

STUDENTS' EXPECTATIONS OF INTRODUCTORY STATISTICS INSTRUCTORS

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ABSTRACT

The purpose of this phenomenological study was to talk to students about their experiences taking introductory statistics. The author met with eleven students individually for four interviews throughout the semester, followed by a member-checking focus group during the last week of classes. One of the most salient themes to emerge was the students' reliance on their instructor for feedback about performance, directions on taking notes, and the creation of a classroom environment that motivated them to study. As part of the phenomenological tradition, the author presents his own reflections based on these students' comments. Conclusions include the encouragement of instructors to be more mindful of students' reactions to course content, and suggestions for developing a more learner-centered learning environment.

Keywords: *Statistics education research; Teaching statistics; Statistics classroom; Learning environment; Phenomenology*

1. INTRODUCTION

The current statistics reform paradigm stresses instructors teaching and students learning statistical concepts over mechanics (Chance & Garfield, 2002). One goal of this model is to help students develop *relational* or *structural knowledge* in addition to declarative and mechanical knowledge (Earley, 2001; Schau & Mattern, 1997). With relational knowledge, students go beyond just “knowing that” standard deviation is the square root of variance as well as “knowing how” to compute a standard deviation. How students connect standard deviation with concepts they already know demonstrates their relational or structural knowledge. The shift away from mechanics and toward understanding is one attempt to decrease students' anxiety levels, under the assumption that reducing the mathematical content and rote memorization of definitions and formulae reduces students' worries about course performance (Onwuegbuzie, DaRos, & Ryan, 1997). The most frequently cited implication is the need to develop class activities and assessment tools that are more concept-based and less calculation-based (Gal & Garfield, 1997). Carpenter and Lehrer (1999) discuss understanding in mathematics courses as a “mental activity” as well as something “*emerging or developing* rather than presuming that someone either does or does not understand a given topic, idea, or process” (emphasis added, p. 20). Garfield (1995) warns instructors, “no [teaching] method is perfect and will work with all students” (p. 32) and “teachers often overestimate how well their students understand basic concepts” (p. 31). These statements imply researchers and classroom teachers would be wise to invest time listening to individual students to get a

sense of how well their own teaching methods help students develop conceptual understandings of introductory statistics concepts.

What we are not seeing in the literature are discussions of how students' understandings are impacted by the classroom environment. What is also not heavily discussed in the literature is how students respond to more conceptually-based classrooms (Batanero, Garfield, Ottaviani, & Truran, 2000). Of course, this does not include references to the well known statistics anxiety phenomenon. Few researchers have explored any of our students' *experiences* in statistics courses – there is a more consistent focus on achievement outcomes (Becker, 1996). Gordon stated that “as in other fields, a major challenge currently facing researchers in statistics education is to improve our understanding of learning” (1995, para. 6) and “in order to teach statistics effectively, we must first understand the learners” (2000, p. 16). Gordon's work focuses on activity theory and the social, historical, and cultural aspects of classroom environments to help understand statistics learners (1995, 2000, 2004). Through this perspective, she concluded in a 1995 study that statistics classrooms must be supportive, instructors must provide guidance to students, and teaching must “build on the personal experience of the learner” (para. 47). Nine years later, Gordon (2004) indicated there is still a need for statistics education researchers and statistics educators to understand our learners. To this end, her interview work done for a 2004 report led to five categories of meanings students attach to statistics: statistics as having no meaning, statistics as processes, statistics as mastery, statistics as a tool, and statistics as critical thinking.

These meaning categories parallel those described by Reid and Petocz (2002), in which students described statistics as having (a) a focus on techniques, (b) a focus on using data, and (c) a focus on meaning. In a later report they redefined these conceptions as (a) doing, (b) collecting, (c) applying, (d) linking, (e) expanding, and (f) changing (Petocz & Reid, 2003). In both cases, the authors describe these conceptions as a continuum from limited to expansive. More limited conceptions, according to Gordon (2004), have the potential to limit students' study strategies and motivation for learning statistics. All of these studies suggest understanding students' descriptions of what “statistics” means is an important precursor for improving students' learning and ultimately their experiences in our courses. One question to address is how students create these meanings: Do they come in to class with them, do specific aspects of the classroom environment change initial meanings or create new ones (as Gordon suggests), and do these meanings change over the course of the instruction? In other words, what kind of impact does the learning environment created by instructors have on students' meaning-making?

