Student Perceptions of Learning Experiences in Large Mechanics Classes: An Analysis of Student Responses to Course Evaluation Surveys

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Introduction

Fundamental mechanics courses (e.g., Statics, Dynamics, and Strength of Materials) provide the foundation upon which advanced discipline-specific courses are built. They are also characterized by conceptually-challenging material and are usually taken with similarly challenging courses, such as Physics and higher Calculus[1]. However, rising costs and student populations have led large institutions that offer multiple engineering programs to teach certain courses (usually courses taken across multiple disciplines, such as Mechanics courses) in large classes in order to manage resources[2–4]. As such, students are being placed in classroom situations where there is less opportunity for quality interaction between the instructor and the students, a commonly observed reality in the large class setting [5]. With diminished quality of interaction, some students either fail these courses, or pass them while still having fundamental knowledge gaps that may affect their performance in succeeding courses. These experiences of failure and lower academic performance can also lead to issues of student persistence in engineering[1, 6].

While large classes are increasingly becoming a new normal in many large universities[7], defining what constitutes a large class is still unclear. Informed by others (e.g., Mulryan-Kane, 2010), we consider a large class to be one in which the learning environment is significantly compromised due to increasingly unfavorable student-to-teacher ratios. Challenges as a result of large classes are well-documented in the literature and can include observable behaviors (e.g., decreased engagement, declining achievement)[8, 9], self-reported perceptions (e.g., declining motivation, dissatisfaction with instructor/pedagogy)[10], and physical infrastructure limitations (e.g., adequate audio/video projection, wireless network capacity)[10]. To the faculty, these challenges manifest as feelings of difficulty establishing rapport, monitoring students' academic performance to a level where providing individualized, timely, and quality feedback is possible, and actively engaging everyone in the class[9]. Even the most well-intentioned instructor can easily become that person up front and in the center of the room that the students at the back can only hear but not really listen to, much less interact with in meaningful ways. These challenges and feelings make it all the more difficult to cultivate a sense of classroom community, and to use this environment to foster deep learning.

A pilot study on faculty teaching large foundational engineering courses[11] gave the following descriptions of learning in large classes, from the perspective of faculty: diminished quality of interaction between instructor and students and a perceived lack of cognitive engagement among students. This description by faculty prompted us to ask the following questions: *How do students describe their learning experiences in large mechanics courses? How do their perceptions align with those expressed by the faculty who taught these courses?*

The student perceptions of teaching (SPOT) survey is used to gather institutional data on student experiences. Students are given an opportunity to express their thoughts about their learning experience in the class, and to make these observations known to the instructor. Ideally, this data may be used to inform curricular and pedagogical decisions, as well as aid in reflective practice; unfortunately, this potential is usually not maximized [12]. By examining the responses to open-ended questions in SPOT surveys of Mechanics courses, we were able to document the student learning experience in these courses, specifically in the large class setting. It also provided an opportunity to explore how to synthesize and present SPOT survey data in a form that is more meaningful and useful to the instructors of large Mechanics classes.

Data and Methods

The study analyzed existing institutional data, consisting of responses from surveys on student perceptions of teaching (SPOT) for all offerings of Statics, Dynamics, and Strength of Materials in a large public research university over a period of four consecutive regular semesters (Fall 2014, Spring 2015, Fall 2015, and Spring 2016). The use of existing data for original research is considered as a way to maximize the usefulness of previously-collected data[13]. In the case of the data used for this study, SPOT surveys are routinely collected by the institution for non-research purposes (e.g. evidence for tenure and promotion), but contain rich, descriptive information that we believe is worthy of qualitative analysis for research purposes. The data was provided by the office that facilitated the administration of the surveys and stored survey responses. It contained no information that identified respondents, and code names were generated and used to replace names and references to the course instructor wherever these appeared. We also sought review and approval of our study protocol from our Institutional Review Board prior to requesting for and analyzing the data.

We focused on responses to four open-ended items (3,917 responses); these items are listed in Table 1. The questions were included at different points within a Likert-type survey and served as opportunities for students to give specific comments about their instructor, the learning environment, and their perceptions of themselves as learners which cannot be expressed through the Likert-type items.

Table 1. Items included in analysis

Open-ended items, SPOT
What did the instructor do that most helped in your learning?
What could you have done to be a better learner?
Please add any additional comments regarding the course and/or instructor
Please add any comments about the physical environment

We wanted to allow descriptions and themes about the student learning experience to emerge from the data, and chose *qualitative content analysis* and the *constant comparative* method during coding to accomplish this goal. *Qualitative content analysis* generates a "*subjective interpretation of the content of text data through the systematic classification process of coding* *and identifying themes and patterns*" and is a way of analyzing text data from open-ended survey questions[14]. The *constant comparative* method iteratively takes information from the data and compares it with categories that emerge from the data, until all information that can be gleaned from the data is identified[15]. It is traditionally used in the formulation of a theory for grounded theory studies, but was used here to exhaustively identify descriptions of the student learning experience out of the data.

