for teachers to embark on a professional development drive, the question remains as to the extent to which professional development programmes impact on students' achievement. Accordingly, it will be advisable to undertake further research to investigate the effect of teacher learning through design teams, on students' achievement. Finally, further investigations could explore the potential of collaborative curriculum design in design teams for teacher professional development in a different tertiary institution. This kind of research will be interesting to analyse in public and private universities in Ghana or sub-Saharan Africa.

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ENGLISH SUMMARY
Teacher professional development through collaborative curriculum design in Ghana's polytechnics

INTRODUCTION

This dissertation entitled *Teacher professional development through collaborative curriculum design in Ghana's polytechnics is* a research conducted among polytechnic teachers in Ghana. Polytechnic development, curricular reform, improving the quality of teaching and teachers' knowledge needs prompted this research. The aim of the research as detailed in this dissertation is to provide professional development support for teachers to (1) update their courses through collaborative course design in design teams; (2) effectively engage in curriculum design to ensure curriculum relevance; (3) update their knowledge and skills in their respective domains; (4) apply relevant knowledge in their classroom practices and (5) enhance collegial interaction and collaboration.

PROBLEM DEFINITION

The year 2007 marked a major step-up in polytechnic institutions in Ghana when the Government Polytechnic Law 745 was promulgated and thus paved the way for polytechnics to offer degree programmes (Bachelor of Technology) alongside Higher National Diploma (HND) programmes. Having been made higher institutions of vocational learning by law, the ten polytechnics embarked on rigorous curriculum reform. One of the major internal challenges faced by the polytechnics in meeting the demands of relevant curriculum and quality teaching and learning, was professional development of teachers, as curriculum design became their responsibility. This study employed a collaborative approach to curriculum design to support teachers in redesigning the HND programmes. The use of collaborative curriculum design has been

considered in this study due to its workable, cohesive and interactive nature and as an effective professional development strategy among teachers. Collaborative curriculum design is gradually gaining ground in education as a promising way to create teacher ownership by involving them in curriculum innovation/reform and has the potential to contribute to the professional development of the teachers involved.

Research questions

This research was designed to investigate teacher collaborative curriculum design in design teams and how it affects teacher professional development and classroom practices as the polytechnics underwent curriculum innovation and progress in their evolution as tertiary institutions. Teachers' collaborative course update was facilitated through design teams during which they were supported through industry visits to strengthen their knowledge-base for effective contribution to a relevant curriculum. The research therefore focused on investigating teacher professional development during the collaborative course design process. The main question that guided the conduct of the entire study was: w*hat is the impact of collaborative curriculum design on teacher professional development and curriculum reform practices?* The research approach applied in this dissertation to unearth responses to the main research question was inspired by design based research. The four main phases of the research were the context and needs analysis, first implementation, second implementation and impact study.

RESEARCH METHODOLOGY

Design-based research approach was used in this research to find out how teachers' participation in design teams enabled them to effectively engage in a collaborative curriculum design and maximise opportunities thereof for their professional development. The design-based research was appropriate for this study because it entailed a context and needs analysis stage which provided empirically-based awareness about the problem in context. In effect, design-based research allowed for the problem to be situated in educational practice and actively involved educational practitioners. Based on the context, a professional development programme was implemented in two iterations of design, implementation, evaluation and refinement. Data collection during each iteration generated information on how to refine the programme and whether the professional development programme yielded desired impact.

After the iterations, a final study was conducted to ascertain the sustainability and up-scale of the professional development programme. The method was useful in finding realistic answers to the question posed for the research.

OUTCOMES OF THE STUDY

In this research teachers' professional development was supported during collaborative design of their courses in a curriculum reform context in polytechnics in Ghana. Teachers in the mechanical and electrical departments of the engineering faculty in two polytechnics received support through design team introductory workshops, teamwork in design team and industry visitations. The professional development of teachers took place in several forms during the collaborative course design process facilitated through design teams. Outcomes in this dissertation have shown that collaborative curriculum design in design teams did not only improve the relevance and quality of curriculum but was a valuable means of teacher professional development and had positive impact on their teaching.

Domain knowledge

Teachers acquired subject matter knowledge during collaborative curriculum design activities in design teams. They discovered central concepts, facts and principles relating to their courses. Teachers had a broader and deeper understanding of certain topics in the courses they teach. Due to the importance of practical lessons teachers teach, they learnt about tools, the functioning of some equipment, the maintenance procedure for certain machines and certain production processes. (1)Teachers developed their knowledge further through interacting with colleagues on subject matter. Both experienced and less experienced teachers within the teams learned from each other's contributions on subject matter. (2) Delving into the syllabus to identify need areas for update and the process of reshaping content were learning grounds for teachers as they immersed themselves in their domains to ensure curriculum quality. (3) Teachers learned as individuals since they personally discovered certain information, knowledge and skills from others; their idiosyncratic sensitivity to the complex interactions with content, teaching and fellow teachers improved their knowledge-base. (4) For the group, interactions on team assignments were pervasive. They also viewed their learning as a collective venture due to the continual interactions for a relevant curriculum. (5) In addition, teachers' industry visits strengthened their

knowledge-base for effective contribution to a relevant curriculum. They discovered relevant knowledge at the industries concerning contemporary industrial operations, services and servicing, machines and equipment as well as procedures in production. This direct contact and interaction at the industries constituted firsthand knowledge acquisition in subject matter domains and was useful and handy for teacher professional development, course update and teaching. Apart from getting to know about relevant industrial trends, teachers individually handled equipment in brief training sessions to improve their hands-on experience. The personal handling of equipment through training at the industry boosted the practical skills of teachers and was a relevant experience for their practical lessons in particular. In effect, teachers acquired domain knowledge during collaborative curriculum design of the syllabus in this research.

Curriculum design knowledge

During collaborative curriculum design, teachers shared experiences and learned from each other since the target for them was mutual growth and attainment of shared instructional and curricular goals. Their participation in curriculum design activities increased knowledge in curriculum design and content. Teachers became more skilled in discussing and describing content on the basis of curriculum components (Akker van den, 2003). They became more familiar with the structure of the syllabuses and stated objectives. Additionally, teachers' reflections on subject matter, delivery and outcomes in the teams enhanced interaction and knowledge sharing. (2) Involvement in collaborative curriculum design granted teachers the opportunity to reflect on realistic challenges they encountered with their courses both in theory and practical lessons. The examination of course structure and its update impacted positively on teachers' skills and competence for course redesign and teaching. Analysing the course structure, incorporating competencies that students need to possess, balancing technical and industry-specific skills and bridging the gap between the syllabus and industry competency standards were among the concrete practical tasks and learning experiences for teachers. (3) Through collaborative curriculum design, teachers learned to bridge the gap between the syllabus and industry competency standards, and they designed situational learning experiences based on the understanding of workplace contexts and changes. They embarked on their design tasks which called for documenting their newly acquired knowledge from industry for curriculum design purposes, a process which had phenomenal effects on their knowledge through the intensive brain work to restructure their syllabuses to reflect current needs of industries. (4) Teachers received pedagogical support from the team for the

teaching of updated courses after the course redesign. Discussions on delivery were useful since teachers needed pedagogical support to present certain fresh industry information to students. (5) The teaching try-outs were based on the updated courses and were also a learning ground for teachers and enabled them to practice what they had learned from the industries. Teachers therefore gained knowledge in curriculum design during the collaborative curriculum design process in this research.