Petocz and Reid (2002, 2003) have addressed some of these questions by connecting students' conceptions of statistics with expectations students have of statistics instructors. Again, the authors describe these conceptions as most limited to most expansive:

- Conception 1: Providing materials, motivation, and structure
- Conception 2: Explaining material and helping with student work
- Conception 3: Linking statistical concepts and guiding learning
- Conception 4: Anticipating student learning needs
- Conception 5: Being a catalyst for ‘open-mindedness’

The important addition in this work is the *blending* of students' conceptions of statistics and their expectations of instructors. As an example, Petocz and Reid (2004) describe one mix as students' conceptions of “doing” and “collecting” along with students' expectations of their instructors to provide materials, motivation, and structure (Conception 1). This would be the most limited blend of both sets. Although her interviews did not directly ask about students' expectations of their instructors, Gordon

(2004) did interview two instructors and also discusses their impression of the interactions between how students attach meaning to statistics and what goes on in the classroom.

One important aspect of these studies is their reliance on interviews and open-ended survey responses at *one point in time*. Any discussion of how classroom environments and instructors impact students' conceptions should incorporate a more longitudinal data collection strategy. For example, Murtonen and Lehtinen (2003) conducted a study with Finnish students in which they asked participants to write in "learning diaries" throughout the entire term. Students were to record difficult concepts they encountered as well as what they thought led to the difficulties. Students' reasons for difficulties fell into five categories: (a) superficial teaching, (b) difficulty linking the theory of quantitative methods with the doing, (c) unfamiliarity and difficulty with content (e.g., too many concepts to absorb), (d) lack of connections across bits of information, and (e) negative attitudes toward quantitative methods. Similar to the typologies of Gordon (2004) and Petocz and Reid (2003), Murtonen and Lehtinen's categories begin to blend students' understandings of quantitative material with how it is taught. Interestingly, they conclude "the experience of difficulty did not occur because of the major subject or any specific teacher, but because of some more general reason" (p. 182), indicating again that understanding students' backgrounds could be an important precursor to developing more effective classroom environments. What is also important from this work is its longitudinal design. Ultimately, the authors chose to combine responses from throughout the term, however, so we still have no presentation of how individual students' experiences change (if at all) as the course progresses. Petocz and Reid (2003) posit that students "would develop their approach to learning, and maybe change their conceptions of teaching from time to time" (p. 41), suggesting that rather than exploring class marks on assessments, an additional approach to data collection that also explores *individual students' experiences* would help statistics educators understand further what students take away from the course.

This expectation, along with Carpenter and Lehrer's (1999) assertion that mathematical learning is developmental, suggests that expanding this body of work through more longitudinal explorations of students' experiences *throughout* their course would be useful. Talking to students more frequently allows researchers to gather more information about students' experiences, such as: What do students do to prepare for class? What do students do while in class? What goes through students' minds during class? What aspects of class time help or hinder students' understandings of the material? What do students do when they leave class? For these reasons, the general purpose of the current phenomenological study was to begin this exploration with one very broad guiding question: "How do students describe their statistics course at different points *during the term in which they are taking the course?*"

2. METHODS

2.1. THE PHENOMENOLOGICAL TRADITION

The use of phenomenology allows us to understand student experiences differently than through surveys or other qualitatively-oriented traditions. Rather than "averaging" or grouping students' experiences together, phenomenology seeks to present "the qualitatively different ways in which a phenomenon is experienced" (Pietersen, 2002, para. 14). Van Manen (1990) stresses phenomenology as "human scientific study" with an emphasis on "explicat[ing] the meanings as we live them in our everyday experience,

our lifeworld” (p. 11). Phenomenological research incorporates the researcher as someone learning about a phenomenon by “borrow[ing] other people’s experiences and their reflections on their experiences” (Van Manen, 1990, p. 62). In phenomenology, it is the actual doing and living that constitutes knowledge – “a kind of knowing that can only be obtained through active engagement” (Ladkin, 2005, p. 116). Ultimately, phenomenological research attempts to present the unique lived experience of others so that the reader also develops a new understanding of the experience.

An essential first step in conducting phenomenological research is for the researcher to first understand his or her own experience with the phenomenon under investigation (commonly referred to as *bracketing* or *époche*) (Ladkin, 2005; Lavery, 2003). As one reads different descriptions of phenomenology, this process is part of what distinguishes the various approaches (Kerry & Armour, 2000; Lavery, 2003). Rather than completely “suspend” our own understandings, as Edmund Husserl’s description of *époche* would have us do (Creswell, 1998), hermeneutic phenomenology, most commonly attributed to Hans-Georg Gadamer, (Kerry & Armour, 2000; Ladkin, 2005), incorporates these understandings as essential to the interpretive process to follow. In other words, because the researcher will interpret participants’ experiences while developing a description of the phenomenon, an understanding of the researcher’s own experiences is necessary so the reader has an idea of the researcher’s interpretive lens. Van Manen (1990) describes this as the “intersubjective” nature of phenomenological research: “the human science researcher needs the other (for example, the reader) in order to develop a dialogic relation with the phenomenon” (p. 11).