The iterative nature of constant comparative analysis requires initially going through a subset of the data and reviewing clusters or categories that emerge from the data[15]. For this stage of the study, we chose to analyze a stratified random sample[16] of the responses (1,281 responses, 32.7% of total number of responses). Each stratum consisted of at least 4 responses or 25% of the responses given in each class offering of the Mechanics courses included in the study, whichever is higher; for strata where the total number of responses was less than 4, all responses for that stratum were analyzed. This ensured that the subset of responses included in the analysis represented responses for all class offerings of Mechanics courses. Future stages of the study will analyze the remaining responses, and the succeeding analyses will be informed in part by the emergent themes generated from the sample in this stage of the study, continuing the *constant comparative* method of analysis.

Two investigators concurrently analyzed the sample by *coding* responses. Coding consists of assigning words or short phrases (*codes*) that captured or described the experience shared by the respondent[17]. The coding process consisted of two coding cycles. First-cycle coding used *in vivo* and descriptive coding techniques to assign labels to the data[17, 18], and was done by each coder independently. Simultaneous coding (assigning *multiple codes* to the same word, phrase or section of a response) was used when necessary and appropriate. Second-cycle coding clustered the labels generated by the two coders in the first-cycle coding process. Pattern coding techniques were then used to identify emergent themes based on the clusters generated by the second-cycle coding process. Memos and notes were also generated and associated with data and labels through both cycles of coding. All labels were documented in a codebook for organization, management, and collaboration purposes[17, 18]. The codebook may also be used to inform the development of a system to analyze and present responses to open-ended questions in SPOT surveys so that this data can be used more meaningfully by faculty, departments, and institutions.

Establishing *trustworthiness* is an important consideration in qualitative research efforts, as it serves as evidence of the integrity of research findings[19, 20]. There are various ways to establish trustworthiness, and Creswell (2012)[15] recommends using at least two in each study. We used *triangulation* (*multiple investigators/coders* analyzed the data) and *peer examination* (a peer who was not involved in coding examined the meanings and interpretations that were applied to and emerged from the data) to establish *trustworthiness*[19].

Results and Discussion

The primary purpose of this study was to describe the learning experience in a large Mechanics course from the students' point of view, and to see how it aligns with perceptions expressed by faculty who taught some of the courses included in this analysis[11]. First-cycle coding generated 184 labels. As described in the methods section, the second-cycle coding process clustered together labels that captured similar perceptions and phenomena, generating 32 codes that were examined further to develop major themes from the data. For this phase, analysis was guided by the results of a pilot study on faculty perceptions of teacher-student interaction in foundational engineering courses and theories on learning and motivation (social cognitive theory, self-efficacy, expectancy-value)[21].

Four major themes emerged: *facilitator of learning*, *quality interaction*, *self-regulated learning*, and *physical environment*. Tables 2 – 5 shows the codes and themes that were generated by the analysis.

Facilitator of learning

Student experiences indicated a preference for instructors who assume the role of *facilitator of learning*, which is in keeping with the nature of the role of the instructor in a classroom environment that espouses the *learning paradigm* (a paradigm that focuses on *producing learning* as opposed to *providing instruction*), as described by Barr and Tagg[22]. We operationalized *facilitator of learning* as the ways that students described their instructor's contribution and role in their learning process in terms of the resources that the instructor provided, what the instructor did in class, what the instructor asked and allowed students to do both inside and outside of class, and how much the instructor involved students in their learning process.

Table 2. Emergent theme: Facilitator of learning

Code	Description
Success	Statement talks about student perception of faculty effort to helps students succeed/increase their capability to succeed in the course and build a good learning environment
Cognitive Modeling	Statement talks about the professor demonstrating how to work problems and how to think about the problem, task or topic
Provided resources	Shared experience of receiving resources/materials, both concrete (textbook, printed notes, uploaded notes and slides, handouts) and conceptual (discussed examples in class, online examples)
Scaffolding	Statement talks about facilitating the construction of knowledge
Material/Test Disparity	Statement talks about alignment between instruction and assessment
Sense of Autonomy	Statement expresses level of student involvement in directing the learning process
Class Routine	Sequence of activities regularly followed during class time
Class Structure	Response talks about pacing of the lecture, how time in the classroom is allocated, group work and homework policies and practices, and grading policies and practices
Affirmation	Sweeping statements of praise or dissatisfaction of a professor

Students appreciated instructors who made an effort to ensure clarity of the course content by providing appropriate resources, leveraging and building upon prior knowledge, using practical and real-world examples, and providing targeted and timely feedback *("Explained the concepts* *very clearly and with much detail;" "Provided many useful examples that solved a concept multiple ways;" "Provided great feedback on tests and offered several example videos and notes for viewing"*). They showered praise upon instructors who they felt showed compassion for students and were approachable, accommodating, helpful and personable *("Always has office hours that are open for anyone… If I was stuck on a problem or concept he always was willing to help me until I understood"*).