Knowledge through collaboration

Teachers acquired knowledge through interacting with each other during collaborative curriculum design in design teams to improve their instruction. (1) Collaboration among teachers in design teams enhanced their knowledge in content and curriculum design. It opened up the opportunity for dialogue on their subject matter, discussions on what should be taught, and brainstorming on relevant information from industry and brought teachers with varied experiences and ages to a level of thinking and cohesion. Their collaboration enabled them to converse knowledgably about the curriculum to achieve the objectives of the programmes. (2) Collaboration thus enabled teacher interdependency and interaction. Their participation in design teams for course design improved collaboration making them discover how to share knowledge and ideas, to communicate with others, be resourceful, broadminded and tolerant as well as to learn how to find information on subject matter. (3) There were consequences of design teams during the design process such as tolerance of diverse characters and behaviours, seeking ideas from colleagues, unearthing of research ideas, learning to communicate with others, uniting with others to achieve set targets and being open to criticisms. In this research therefore, teachers' collaboration in design teams during collaborative curriculum design resulted in knowledge acquired in diverse ways on content, designing the curriculum and teaching.

Usefulness of design teams

The foray into design teams helped to understand how teachers negotiated their environments in relation to their own learning. The design team concept in this research aimed at providing an environment for teachers to engage in collaborative curriculum design, and where teacher professional development can take place. (1) Teachers benefited from collaboration in design teams as it stimulated their learning from one another and from group initiatives. Individuals had the opportunity to expand their experiences; therefore teacher collaboration in design teams was particularly successful in promoting teacher

learning. (2) Teacher learning and professional development was impressive during collaborative curriculum design in design teams. The approach changed teacher practices and beliefs with regard to improving their knowledge and skills and had important implications for teacher professional development in higher education. (3) Groups of teachers meeting to share and work together provided an opportunity to extend their professional boundaries which they found very interesting. Their professional activities which included curriculum design embedded individuals' learning in the social environment of the design teams. (4) It became evident that in professional development, it is worthwhile to engage teachers in teamwork to rigorously plan and implement their own learning and deliberate on the curriculum. Findings from this research provided evidence that design team approach in collaborative curriculum design can foster teacher professional development and collaboration. The research provided new insights for professional development activities which employ teamwork for teacher learning and change. Design teams in this intervention clearly appeared to be a worthwhile approach to teamwork among polytechnic teachers for them to update their knowledge and skills, update their courses and improve teaching. It becomes evident from the implications of this research that it is useful to connect teachers through teamwork and allow their reflections on current practices and promote creativity. Given promising findings, it is worthwhile considering the application of this research in other polytechnics in Ghana and in sub-Saharan African due to its far reaching implications.

RECOMMENDATIONS FOR PRACTICE

The use of collaborative curriculum design in design teams employed in this research emerged as a useful venture for the update of teachers' knowledge and skills. The concept of design team has made considerable progress in defining what counts as professional development among the polytechnic teachers in this research as well as in delineating conceptualizations of how professional development works. Despite the current level of awareness of design teams in the two polytechnics, it is still important for management to encourage design teams in the polytechnics as curriculum design and professional development continue to fall within the boundaries of teachers' profession. A clear articulation of policies within the framework of the polytechnics' academic milieu could ensure better grounding for design teams and make it permeate all the departments in the polytechnics. Leadership support is essential to the sustainability of design teams since they can be helpful in providing teachers with positive incentives such as verbal

encouragement, allocate time for meeting and liaisons in promoting a positive attitude towards design teams. There is the need for departments to assign curricular responsibilities to design teams and maintain it by allocating meeting times to fall within the polytechnic schedule. The importance of effective teamwork during participation in the programme can also be capitalized on by leadership, through improving the conditions and support for collaborative work within design teams. That effectiveness depends in part on unified commitment from members: loyalty to and identification with the team, fostered through a balance between respecting individual differences and requiring unity.

NEDERLANDSE SAMENVATTING
Professionele ontwikkeling van docenten door middel van gezamenlijke curriculum ontwerp in Ghana's hogescholen

INLEIDING

Dit proefschrift getiteld Professionele ontwikkeling van docenten door middel van gezamenlijke curriculum ontwerp in Ghana's hogescholen bevat de rapportage van een onderzoek uitgevoerd onder docenten van polytechnics in Ghana. De ontwikkeling van polytechnics (hogescholen), de vernieuwing van het curriculum, het verbeteren van de kwaliteit van het onderwijs, en de kennisbehoeften van docenten hebben de noodzaak van dit onderzoek bepaald. Het doel van het onderzoek zoals beschreven in dit proefschrift is om de professionele ontwikkeling van docenten te ondersteunen om (1) hun cursussen te vernieuwen via het gezamenlijk ontwerpen van curricula in ontwerpteams, (2) effectieve participatie van docenten in het proces van curriculumontwerpen en daardoor de relevantie van het curriculum te waarborgen; (3) hun kennis en vaardigheden in hun respectievelijke domeinen te actualiseren, (4) relevante kennis in hun onderwijs toe te passen, en (5) collegiale interactie en samenwerking te verbeteren.

PROBLEEMSTELLING

Het jaar 2007 betekende een belangrijke stap-up in de polytechnics in Ghana, toen Wet 745 op de Polytechnics werd afgekondigd en daarmee de weg vrijgemaakt werd voor hogescholen om opleidingen (Bachelor of Technology) aan te bieden naast Higher National Diploma (HND) programma's. Met deze wetswijziging zijn de tien polytechnics begonnen met een rigoureuze hervorming van de curricula. Een van de belangrijkste interne uitdagingen voor de polytechnics bij het voldoen aan de eisen van een relevant curriculum en van hoge kwaliteit van het onderwijs, was de professionele ontwikkeling van

docenten, mede omdat curriculumontwerp hun verantwoordelijkheid werd. Deze studie was gericht op een gezamenlijke aanpak om het ontwerpen van curricula door docenten te ondersteunen bij het herontwerpen van de HND-programma's. De gezamenlijke curriculum ontwerp aanpak is in deze studie gekozen vanwege het werkbare, samenhangende en interactieve karakter van deze aanpak en vanwege de strategie vooreen effectieve professionele ontwikkeling van docenten. Het gezamenlijk ontwerpen van curricula wint geleidelijk aan terrein in het onderwijs als een veelbelovende manier om eigenaarschap van docenten te bevorderen door ze te betrekken bij curriculumvernieuwing en -hervorming en het heeft de potentie om bij te dragen aan de professionele ontwikkeling van de betrokken docenten.