This also means the researcher’s own understanding develops during the research process – in his description of the phenomenological data collection process, van Manen refers to this as the “reflective data” (2002; see also Lavery, 2003) researchers collect alongside the “empirical data” (i.e., interview data) from our participants. van Manen (1990) indicates social science researchers “borrow” participants’ experiences in order to develop a complete description of the experience. In this sense, the researcher is developing the description as his or her own developing understanding of the phenomenon under study. Kerry and Armour (2000) indicate “these personal histories lead to a unique perception of different experiences and that this personal history cannot be bracketed out; it is fundamental for interpretation” (p. 6). For example, Finney (2000) presents her own experience with success in statistics courses prior to detailing six other students’ success experiences. The reader then understands how her interpretation and summary of the experience of success is shaped by her own initial perceptions. Mayhew (2004) also presents his experiences with spirituality prior to describing the meanings eight undergraduate students attribute to spirituality “to give the reader a sense of any prejudice or orientation that may have shaped [his] interpretation or approach to the study” (p. 656).

2.2. PARTICIPANT SELECTION

In phenomenological research, the researcher bases participant selection on finding and recruiting individuals who have experienced the phenomenon of interest (rather than selecting key informants in ethnography, or selecting individuals based on their life experiences for a life history) (Creswell, 1998; Lavery, 2003; Moustakas, 1994; van Manen, 1990). The quantity and depth of the data to be collected determines how many participants the researcher can recruit. In phenomenological inquiry, the primary data source is the interview, and depending on the phenomenon of interest, there may be more than one interview per participant. The researcher must have each interview transcribed

for analysis, creating a large set of data to read through and analyze, so the number of participants is generally kept to a minimum (Creswell, 1998). There are no specific guidelines on what constitutes this “minimum” – “Boyd (2001) regards two to 10 participants ... as sufficient to reach saturation and Creswell (1998, pp. 65 & 113) recommends ... 10 people” (as cited in Groenewald, 2004, p. 11). Because I was interested in interviewing participants four times during the semester and interviewing all participants within a week of each other, a number around ten seemed manageable and was my goal.

Six departments across four colleges at our institution offered 40 sections of introductory statistics courses during the spring 2003 term (this includes multiple sections of the ten different courses). Students in this study came from multiple sections of four of these courses. All of these courses are traditional in scope, covering introductory descriptive and inferential statistical analyses in one term. The “Psychology 270” course is the required introductory course for psychology majors. The “Statistics 211” is the first in a required two-course sequence for all majors in the College of Business Administration. The “Math 115” course is offered to students not majoring in mathematics; many undergraduates take this course to fulfill the mathematics requirement for the university if a different course is not specified by their College. Mathematics majors take a different introductory statistics course, so the “Math 115” course is not calculus-based. The “EDFI 641” course is a required course for master’s level students in the College of Education and Human Development. All of these departments offer more advanced courses, but only students in the College of Business Administration are required to take a second course.

My goal for recruiting participants was to get a mix of participants from across all of these courses. Eligible students included those over the age of 18 and enrolled in any introductory statistics course during the spring 2003 term. In January 2003 I posted flyers next to the doors of each classroom in which one of the 40 introductory statistics sections met. This method of recruitment does introduce typical volunteer bias, but the advantage is that if students are interested in talking about their experiences (whether good or bad), they will volunteer (a necessary participant characteristic in phenomenology). The flyer asked students to contact me via phone or e-mail if interested in taking part in my study, and I set up times to meet with the twelve who did so by the end of the third week of classes in order to have a first interview for each participant completed during the third or fourth week of the term. At our first interview, I informed participants of a \$120 incentive to those who completed the study by returning for interviews throughout the semester. Although the issue of incentives is still controversial (Adler & Adler, 2002), I do believe in giving participants something in appreciation of their time (Weiss, 1994). I do not feel this had an impact on the quality of my participants’ contributions because each participant was engaged during our conversations and each had much to say about their experiences in their statistics class.

To give the reader a general description of the participants, Table 1 lists demographic information for the final set of eleven students I interviewed (one student dropped out of the study after the first interview). I did achieve the variety I initially wanted: My group includes participants from freshman to senior with one graduate student, a grade point average (GPA) range of 2.00 – 4.00 (i.e., students fell across the general academic performance spectrum from “average” to “excellent” students), and students from courses in four of the six departments offering statistics courses in the spring (no students from the Sociology or Criminal Justice courses contacted me).

Table 1. Demographic summary

Participant ^a	Gender	Course Taken ^b	GPA ^c	Class
Aileen	Female	Psychology 270	3.60	Senior
Alastair	Male	Statistics 211	2.60	Sophomore
Brice	Male	Psychology 270	4.00	Senior
Brigit	Female	Math 115	3.77	Sophomore
Cecily	Female	EDFI 641	4.00	1 st Year Graduate
Cedric	Male	Statistics 211	2.92	Freshman
Dillan	Male	Math 115	2.90	Sophomore
Eleya	Female	Math 115	4.00	Freshman
Evan	Male	Statistics 211	2.50	Sophomore
Griffin	Male	Math 115	2.00	Freshman
Ian	Male	Statistics 211	3.66	Sophomore

^a All names used in this report are pseudonyms.

^b All courses are introductory-level statistics courses designed for non-statistics majors.

^c GPA = Grade Point Average, calculated as an average of the students' grades for all of their coursework to date after converting the letter grades to "grade points": A = 4, B = 3, C = 2, D = 1, F = 0.

2.3. DATA COLLECTION

Phenomenological data collection proceeds in two parallel processes: (a) empirical data collection, typically in the form of in-depth interviews with participants, and (b) reflective data collection, in which the researcher reflects on his or her interactions with the empirical data (van Manen, 2002). The power of phenomenological inquiry is this interaction, where the researcher first presents his or her own experiences with the phenomenon of interest, and then *reflects on how his or her experience and understanding of the phenomenon changes and develops while listening to the participants' stories* (Moustakas, 1994).

I met with each student four times for one-on-one interviews in my office (the only exception was Ian, who started the study late and only met with me three times). We spaced interviews approximately 3 to 4 weeks apart depending on the student's schedule. I had an initial list of questions I wanted to discuss, based in part on my interests and in part on themes emerging from the previous interviews. Each interview began, however, with the general question, "So how is class going for you?" From there, we discussed whatever the student brought up as important at that time. Interview times ranged from 15 to 45 minutes, entirely dependent on how much the student had to say. I audio taped the interviews and took fieldnotes during our discussion. I then transcribed audiotapes, taking additional fieldnotes as I listened to our discussion again.

To increase the accuracy and representativeness of the themes I saw emerge (Maxwell, 2005), I met with nine of my participants in two member-checking focus groups during the last week of classes prior to final exams. "Member-checking" is described as a process of going back to the participants to have them review the researcher's interpretations of and conclusions drawn from the data. Through this process, participants comment on whether the researcher "got it right" (so to speak) (Creswell, 1998; Glesne, 1999; Maxwell, 2005). Due to the scheduling so close to the end of the term and final exams, I gave students two options: an afternoon time with lunch, selected by two participants, or an evening time with dinner, selected by seven. Two of my participants could not make these focus groups due to scheduling conflicts. I

presented students with a summary of the major themes on slides, one at a time, and solicited group feedback on whether these were actually important to the students. To get this feedback, I asked students to think about what they would tell a group of statistics instructors about their experiences taking statistics. Students changed the wording on some (e.g., the course is “easier when instructors ...” not “easy when instructors ...,” as I had first worded one of the themes), but otherwise agreed these were important ideas to them and ideas they would share with statistics instructors as important.

2.4. DATA ANALYSIS

To come to an understanding of how my participants experienced their statistics courses, I analyzed and reflected on the transcribed data throughout the study. After each interview, I took time to make notes on ideas the student seemed to stress or return to often. I also noted student comments that, for some reason, stood out for me. After each *round* of interviews, I explored major patterns across all 11 participants and developed questions for the next round of interviews. After the study ended, I also developed time-ordered displays (Miles & Huberman, 1994) of students’ main comments from the beginning to the end of the term to explore changes in their descriptions of class. Because I developed interview protocols based in part on the ongoing analysis of each round of interviews (i.e., what did I find important or interesting that I wanted to explore again in the next interview?), I include here a list of the major “topics” for each round of interviews. I introduced these additional topics into the interview after the opening question about how class is going.

Interview 1: Discuss a general description of the class, what happens during class, what student does in between class meetings, other issues student brings up.

Interview 2: How does student take notes? What does student do with notes during and outside of class time? Why does student take notes? Does student only take notes in class, or does student read the textbook and take notes as well?