Onderzoeksvragen

Dit onderzoek was gericht op het analyseren van het gezamenlijk curriculum ontwerpen door docenten in ontwerpteams en op de invloed ervan te bestuderen op de professionele ontwikkeling van docenten en op de onderwijspraktijk, in de context van de veranderingen die de polytechnics hebben ondergaan in het nieuwe systeem van het hoger onderwijs in Ghana. Het werken in ontwerpteams werd gefaciliteerd door bezoeken aan bedrijven om daarmee hun kennisbasis te versterken en tevens om een effectieve bijdrage te leveren aan een relevant curriculum. Het onderzoek richtte zich daarom op het onderzoeken van de professionele ontwikkeling van docenten in het proces van gezamenlijk curriculum ontwerpen. De belangrijkste vraag voor het gehele onderzoek was: wat is de impact van het gezamenlijk ontwerpen op de professionele ontwikkeling van docenten en op de hervorming van de curricula? De onderzoeksbenadering die in dit proefschrift is toegepast om de onderzoekvraag te beantwoorden, is geïnspireerd door het ontwerpgericht onderzoek. De vier belangrijkste fasen van het onderzoek waren de context analyse en de analyse van de behoeften van docenten, de eerste implementatie van de oplossing op kleien schaal, de tweede implementatie op grotere schaal, en het onderzoeken van de effecten.

ONDERZOEKSMETHODE

De ontwerpgerichte aanpak werd toegepast in dit onderzoek om uit te vinden hoe de deelname van docenten aan ontwerpteams hen in staat stelde effectief samen te werken aan het ontwerpen van curricula en mogelijkheden voor hun professionele ontwikkeling te maximaliseren. Het ontwerpgericht

onderzoek was geschikt voor deze studie, omdat het een context- en behoefteanalyse kent die zorgt voor een empirische basis van het probleem in context. In feite zorgt ontwerpend onderzoek voor de situering van het probleem in praktijk van het onderwijs en van actief betrokken docenten. Binnen deze context was een programma voor de professionele ontwikkeling van docenten ontworpen en geïmplementeerd via twee iteraties van ontwerp, evaluatie, revisie en implementatie. Het verzamelen van gegevens tijdens elke iteratie genereerde informatie om het programma bij te stellen en de vraag of het professionele ontwikkelingsprogramma de gewenste impact zou kunnen opleveren. Na de iteraties, werd een laatste studie uitgevoerd om de duurzaamheid en een up-scaling van het professionele ontwikkelingsprogramma vast te stellen. De methode bleek bruikbaar bij het vinden van realistische antwoorden op de onderzoeks.

RESULTATEN VAN HET ONDERZOEK

In dit onderzoek werd professionele ontwikkeling van docenten ondersteund door het gezamenlijk ontwerpen van hun curricula in een context van onderwijshervorming in polytechnisch in Ghana. Docenten in de werktuigbouwkundige en elektrotechnische afdelingen van de technische faculteit binnen twee polytechnics ontvingen ondersteuning door middel van inleidende workshops in ontwerpen, in teamwork in ontwerpteams en in bedrijvenbezoeken. De professionele ontwikkeling van leraren vond op verschillende manieren plaats gedurende het gezamenlijke ontwerpproces dat mogelijk werd gemaakt door middel de ontwerpteams. De resultaten van het onderzoek in dit proefschrift tonen aan het gezamenlijk ontwerpen van curricula in ontwerpteams niet alleen de relevantie en de kwaliteit van het curriculum verbetert, maar het is ook een waardevolle methode voor docentontwikkeling en daarmee op de kwaliteit van het verzorgde onderwijs.

Domeinkennis

Docenten verwierven ook vakinhoudelijke kennis tijdens de gezamenlijke curriculum ontwerpactiviteiten in de ontwerpteams. Ze maakten nader kennis met en vergrootten hun inzicht in centrale begrippen, feiten en principes binnen hun cursussen. Het belang van praktijklessen in hun curriculum bracht hen ertoe zich verder te bekwamen in het gebruik van apparatuur, in het onderhoud van machines en in bepaalde productieprocessen. Docenten ontwikkelden hun kennis verder door middel van interactie met collega's op hetzelfde vakgebied. Zowel ervaren als minder ervaren docenten binnen de teams leerden van elkaars bijdragen. Verdere verdieping in het curriculum en

de curriculummaterialen versterkten het leren van de docenten en gaven aanleiding, door het nadrukkelijker bezig zijn met de inhoud, tot vernieuwing van de inhoud van het curriculum. Het leren door leraren had duidelijk een individuele opbrengst. Hun kennisbasis werd vergroot door de intensieve samenwerking met collega-docenten die een andere confrontatie met het onderwijs, de inhoud, en collega's met zich meebracht. (4) Voor de groep betekende de samenwerking in het uitvoeren van curriculumontwikkelactiviteiten ook nieuwe vormen van kennisverwerving hetgeen de collectieve opbrengst, een vernieuwd curriculum ten goede kwam. Ook de bezoeken aan bedrijven droegen bij aan het individuele en collectieve leren. Zij ontdekten tijdens de bezoeken aan bedrijven vernieuwde inzichten in productieprocessen, in dienstverlening, en in onderhoud van machines en apparatuur. Dit directe contact en de interactie met bedrijven en industrieën leverden kennis uit eerste hand op die nuttig en handig waren voor de professionele ontwikkeling van de docenten, en voor een vernieuwing van hun eigen kennis en van het onderwijs. Niet alleen leverden de bezoeken nieuwe inzichten op maar ook kon door korte trainingen nieuwe kennis en vooral praktische vaardigheden worden verworven. Dit laatste had meteen ook een positief effect op de kwaliteit van de praktijklessen.

Curriculumontwerp kennis

Tijdens de ontwerpactiviteiten deelden de docenten ervaringen en leerden van elkaar hetgeen een versterking van de curriculumontwerp kennis en ook de inhoudelijke kennis betekende (van den Akker, 2003). Ook de reflectie door docenten droeg bij aan de kwaliteit van de interactie en het kennisdelen in de teams.

De betrokkenheid bij het gezamenlijk ontwerpen door ook de gelegenheid na te denken over realistische problemen waarmee zij geconfronteerd werden in hun opleidingen, zowel in de theorie- als praktijklessen. Het bestuderen van de structuur van de curriculumonderdelen en het aanpassen aan nieuwe eisen had een positieve invloed op de vaardigheden van docenten in curriculumontwerpen en in onderwijzen. Tot de concrete activiteiten en leerervaringen voor de docenten behoorden de curriculumanalyse, het verwerken van nieuwe competenties voor studenten in het curriculum, een goede balans vinden tussen technische vaardigheden en bedrijfsspecifieke vaardigheden en het overbruggen van de kloof tussen het huidige curriculum en de inhoudelijke eisen die bedrijven stellen.

Door middel van het gezamenlijk ontwerpen van curricula, leerden de docenten de kloof te overbruggen en zij leerden leeromgevingen te creëren op grond van kennis van de werksituatie en de veranderingen die daarin

plaatsvonden. De ontwerptaken vereisten het documenteren van hun nieuwe kennis uit het bedrijfsleven, een proces dat een uitbereiding betekende van hun kennis mede door de intensieve samenwerking met de industrie.
Docenten kregen didactische ondersteuning van het team voor het verzorgen van de geactualiseerde opleidingen. Nieuwe didactische werkvormen waren immers nodig recente ontwikkelingen in de bedrijven goed over te kunnen brengen.
Try-outs in het verzorgen van de nieuwe en bijgewerkte cursussen betekenden ook nieuwe leerervaringen voor de docenten die hen in staat stelde om te oefenen wat ze hadden geleerd in de intensieve contacten met de industrie. De door docenten opgedane kennis was een belangrijk resultaat van het gezamenlijk ontwerpen van curricula in dit onderzoek.