Interview 3: What would happen if there were no identifiable instructor? What would the student miss?

Interview 4: Summary of student’s thoughts about course, additional comments, and comparison of their statistics course with another course they are taking (students chose one of their other courses and we discussed similarities and differences between that course and their statistics course).

All participants, after the first interview, came prepared to answer the “How is class going?” question – they clearly had topics they wanted to share with me. After this discussion, I introduced questions addressing each of the ideas listed above.

3. RESULTS

3.1. BRIEF REFLECTIONS ON MY OWN EXPERIENCE

My experiences taking statistics courses began with a required course for my (then) economics degree. I clearly remember a lot of frustration and confusion as the instructor filled blackboard after blackboard with Greek symbols and mathematical formulae. We used a computer software package for homework problems, without the benefit of a user’s manual or any training on how to use the software (back then, the software required writing programs to run analyses as opposed to today’s “point-and-click” platforms). My solution to this confusion and lack of understanding was to give in, earn a D-, and retake the course the following term.

This new instructor was so radically different from my first – primarily because he actually made class enjoyable. I *wanted* to be in class, and worked hard between class meetings in order to participate fully each week. We used computer software, but now he guided us through the programming during class time before sending us out on our own. I recall measuring 100 leaves from trees around campus for one of our early homework exercises – data we would analyze and discuss throughout the course. After being in class with this instructor (and concurrently taking an advanced economic theory course in which I was struggling), I switched my major to mathematical statistics at the beginning of my sophomore year and finally felt “at home” with my coursework.

Although I have had many (many) statistics courses since my start in 1989, I turn now to some brief reflections on my observations as an instructor of introductory statistics in education courses (note that none of the students in my classes participated in this study). Many of these informal observations are what led me to develop an interest in finding out what exactly my students experience when they take my course. Have I avoided creating a classroom environment similar to that very first environment in which I failed? Have I created a motivating and interesting classroom environment similar to my *second* experience (along with many other inspiring instructors and classes along the way)?

No matter what I do or say, students consistently come in to my course with the typical fear and anxiety. It seems at times that I am an actor on a stage, begging my audience to laugh and enjoy themselves. After careful attention to the textbook I use, the way I structure class meetings, the assessment system, and my own concern for students’ success, some students still carry that fear and anxiety throughout the term. I hear from students that the textbook is confusing and impossible to read. I hear from students how they can follow along in class, but seemingly all is lost when they leave the classroom; they have no idea what they are looking at when they study at home. Student evaluations of the course consistently rate “relevance to my profession/degree program” the lowest of all evaluation items. Students come in the first day and announce this is their last course – all they want is their grade of “C” so they can graduate and move on.

The power of phenomenological inquiry is the “connections” researchers and participants can make through their shared experiences. Moving into this particular study, all of my own experiences, attitudes, beliefs, and values related to introductory statistics form the context in which I talk to participants, listen to their words, and try to make sense of what we discuss. Rather than considering this a major bias to the study, however, this context allows the reader to understand this narrative as *my understanding* of these students’ experiences (as is the case with any naturalistic inquiry process). I have paid close attention to verbatim transcripts, and my reflections at the end of this narrative point to the “surprises” and discussion topics that made me reflect deeper on my role as instructor. The member-checking focus groups conducted with my participants helped validate the themes I saw emerge, to which I now turn.

3.2. THE VOICES OF MY PARTICIPANTS

Even with the variety of students I talked to, as well as the diversity of their classroom environments, three common themes emerged across all of our discussions: (a) *student behaviors and characteristics*, (b) *instructor behaviors and characteristics*, and (c) *resources students use for studying*. This report focuses on the second of these: the students’ perceptions of the instructor and his or her behaviors. During the first two sets of discussions, this idea came across in a variety of my participants’ responses to

questions, regardless of whether I had directly asked about the instructor. Based on this preliminary analysis, I asked students the following question during our third discussion:

Imagine you had to take this course entirely online. There is no identified instructor now – you read texts and examples online, complete assignments and tests online, and receive scores via e-mail. What would that be like?

My intent here was to focus on what students would miss about their instructors, having discussed them so much during our first two interviews.

Responses to this question, along with questions from earlier discussions, fell into three major sub-themes:

- (1) The instructor's use of class time (including pace and teaching style),
- (2) The instructor's role in the note-taking process, and
- (3) The instructor's assessment strategies (including homework and exams).

I present next my interpretations of each of these themes along with representative quotes from my participants' responses.

The instructor's use of class time One of my early interests in conducting this study was to find out what it is like just to be in a statistics class: What are students thinking, what kinds of behaviors do they feel are important during and between class meetings, and most importantly, *why*? For most students, the response to what they do in class was "sit there and take notes." What thoughts did they have during class? For some, they were random because, as Brigit said,

Brigit: It's hard to stay focused on it because all she does is write definitions from the book onto the board and then just reads them and explains them a little bit. Very rarely we go through examples of things but mostly it's just definitions.

For Brigit and others, instructors organized class time around the traditional "lecture" approach with very little interaction among students. There were exceptions, in particular Griffin's instructor, who did no formal instruction but rather assigned group work from the text.

Griffin: He gives us problems to do from the book and then sits up front and watches us. He is there to answer questions. If we don't have any questions, we finish our exercises and leave.

Int: Do you like that approach?

Griffin: Well he seems pretty unmotivated to teach the class and not interested at all.

Int: What do you think of that?

Griffin: There is no reason for me to do any work outside of class. Why should I care if he doesn't?

When asked about the online course, only Griffin was excited at the prospect of "taking the class while [he stays] in bed." The remaining ten participants each expressed concern that this type of setting, most notably the absence of a live instructor, would never work for statistics. Cecily was most vocal (her eyes nearly popped out of her head when I asked her that question) in wanting to avoid this type of course.

Cecily: Wow ... no way of asking questions? There's gotta be a way of asking questions ... yeah I may be able to pass the class but I wouldn't know it. I wouldn't be able to use it.

Int: So you need the instructor there to ask questions to.

Cecily: Absolutely. I have a math background, I'm pretty good at math. But this is not just a

math class ... there's a lot of concepts here that just reading the book [won't work] ...

Cedric also expressed concern over the “completely online” approach.

Cedric: I don't think that would work at all.

Int: Why not?

Cedric: Because, for example, I'll hit a stumbling block where I don't understand it, but then I talk to a peer and that sheds a different light on it. It makes it so much easier. Without that interaction between students it makes it more difficult, especially because the instructor can shed another different light on it.

Int: So having the different viewpoints are helpful.

Cedric: Yes. The textbook is good at telling you what to do, but not as good at telling you why this happens.

Int: So is that something the instructor has been helpful for? Presenting the whys?

Cedric: Yes.

Overall, students who had instructors giving *and explaining* examples in class were more comfortable with their experience – students like Cedric who were not getting these examples wished their instructors would do more of “the whys” instead of just “the whats.”

I clearly recall my own desire to skip class meetings the first time I took statistics contrasted with my excitement to be in class the second time – student comments about how the instructor guided class time resonated strongly with me. As an instructor, I am keenly aware of students who do not appear engaged or “with me” – most likely a result of my own early experiences. My participants integrated the first four of Petocz and Reid's (2003) conceptions into their expectations of how class time is used: They expect instructors to be organized, present more than just an outline of the text, explain concepts beyond what the text offers, and be there to address student questions and provide alternative explanations when needed. This is different from Petocz and Reid's analysis, in which students could be described by one or two of the conceptions – all 11 of my participants discussed all four of these conceptions throughout the term.

The instructor's role in the note-taking process A natural progression from the first sub-theme on instructor behaviors and characteristics is how these behaviors influence students' note-taking processes. Students consistently reported relying predominately on their notes for studying course material. This is also how they each spent their time in class (again with the exception of Griffin noted above) – listening to the instructor and writing down whatever he or she wrote on the blackboard or overhead. I asked students how they decided what to write down, and most indicated it was “whatever [or everything] the instructor writes down.” Only Brice and Cedric mentioned they also jot down additional notes to themselves about key formulae or concepts to remember.

Evan, Ian, and Alastair each had instructors who provided handouts with full or partial notes already on them. For these students, this meant they just followed along and maybe filled in an example or two – Evan called this “being spoon fed” the information.

Evan: He passes out sheets and he goes over the stuff in class ... I remember a lot of it from last semester, so I'll go through and do the stuff that I know. And I'll just sit around and wait for a question that I didn't know and fill in the answer as he explains it.

Int: So then when you're in class you're going through and doing on your own the stuff that you remember and then waiting?

Evan: If I hear something that I didn't write down or don't remember from last semester,

- I'll write that down.
- Int: Do you take any other notes besides those on the sheet he hands out?
- Evan: No he usually has a lot of space on the side to put extra stuff there. He spoon feeds us most of it.

With or without these handouts, students rely very heavily on their notes for studying outside of the classroom. Cedric further indicated that he has experienced the “false safety net” of feeling as though he is following along in class, not taking any notes as a result, and then being lost when he got home to study for the test (having no notes to refer to). Here again, students all mentioned either being happy with an instructor who walked through examples in class (so these could go into their notes) or being unhappy with an instructor who did not do so.