Kennis door middel van samenwerking

Docenten verwierven kennis door middel van interactie met elkaar tijdens het gezamenlijk ontwerpen van curricula in ontwerpteams om hun onderwijs te verbeteren. (1) De samenwerking tussen docenten in ontwerpteams versterkt hun inhoudelijke kennis en ontwerpkennis. De samenwerking opende de mogelijkheid voor het opzetten van een dialoog over de domeinkennis, van discussies over wat moet worden geleerd, en van brainstorming over de relevante informatie uit de industrie en tevens bood de samenwerking docenten met uiteenlopende ervaring en van verschillende leeftijden tot een hoog niveau van denken en ook van cohesie. Hun samenwerking stelde hen in staat met kennis van zaken te praten over het curriculum om de doelstellingen van de programma's te bereiken. (2) Op deze wijze leidt samenwerking tot interdependentie en interactie. Hun deelname aan ontwerpteams verbeterde ook de samenwerking waardoor ze ontdekten hoe kennis en ideeën uit te wisselen, hoe te communiceren met anderen, hoe hun vindingrijkheid, ruimdenkendheid en tolerantie te benutten, alsook om te leren hoe informatie over het domein te vinden. (3) Belangrijke uitkomsten van het samenwerken binnen de teams kunnen worden genoteerd: tolereren van diverse persoonlijkheden en gedragingen, op zoek gaan naar ideeën van collega's, onderzoeksideeën genereren, leren om effectief te communiceren, verenigen van ideeën om doelen te bereiken en openstaan voor kritiek. Uit dit onderzoek komt naar voren dat samenwerking tussen docenten in curriculumontwerpteams resulteert in nieuwe kennis, verworven op verschillende innovatieve wijzen, over de inhoud van nieuwe curricula, over het ontwerpen van vernieuwde curricula, en over het onderwijzen.

Nut van ontwerpteams

Het gebruik van ontwerpteams heeft meegewerkt aan het begrijpen hoe docenten hun omgeving kunnen mobiliseren om hun eigen leerproces te optimaliseren. Het concept van ontwerpteams was in dit onderzoek gericht op het creëren van zo'n omgeving voor docenten om deel te nemen aan gezamenlijk curriculumontwerpen, en om daarmee de professionele ontwikkeling van docenten te bevorderen. (1) Docenten profiteerden van samenwerking in ontwerpteams om individueel en groepsleren plaats te laten vinden. Ze kregen de gelegenheid om hun ervaringen uit te breiden, waardoor samenwerking in ontwerpteams was het leren van docenten kan bevorderen. (2) Leren van docenten en hun professionele ontwikkeling was effectief tijdens het gezamenlijk curriculumontwerpen in ontwerpteams. Deze benadering veranderde het doceren en de opvattingen van docenten met betrekking tot het verbeteren van hun kennis en vaardigheden en had belangrijke implicaties voor de professionele ontwikkeling van leraren in het hoger onderwijs. (3) Bijeenkomen en samenwerken dragen tot tevredenheid van docenten bij aan het professionaliteit te versterken. Die professionele activiteiten bevorderden het leren in de sociale omgeving van het ontwerpen. (4) Het is duidelijk dat voor professionele ontwikkeling het de moeite waard is docenten deel te laten nemen aan teamwork om eigen leren te plannen en uit te voeren en te beraadslagen over het curriculum. Resultaten van het onderzoek bevestigen dat de ontwerpteam benadering de professionele ontwikkeling en samenwerking bevordert, alsook nieuwe inzichten oplevert voor het organiseren van de professionele ontwikkeling waarbij teamwork voor leren en veranderen wordt gebruikt. Ontwerpteams in deze interventie bleek een waardevolle benadering van teamwork tussen docenten om hun kennis en vaardigheden te actualiseren, hun cursussen en hun onderwijs te verbeteren. Gezien de veelbelovende bevindingen is uitgebreide implementatie in andere hogescholen in Ghana en in sub-Sahara Afrika de moeite waard.

AANBEVELINGEN VOOR DE PRAKTIJK

Het gebruik van gezamenlijk ontwerpen van curricula in ontwerpteams werkzaam bleek in dit onderzoek een nuttige onderneming voor het actualiseren en versterken van kennis en vaardigheden van docenten. Het concept van het ontwerpteam heeft aanzienlijke vooruitgang geboekt met het nauwkeurig definiëren van professionele ontwikkeling van polytechnics docenten en verdere conceptualisering van de werking van de professionele ontwikkeling. Ondanks de beperkte diffusie van de ontwerpteam benadering in

de twee hogescholen, is het zonder meer belangrijk dat het management ontwerpteams gaat stimuleren als middel om curricula te ontwerpen en om de professionele ontwikkeling te bevorderen. Curriculumontwerpen en de professionalisering zijn immers belangrijke taken voor docenten. Een duidelijker beleid binnen het academische milieu van de hogescholen zou kunnen zorgen voor een betere verankering van ontwerpteams en bewustwording binnen alle afdelingen van de twee hogescholen. Steun van het management is essentieel om de ontwerpteams op langere termijn te benutten door positieve prikkels, zoals verbale aanmoediging, toe te wijzen tijd voor bijeenkomsten en stimuleren van samenwerking om een positieve houding ten opzichte van ontwerpteams te ontwikkelen. Het is noodzakelijk binnen afdelingen curriculaire verantwoordelijkheden toe te wijzen aan ontwerpteams en deze te onderhouden door vergadertijdtijd te alloceren binnen het hogeschoolrooster. Het belang van effectief teamwork kan ook worden benadrukt door voorwaarden te creëren voor ontwerpteams door het management en zo steun te bieden aan werken binnen ontwerpteams. De effectiviteit ervan is mede afhankelijk van commitment van de leden van het ontwerpteam: de loyaliteit aan en identificatie met het team, bevorderd door enerzijds respect voor individuele verschillen en anderzijds het bewaren van die eenheid.

APPENDIX A
Data collection instruments for Chapter 2

A1 Questionnaire for teachers on their

A. Biographical data

Name of teacher:_____
Polytechnic:_____
Department:_____
Age:_____ Gender:_____
Highest academic qualification:_____
Years of teaching in polytechnic:_____
Years of teaching in general:_____

What other responsibilities do you have in this polytechnic apart from teaching?
_____
_____

Please be as candid as you can in your responses

B. Curriculum design

1. Which of the following curriculum design task(s) do you engage in? (Please tick as many as are applicable to you)

Curriculum Design Tasks	Place a tick
Deriving objectives	
Developing instructional/learning techniques	
Developing evaluation techniques/procedures	
Selecting course periods	
Deciding on learning venues	
Determining student groups	
Deciding on teachers' tasks	
Deciding on learning materials	
Determining course content	
Any other (Please Specify) _____	

2. Does getting involved in curriculum design tasks empower you as a professional?
   Yes [ ] No [ ]

3. Do you take part in the design of courses you teach? Yes [ ] No [ ]

4. What do you perceive to be what your curriculum design tasks should ideally be? (Please tick as many as are applicable to you)

Curriculum Design Tasks	Place a tick
Deriving objectives	
Developing instructional/learning techniques	
Developing evaluation techniques/procedures	
Selecting course periods	
Deciding on learning venues	
Determining student groups	
Deciding on teachers' tasks	
Deciding on learning materials	
Determining course content	
Any other (Please Specify) _____	

C. Professional development

1. Please indicate which of the following staff development programmes are applicable to you in terms of priority.

Items	Responses		
	Not at all important	Somewhat important	Very important
Refresher courses organised by professional institutions			
Pursuance of further academic studies			
On-campus workshops in subject area			
Industrial attachment to update practical skills			

Note: In responding, also have in mind the following: undergraduate programmes, post graduate programmes, in-service training, subject matter specialists workshop, conferences and seminars, mentorship, industrial attachment.