Three of my participants had sold their books back by the first interview (within a month of class starting), another two sold them back later in the term, and five of the remaining six students used their books for assigned homework problems only. Only Cecily read the textbook in between classes, though she indicated this was difficult to do. Brigit and Dillan struggled with this the most because their instructor “lectured” directly from the book.

- Brigit: This class is different [from my other classes] because instead of having the professor's point of view on the notes, it's just point blank – I look at my book and I looked at my notes and it's word for word.
- Int: So what do you do then?
- Brigit: I have random thoughts during class. It's hard to focus when it's just like being dictated to. Plus I know if I miss anything it'll be in the book.

Dillan indicated it was almost “stupid” to go to class because he can sit at home and read the book – what he and other students want from instructors is explanations and “different viewpoints,” not dictation. The textbook was not enough for them to learn the concepts, and the instructor in this case was not serving as an extra resource, which bothered them. For these students, and students who cannot or do not read the text even though they keep it, there is an even greater importance placed on course notes.

The instructor's assessment strategies There was an overwhelming consensus from all of my participants that regular homework and frequent assessment are necessary in order for students to know whether or not they are learning anything. As Brice put it:

- Brice: Each person in the class was left on their own to make sense of what was being presented ... maybe it felt like a struggle because if we'd had some more problems ... we'd have some confirmation of whether or not we understood the material. Maybe it was a struggle because we just didn't know for sure if we understood it or not – we just really didn't have any confirmation of that.

Brice and others were concerned that with no practice, no regular homework, and no assignments to work on, preparing for exams was more difficult and led to an increase in anxiety prior to exams. Cecily mentioned that “a computer can give you the answer, but it doesn't give you how it got the answer,” and so for her the additional need was for the instructor to *go over* the assessments when returning them to students.

Students also indicated that “what the instructor told us would be on the test” was their study guide, and any deviation from this on tests and quizzes was frustrating for students. Although I did not look at individual assessments unless the student asked me a question about them, what they perceived to be poor test development clearly impacted

their class experiences. A major challenge was tests based on “applications” when instructors did not give students application models in class. Even though many students called for and recognized the need to understand what it is they were doing, they wanted instructors to guide them in this process. Cedric’s first exam experience was particularly enlightening:

Cedric: I wasn’t happy with my first test.

Int: What happened?

Cedric: Right answer, wrong work, so a lot of points were taken off. The one thing is, she doesn’t accept just the answer. Even if you do some work, unless you do the right work it will be marked wrong. I can understand that if we’re majors, but we’re general business majors. Just getting the right answer is enough. Recognizing wrong answers is good, but not exactly knowing step-by-step.

This conflict between Cedric’s realization that understanding is important (from earlier conversations) but not being comfortable when tested on this understanding is important to me. These data highlight the need for instructors to match more closely their instruction and assessment procedures so students do not get these conflicting messages. These data also suggest that instructors need to make explicit connections between instruction and assessment, as instructors’ intentions are not always clear.

4. DISCUSSION

All of these sub-themes are intimately related to each other, as well as to the two other larger themes of student characteristics and behaviors and use of resources. Students in this study spoke frequently about the role the instructor plays in their class experiences, but for me the surprising aspect of all of our conversations was the *extent* to which students relied on their instructors. What we do in the classroom has far-reaching impacts beyond how students feel during class. When on their own, students need resources that will help them make sense of class material (Petocz and Reid’s (2003) “Conception 3,” p. 46). Those participants most comfortable with their experiences indicated they could take their notes home, complete homework assignments by referring to their notes as necessary, and received consistent feedback from their instructor as to whether they were indeed “getting it.” Oathout’s (1995) participants echoed “strongly favor[ing] frequent tests” (p. 50) and a lack of “mapping from lectures and assignments to test content and format [as] equally problematic” (p. 48).

Many students, however, did not do much work outside of class because graded assignments were either non-existent or infrequent. This meant their statistics course was the lowest priority class when studying during the week, and they rarely did anything with their statistics material outside of class time. This changed around exam time, when there was a need for notes to be clear and complete, and for these notes (typically verbatim from instructor notes in class) to be reflective of what would be assessed on the exams (similar to Petocz and Reid’s (2003) “Conception 1” on teaching statistics, p. 44). The exams became the focal point for these students – they took notes so they would have something to study so they could do well on the exams. As Garfield (1995) states, “students learn to value what they know will be assessed” (p. 32) – Petocz and Reid (2003) discuss this as “doing” statistics (p. 42). Students in the current study usually waited until an exam was coming up to actually go back over their notes, so any questions they had could not be addressed and they were sometimes still confused and unsure going into the exam. How the instructor conducts class, how the students record classroom events and discussions in their notes, how the instructor assesses students in

between exams, and how the instructor develops exams all become a single system to which instructors need to pay close attention.