2. Which professional development activities do you consider relevant to responding to your learning needs for curriculum design tasks?

   _____

   _____

3. Please use the space below to offer any information on your professional development needs for curriculum design.

   _____

   _____

A2 Interview guide for teachers

Name of teacher:_____
Polytechnic:_____
Department:_____
Age:_____ Gender:_____ Highest academic qualification:_____
Years of teaching in polytechnic:_____ Years of teaching in general:_____

1. What currently are the curriculum design tasks performed by teachers?
2. In which way(s) do teachers contribute to the design of the HND and bachelor curricula?
3. How does polytechnic management ensure that teachers get involved in curriculum design during this current curriculum reform?
4. In which ways does the polytechnic ensure professional development of teachers?
5. What formal learning structures are in place for teachers' professional development?
6. What are teacher professional development challenges in this polytechnic?

7. Which professional development activities do you consider relevant to responding to teachers' learning needs for them to play an active role in curriculum design?
8. What are your suggestions in terms of teacher professional development for their effective contribution to curriculum design in the polytechnic?

A3 Interview guide for polytechnic leadership

Biographic data
Name of Department/Faculty/Administrative Section: _____ Name of HoD/DoF/AR/VR:_____ Name of polytechnic:_____ Age:_____ Gender:_____ Highest academic qualification:_____ Years of teaching in polytechnic:_____ Years of teaching in general:_____ How long have you been HoD/DoF/AR/VR? _____
HoD=Head of department, DoF=Dean of faculty, AR=Assistant registrar, VR=Vice rector

1. Who are the key players in curriculum design at the polytechnic?
2. What currently are the curriculum design tasks performed by teachers?
3. In which way(s) do teachers contribute to the design of the HND and bachelor curricula?
4. What feedback do you receive from teachers concerning what they perceive should ideally be their curriculum design tasks?
5. What are the measures taken by the polytechnic management to ensure that teachers get involved in curriculum design during this current curriculum reform?
6. What are the primary goals of staff professional development in the polytechnic?
7. In which ways do management support teachers to develop professionally?
8. What formal learning structures are in place for teachers' professional development?
9. What are teacher professional development challenges in this polytechnic?
10. Which professional development activities do you consider relevant to responding to teachers' learning needs for them to play an active role in curriculum design?
11. What are your suggestions in terms of teacher professional development for their contribution to curriculum design in the polytechnic?

APPENDIX B
Data collection instruments for Chapter 3

B1 Questionnaire on teachers' perception of design team

Biographical data

Name of teacher:_____
Name of design team: _____
Department:_____
Age:_____ Gender:_____
Highest academic qualification:_____
Years of teaching in polytechnic:_____
Years of teaching in general:_____

Please be as candid as you can in your responses

This is questionnaire to find out teachers' perceptions of design team. For each of the following statements about design team, indicate the extent to which you agree or disagree: Strongly Disagree (SD), Disagree (D), Neutral/Not Sure (N), Agree (A), Strongly Agree (SA)

Design team perception	SD	D	N	A	SA
Design team can improve my content knowledge					
In design team I can obtain new ideas in my subject area					
It is not difficult to make time for design team					
Easy to discuss my learning needs in design team					
Design team is beneficial to update my knowledge					
Design team can help to integrate new ideas in teaching					
Not difficult to conduct focused design team					
Design team is useful for professional development					
Design team can help to solves problems in my subject area					
Design team is useful in my course update					
I want to always be in design team					
I will recommend design team to colleagues					

Thank you for your kind cooperation

B2 Questionnaire on teachers' perceptions of industry visit

You have participated in a design team to visit industry. By means of this questionnaire indicate your perception of the industrial visits.

Biographical data

Name of teacher:_____
Name of design team: _____
Department:_____
Age:_____ Gender:_____
Highest academic qualification:_____
Years of teaching in polytechnic:_____
Years of teaching in general:_____

Please be as candid as you can in your responses

Please indicate the extent to which you agree or disagree with the following statements on the industry visits: Strongly disagree (SD), Disagree (D), Neutral (N), Agree (A), Strongly agree (SA)

Industry visit perception	SD	D	N	A	SA
I achieved my aim for visiting the industry					
My time was well spent at the industry					
I understood proceedings at the industry					
The resource person was knowledgeable and respectful					
All my questions were answered					
I handled equipment myself					
I got relevant information on all the areas we listed					
My visit to industry was useful					
I have learnt enough as I have wished in order to update my course					
What I have learned will benefit my students					
I will wish to be part of another visit to the industry to update my knowledge					
I will recommend that such visits are undertaken on regular basis					
I find it important for teachers to visit industry in a design team					
I like the way we collaborated in design team to visit the industry					
Design team has been useful for visiting industry					
What I learnt at industry will be useful for the update of my course					
Visiting industry in design team is useful for my professional development					

Please state other experiences or suggestions you have regarding your visit to the industry.

_____

_____

Thank you for your kind cooperation

B3 Questionnaire on students' evaluation of teaching try-out

This questionnaire is for you to evaluate this lesson you just had. Please provide genuine responses to each of the questions. Be assured that the information you provide will be treated strictly confidentially.

A. Biographical data

Programme of study:_____
Year of study: _____
Department:_____
Name of course:_____
Topic of lesson: _____
Age:_____ Gender:_____

Please be as candid as you can in your responses

Personal experience with teaching try-out
What is your overall experience with the course that was taught? Please tick one of the responses to each statement: Strongly disagree (SD), Disagree (D), Neutral (N), Agree (A), Strongly agree (SA)

Experiences	SD	D	N	A	SA
The course was generally interesting					
The lesson helped me to understand more about the topic					
The lesson explained concepts that I found difficult					
The course content was clear					
The course content was well understood					
The course content was well delivered					
I had an understanding of the explanation of the practical component					
The organization of the lesson was appropriate, logical and clear					
The delivery of the course was well supported by examples					
The examples given enhanced my understanding of the course					
I had a clear and vivid picture of equipment/ material discussed					
I found the lesson exciting					
I liked the mode of presentation during the course delivery					
Enjoyed the class and wish such teaching will continue					
There was clarification of some difficult concepts					
My questions were well answered					
I got useful information during this lesson					
Due to clarity I can do my assignment with ease					
I will recommend that other lessons are taught in this manner					

Thank you for your cooperation

B4 Interview guide for teachers on industry visit

Biographical data

Name of teacher:_____
Name of design team:_____
Department:_____
Industry visited:_____
Date of industry visit:_____

Teachers' perceptions of the industrial visits and what information/skills they acquired to update their courses

1. What information did you acquire at the industry?
2. What hands-on skill(s) did you acquire from the industry?
3. Give details on whether you achieved your aim for visiting the industry?
4. Was the time you spent at the industry enough? Explain further.
5. Did you understand proceedings at the industry? Explain further.
6. Was the resource person responsive to your learning needs? Explain further.
7. How will you describe your visit in terms of targets set?
8. What did you not like about the learning process at the industry?
9. Have you learnt enough as you will have wished in order to update your course? Explain in detail.
10. How will your new knowledge benefit your students?
11. What else did you learn apart from what you intended to learn?
12. What challenges did you encounter during your visit?
13. Explain why you will or will not wish to be part of another visit to the industry to update your knowledge?
14. Will you recommend that such visits are undertaken on regular basis? How often and why?
15. What other information or recommendations do you have about the industrial visit?

Teachers' perceptions of design team usefulness for industrial visits

1. How did you find the idea of visiting industry in design team?
2. In your opinion, what are the advantages of visiting industry in design team?
3. In your opinion, what are the disadvantages of visiting industry in design team?
4. How did your being in the design team to visit industry benefit you?
5. What kinds of support did you consider were useful during the whole trip?
6. What are your comments about collaboration in design team to visit industry?
7. What are your suggestions regarding the use of design team for industry visit?

B5 Interview guide for teachers on teaching try-out

Biographical data

Name of teacher:_____
Name of design team: _____
Department:_____
Name of course:_____
Topic taught:_____

Perceptions of teaching try-out

1. What are your opinions about the teaching try-out you undertook?
2. How different was the content of this teaching compared with others you did for this course?
3. What are the strong points with the teaching you did compared to previous lessons?
4. What new information was added to this topic in particular?
5. How did you like the course that you taught using the updated knowledge?
6. What are your new experiences with the teaching you did?
7. What were your observations on students' reactions during the lesson?
8. How will you describe the students' attitude in this class in terms of understanding?
9. What were students' reactions after the lesson?
10. What challenges did you encounter during the lesson?
11. What technical problems did you encounter during the lesson delivery?
12. In your opinion will you say the teaching try-out was successful?
13. What are the suggestions you have to improve upon course content next time?

B6 Interview guide for teachers on collaborative curriculum design in design team

Biographical data

Name of teacher:_____
Name of design team: _____
Department:_____

1. Explain whether you have been able to redesign your course?
2. How did you find the idea of collaborative course design in design team?
3. In what ways has collaborative course design enhanced your knowledge and skills?
4. In what ways did knowledge acquired from industry benefit your course?
5. What are your strong points for using design teams for collaborative course design?
6. What challenges did you encounter during design team collaborative course design sessions?
7. How did you manage the challenges you encountered during collaborative course design sessions?
8. What are your comments about how teachers in your team are collaborating for course update?
9. What kinds of support do you consider useful during collaborative course design in design teams?
10. In what ways do you think the approach of using design teams has addressed challenges with curriculum design in the polytechnic?
11. What do you think are the benefits so far with your involvement in design team for course update?
12. What are your suggestions regarding the use of design teams for the update/redesign of your course?
13. How did you find the idea of design team for your professional development?
14. In what ways did you benefit from the collaborations in design team for your professional development?
15. What actually have you learned from participation in design team?
16. What things worked best in the design team sessions?
17. What do you value most from the design team experience?
18. What problems do you have with learning in design team?
19. Do you think involvement in design team has enhanced you professional growth?
20. Please state other experiences you have regarding your involvement in design team so far for course design and professional development.

APPENDIX C
Data collection instruments for Chapter 4[7]

C1 Questionnaire for teachers on their perceptions of industry visit

You have participated in a design team to visit industry. By means of this questionnaire indicate your perception of the industrial visits.

Biographical data

Name of teacher:_____
Name of design team: _____ Department:_____
Age:_____ Gender:_____
Highest academic qualification:_____
Years of teaching in polytechnic:_____
Years of teaching in general:_____

Please be as candid as you can in your responses

Please indicate the extent to which you agree or disagree with the following statements on the industry visits: Strongly disagree (SD), Disagree (D), Neutral (N), Agree (A), Strongly agree (SA)

Industry visit perception	SD	D	N	A	SA
I achieved my aim for visiting the industry					
I acquired new knowledge and practical skills relating to my area of study					
I sharpened old skills already acquired in area of study					
I understood proceedings at the industry					
The resource person was knowledgeable and respectful					
The duration for the attachment programme was adequate					
I operated machines and equipment					
I got relevant information on all the areas we listed					
I got acquainted to new technologies heard of and read about					
I have learnt enough as I have wished in order to update my course					
What I have learned will benefit classroom practices					
I like the way we collaborated in design team to visit the industry					
What I learnt at industry will be useful for the update of my course					

Please state other experiences or suggestions you have regarding your visit to the industry.

_____

_____

[7] 1.Questionnaire for teachers on their perception of design team (see Appendix B1)
2. Interview guide for teachers on industrial attachment (see Appendix B4)
3. Interview guide for teachers on collaborative curriculum design and design team (see Appendix B6)
4. Interview guide for teachers on teaching try-out (see Appendix B5)
5. Interview guides in this Appendix apply to Chapter5

C2 Questionnaire for teachers on their experiences with teaching try-out

This questionnaire is for you to evaluate this lesson you taught based on the updated course. Please provide responses to each of the questions.

Biographical data

Name of teacher:_____
Name of design team: _____
Department:_____
Name of course:_____
Topic taught:_____

Please be as candid as you can in your responses

Please indicate the extent to which you agree or disagree with the following statements on the teaching try-out you conducted: Strongly disagree (SD), Disagree (D), Neutral (N), Agree (A), Strongly agree (SA)

Experiences with teaching try-out	**SD**	**D**	**N**	**A**	**SA**
The teaching try-out was generally interesting					
Students understood the lesson					
I explained concepts that students found difficult					
The topic was clear					
The lesson entailed additional information from industry					
I feel confident about the new knowledge acquired for this course					
Students had an understanding of the explanation of the practical component					
The organization of the course was appropriate, logical and clear					
The delivery of the course was well appreciated by the students					
The examples given enhanced students' understanding of the course					
Students had a clear and vivid picture of equipment/ material discussed					
Students found the lesson exciting					
Students liked the mode of presentation					
I enjoyed the class and wish such teaching will continue					
I was able to clarify some difficult concepts					
I found the lesson exciting					
I had the opportunity to apply skills acquired in industry					

Thank you for your kind cooperation

C3 Questionnaire for teachers on their learning in design team

You have participated in a design team for course update. By means of this questionnaire indicate your perception of design team for your learning.