Most importantly, students never talked about “getting it” in terms of understanding what they were doing. Although Cedric indicated that knowing why they are doing an analysis makes doing the analysis easier, students did not ever indicate they understood course material. Rather, they were happy if they could get problems correct and earn all of the possible points. Most of the instructors these students spoke of appear to encourage the “doing” aspect of statistics – solving problems is a large part of how these students spent their time both in and out of class. Students knew their tests would involve solving problems (based on what their instructors told them about the tests), so this was how students studied. If we want students to hold the more expansive conceptions of statistics that include “statistics as critical thinking” (Gordon, 2004) and a “focus on meaning” (Petocz & Reid, 2003), we need instructors to hold and espouse these conceptions as well. These data suggest that future researchers explore these same conceptions with instructors to discern their own conceptions as well as how they create learning environments that support students developing the more expansive conceptions.

5. REFLECTING ON MY OWN CLASSROOM

As I reflected on the discussions I engaged in with these students, my thoughts turned to my own teaching philosophy and classroom environment. Listening to them talk about their instructors and class experiences, I often asked myself, “Do I do that in *my* classroom?” Reflective questions about my own practices that developed because of these discussions, questions I believe worthy of further exploration both in my own practice and in the larger statistics education community, include:

- (1) How much do I actually stress “doing” statistics over “understanding”?
- (2) What are my expectations of students during and outside of class meetings? Am I clear in expressing these expectations to my students?
- (3) What role does the textbook play in my course?
- (4) How can I best assist students in taking complete and accurate notes?
- (5) What is the connection between each class activity and/or discussion and my assessment of student understandings?

I firmly believe as instructors we need to spend more time reflecting on our own teaching philosophies and practices, and for me, this reflection requires student feedback. We can focus our reflections on each aspect of the classroom, understanding which piece(s) are working *for our students* and which are not. Statistics education researchers can also consider these questions, and begin to focus research more on these “emerging understandings.” Through these explorations, we can continue to learn how students are responding to our desire for them to walk away from the course with some knowledge of what and why various concepts were covered, rather than walking away with the feeling that all they did was “plug and chug.”

6. CONCLUSION

Although it appears intuitive that students rely on their instructors in any course, there are some implications that may not be as intuitive. Based on my own observations as an instructor, as well as comments provided by the students in this study, a primary motivation for students in introductory statistics (those who are not statistics majors) to do anything (take notes, work problems, study outside of class, etc.) is how it will impact their final grade (Garfield, 1995). Students further mentioned that they appreciate

feedback on graded assignments as a way to make sure they know what the instructor wants them to know. Here we see a direct connection between how we assess students, the opportunities we provide for assessment (e.g. homework, in-class activities, quizzes, tests, projects), and *why* we even assess them (Chance & Garfield, 2002).

Assessment systems in any course gauge whether or not the students are meeting course objectives. As we work to develop introductory statistics courses oriented more toward understanding and less toward mechanics, our assessment systems must change as well. As we change our assessments, it is important to remember that our classroom environment must also change to encourage students' development of understanding over their mastery of mechanics (Treagust, Jacobowitz, Gallagher, & Parker, 2001). Demetrulias (1988) argues that an "opportunity to understand statistics from an integrated and flexible viewpoint *must go along with a classroom environment that rewards such exploration*" (emphasis added, p. 169). As students in this study report, what happens in class becomes their main resource for any work they do outside of class (Petocz & Reid, 2003). Spending time in class (and with assessments) on "how to understand" as much as "what to understand" becomes critical, and instructors must continue to develop and make use of delivery techniques, classroom examples, and homework activities that focus on this "how to understand" piece. I also encourage sharing these reflections and experiences in the literature, so that others may benefit from what we learn in our own classrooms. Results from this study suggest the need for researchers to encourage more personal accounts of actual experiences of instructors teaching, and students taking, statistics, as opposed to relying only on the more quantitative outcomes currently presented (Becker, 1996). Instructors and their students are "in the trenches," experiencing, reflecting on, and ultimately determining whether any particular classroom environment is or is not successful in increasing students' understandings (Batanero, Garfield, Ottaviani, & Truran, 2000).

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