Biographical data

Name of teacher:_____
Name of design team: _____
Department:_____

Please be as candid as you can in your responses

Please indicate the extent to which you agree or disagree with the following statements: Strongly disagree (SD), Disagree (D), Neutral (N), Agree (A), Strongly agree (SA)

Learning through collaboration	SD	D	N	A	SA
I liked the idea of design team for my professional development					
The design team concept was interesting for teamwork					
I liked collaborations with colleagues during design team sessions					
We shared materials/documents among each other in design team					
Design team group discussions on subject matter was helpful					
We shared experiences in the design team					
Design team engaged me in conversations with colleagues on my course					
Being in design team improved my relationship with fellow teachers					
Collaborations in design team made me learn more about my course					
There was improved communication among us in design team					

Thank you for your cooperation

C4 Questionnaire for teachers on collaborative course design

You have participated in a design team for course redesign. By means of this questionnaire indicate your perception of collaborative curriculum design in design team.

Biographical data

Name of teacher:_____
Name of design team: _____
Department:_____

Please be as candid as you can in your responses

Please indicate the extent to which you agree or disagree with the following statements: Strongly disagree (SD), Disagree (D), Neutral (N), Agree (A), Strongly agree (SA)

Experiences with collaborative course design	SD	D	N	A	SA
I find the idea of using design team for collaborative course update interesting					
My getting involved in design team beneficial for identifying learning needs					
Examining the syllabus to identify need areas improved my design skills					
We cooperate with each other regarding areas in the syllabus for update					
Course redesign gave me the opportunity to work with colleagues in content					
The course update section were time well spent to improve my course					
My concept of course design has expanded					
Subject matter discussion were fruitful					
I will like to continue getting involved in course update in design team					

Thank you for your kind cooperation

APPENDIX D
Data collection instruments for Chapter 6

D1 Questionnaire for teachers on perceptions of design teams

Biographical data

Name:_____
Department:_____
Faculty:_____
Age:_____ Gender:_____
Highest Academic Qualification:_____
Years of teaching in Polytechnic:_____
Name of your design team (if you are member of one):_____

Please be as candid as you can in your responses

Please indicate the extent to which you agree or disagree with the following statements on your perceptions of design teams: Strongly disagree (SD), Disagree (D), Neutral (N), Agree (A), Strongly agree (SA)

Design team perceptions	SD	D	N	A	SA
I can improve my content knowledge in design team					
I can obtain new ideas in my subject area in design team					
Using design teams to identify teacher learning needs interesting					
I like the idea of visiting industry in design team					
I wish to always be part of design team to visit industry					
I find it important for teachers to visit industry in a design team					
Industrial attachment for lecturers should be planned by design teams					
Design team is a tool for teacher professional development					
I like the idea of curriculum design in design team					
Using design teams to evaluate course content is useful					
Design team can help to solve problems in my subject area					
It is not difficult to make time for design team					
It's not difficult to conduct focused design team					
Design team can help me to integrate new knowledge into my teaching					
I like teamwork in design team					
Design team is a source for teacher collaboration					
I like the collaboration design team					
It's easy to discuss subject matter challenges in design team					
Design team engages me in academic conversations with colleagues					
I like to be evaluated by my fellow teachers in design team					
I tolerate fellow teachers in design team					
I am a fan of teamwork					

I feel confident to discuss my weaknesses with fellow teachers					
I participate actively in design team					
I enjoy working in design team					
The design team concept was interesting					
I am willing to always be in a design team					
Design team is recommendable to colleague teachers					
Design team has a future in my department					
Design team should be maintained in this polytechnic					

Thank you for your kind cooperation

D2 Questionnaire for teachers on use of design teams

Biographical data

Name:_____

Department:_____

Faculty:_____

Age:_____ Gender:_____

Highest Academic Qualification:_____

Years of teaching in Polytechnic:_____

Name of your design team (if you are member of one):_____

Please be as candid as you can in your responses

Please indicate the extent to which you agree or disagree with the following statements on use of design teams in the polytechnic: Strongly disagree (SD), Disagree (D), Neutral (N), Agree (A), Strongly agree (SA)

Design team use	**SD**	**D**	**N**	**A**	**SA**
I still visit industry in a design team					
We share information about our courses in design teams					
We visit industries in design teams to update our knowledge					
Design teams still use industry information from previous visits					
We still work in design teams for curriculum design					
Design teams evaluate teaching of updated courses					
Design team meetings are held regularly					
I engage in all design team activities					
Other teachers have joined design teams					
Design teams have expanded to other departments					

Thank you for your cooperation

D3 Questionnaire for teachers on conditions and support necessary to up-scale design teams

Biographical data

Name:_____

Department:_____ Faculty:_____

Age:_____ Gender:_____

Highest Academic Qualification:_____

Years of teaching in Polytechnic:_____

Name of your design team (if you are member of one):_____

Please be as candid as you can in your responses

Please indicate the extent to which you agree or disagree with the following statements on conditions and support necessary to up-scale design teams in your polytechnic: Strongly disagree (SD), Disagree (D), Neutral (N), Agree (A), Strongly agree (SA)

Conditions and support for design teams	SD	D	N	A	SA
Design team meetings should be made part of school schedule					
Teacher development needs should be accessed through design teams					
Design team activities should be recognized by the academic board					
Design team activities should be reviewed at faculty board meetings					
Design team activities should be given attention at departments					
Design team activities should be publicised regularly in polytechnic					
Leadership should occasionally interact with design teams					
There should be a design team coordination team					
Every teacher should be design team member					
leadership should organise design team awareness seminars					
Design teams should have representation on curriculum committees					
leadership should encourage curriculum design in design teams					
Teachers in design teams should be motivated					
Design teams should advice leadership on teacher development					
Design teams should conduct regular scrutiny of the syllabus					
Sharing of ideas should be encouraged in design teams					
Record keeping should be done at design team meetings					
Design team should engage in professional development activities					

Thank you for your cooperation

D4 Focus group interview guide for teachers

Names of teachers present: _____
Number of teachers present:_____
Duration of meeting:_____

How design teams have been sustained

1. What are the activities of the design teams?
2. Which new design teams have been formed in your department or other departments?
3. What are the motivating/conducive factors for sustenance of design teams?
4. What are the hindering factors for the sustenance of design teams?
5. What activities do you engage in through design teams for your professional development?
6. Explain whether industrial attachment in design teams is a relevant for your learning?
7. Which industrial visits have taken place in design teams?
8. What are your personal professional development experiences with design teams so far?
9. How do you think involvement in design teams can enhance teachers' professional growth?
10. What collaborative curriculum design activities have so far taken place in design teams?
11. How do you value collaborative curriculum design in design teams?
12. What are the changed instructional practices so far since your involvement in design teams?
13. What change has occurred in the activities of design teams since its implementation?
14. What aspects of design team have featured in your academic or professional responsibilities?
15. Did the design team activities so far work out or not and why?
16. What challenges do you encounter in design teams and how are they being solved?
17. What measures have teachers taken to maintain collaborative curriculum design in design teams?
18. What measures have teachers taken to continue teachers' industrial attachment in design teams?
19. How can design teams be motivated?
20. What steps has leadership taken so far to support the sustenance of design teams in the polytechnic?

Conditions and necessary support for a sustainable and large-scale implementation of design teams

1. What is your overall perception towards maintenance of design teams for curriculum design and teacher professional development in the polytechnic?
2. What are your suggestions about conditions and measures that are necessary to successfully sustain and expand design teams in the polytechnics?
3. What can teachers do to sustain and expand design teams in the polytechnic?
4. What can be the support from leadership to sustain design teams in the polytechnic?

D5 Interview guide for leadership (Vice-Rectors, Registrars, Deans, Heads of Department)

Name:_____
Current position:_____
Duration in current position:_____
Years of service in polytechnic:_____

How design teams have been sustained

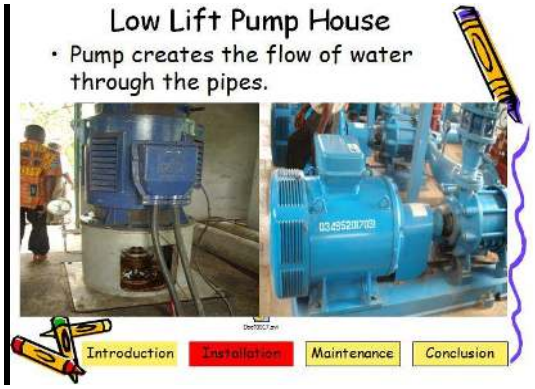
1. Which departments have design teams in this polytechnic?
2. What are the activities of the design teams in this polytechnic?
3. What professional development activities do design teams engage in?
4. What are your personal professional development experiences with design teams so far?
5. What collaborative curriculum design activities have so far taken place in design teams?
6. What measures have leadership taken to maintain collaborative curriculum design in design teams?
7. What strategies are in place to motivate and encourage teachers to engage in design team activities?
8. Are you aware of any measures that teachers have taken to entrench design teams in their respective department?
9. What steps has leadership taken so far to support the sustenance of design teams in the polytechnic?

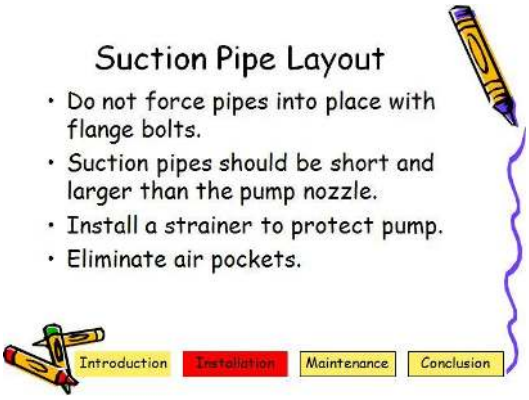
Conditions and necessary support for a sustainable and large-scale implementation of design teams

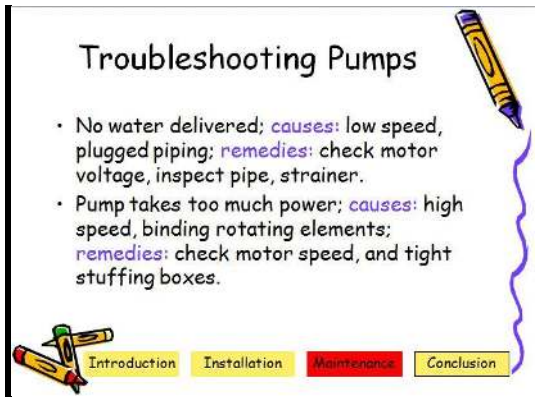
1. What is your overall perception towards maintenance of design teams in the polytechnic?
2. What are your suggestions about conditions and measures that are necessary to successfully sustain and expand design teams in the polytechnic?
3. What can be the support from leadership to sustain design teams in the polytechnic?

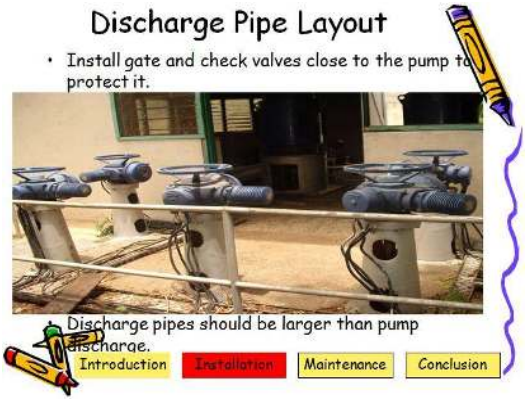
APPENDIX E
Highlights of some teaching try-out powerpoint slides

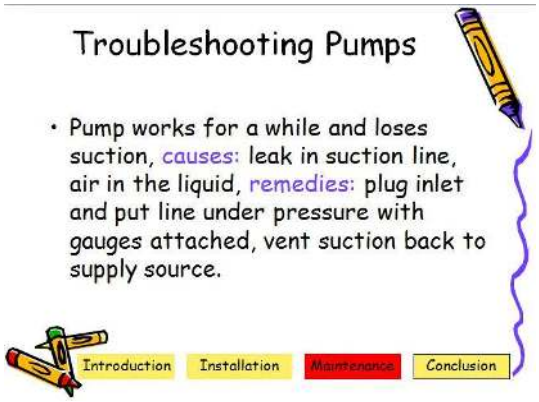
E1 The lesson on "*Installation and maintenance of pumps*"







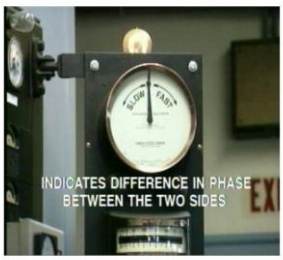




REASONS FOR PARALLELING GENERATORS

1. Local power demand may *exceed* the power of a *single* available generator.
2. Enables shut down *for scheduled or emergency maintenance.*
3. Generators operate at *reduced efficiency at light or part load.*
4. *Load growth* can be handled by added machines.
5. Available machine prime movers can be *matched for economic or optimal utilization.*

SYNCHROSCOPE



SYNCHRONIZATION

OUT OF SERVICE, EXCITATION SYSTEM IS DE-ENERGIZED.

AT START-UP, ROTOR FIELD CIRCUIT IS ENERGIZED.

CONDITIONS REQUIRED FOR PARALLELING

1. The line *frequencies* must be *approximately equal.*
2. The *terminal voltages* must be the *same.*
3. The incoming generator voltage must be *in phase* with the bus voltage.
4. The *phase sequences* must be the *same and voltage wave* of approximately the *same shape* as that of the running generators.

The series of operations required to bring about conditions 1, 2 and 3 is called *synchronization*.

SYNCHRONIZATION AT THE LOW SIDE. (TTPS, TICO, ABOADZE)

APPENDIX F
Pictures of some design team activities

Figure F1.1 An introductory workshop for design teams

Figure F1.2 Teachers during a design team meeting

Figure F1.3 Teachers at a design team meeting

Figure F1.4 A design team being given a lecture at an industry prior to entering the plants

Figure F1.5 Design team members at an industry

Figure F1.6 Design team teachers under training at an industry workshop

Figure F1.7 Design team at an industry preparing to cast

Figure F 1.8 Teachers in a design team at an industry observe a maintenance procedure

Figure F1.9 Design team being taught at an industry

Figure F1.10 Design team at an industry receiving training on production procedure before entering the workshop

Figure F1.11 Teachers in design team are engaged in training at an industry

Figure F1.12 Design team discussing a maintenance procedure with a resource person