Students expressed various perceptions of their ability to succeed in the course, and both positive and negative perceptions of their instructor's outward manifestation or articulation towards helping students succeed (*"[Instructor] had a general want for his students to know and pass his class he works with his students and not against them;" "It's clear to anyone who goes to class and office hours that [Instructor] wanted us all to succeed"*). They appreciated instructors who created a learning environment where they felt that they received the knowledge and skills necessary for them to succeed in the course if they gave the right amount of effort. They further appreciated a display of interest and commitment in seeing students succeed, such as willingness to extend assistance outside of class hours and flexibility in adhering to class routine to ensure conceptual understanding.

Quality of Interaction

Students shared their perceptions of the *quality* of their *interaction* with their instructors when asked about what their instructor did that helped in their learning and to provide any additional comments about their instructor and the course.

Table 3. Emergent theme: Quality of interaction

Code	Description
Accessibility	Statement speaks about/refers to the ability of students to access/interact with faculty outside of class hours/course hours
Innovations in learning activities	Statement shares experience of effort by faculty to develop innovative learning activities
Timely feedback	Shared experience of turnaround for receiving feedback
Caring	Showing compassion to students
Quality feedback	Student perception of the quality of feedback received

These perceptions included how accessible the instructor was in terms of providing assistance and/or feedback outside of class hours, mostly through the availability of office hours or the willingness to attend to questions immediately after class (*"goes above and beyond with time outside of class;" "[Instructor] is in office more hours than any teacher I have ever had"*). Students also shared specific techniques employed by instructors that helped them understand course content better (*"[Instructor] wrote notes on the chalkboard in different colors which helped differentiating variables and equations from the concepts he wanted us to know"; "[Instructor] brought materials and objects into class to provide real world examples of what we were learning"*). Varying observations were given regarding the frequency, timeliness, and quality of feedback on course work and performance, but the general preference of students is for reasonable turnaround for graded work and meaningful feedback.

Self-regulated Learning

Students also included interaction with their peers and efforts towards self-regulated learning in talking about their learning experiences in Mechanics. In some cases, the need for peer interaction, independent initiative, and seeking help was described as an outcome of a negative experience with their instructor ("*I learned everything from the homework or classmates, nothing from the teacher*"; "*I should have sat in on other professor's classes"*). Some indicated that the instructor affected their ability to learn (*"I honestly needed a better teacher to be a better learner"*). In general, students acknowledged the importance of being cognitively engaged in the course material, both during and outside of class, in order to be a better learner. There are students who felt that they have given sufficient effort to the course, as evidenced by their grade (*"I could not have done better to learn in this class, as that I scored well above the class average on all of the tests and averaged an A on all four of the tests"*), although some students still feel they could have done more despite getting good grades (*"I have an A in that class right now, but I could have studied more"*).

Table 4. Emergent theme: Self-regulated learning

Code	Description
Seek help *Sub-code:* *Seeking help in the right places*	Seeking help outside of class hours to aid in understanding of course content *Sub-code: Where to seek help*
Independent initiative	Taking initiative to engage with the material in various ways outside of class
Study strategies with peers	Strategies used for group study with peers
Classroom engagement	Perceived level of cognitive engagement in the classroom
Class attendance	Frequency at which student came to class
Time management	How time for unsupervised learning outside of class is allocated
External attribution	Attributes performance to factors/entities other than the self
Satisfaction with effort	Expression of general satisfaction with amount of effort given to the class
No specific response	Provided the following responses: N/A, not applicable, nothing or no comment, or expressed unwillingness to answer the question.

Some students expressed frustration about the fact that even if they have already applied what they perceive are effective learning strategies, their performance in the class was still unsatisfactory (*"I don't know… I put more effort into learning this material than all of my classes combined, and then some more. To say that I was disappointed in the results is an understatement."*) There are a select few, however, who chose to provide ambiguous responses ("*Nothing*"; "*N/A*"; "*not applicable*") or expressed unwillingness to comment on their learning process as part of the survey (*This is a bad question please stop asking it. It['s] not relevant, I get it I could [have] done more but that's not point of the spot surveys"*). The coders noted ambiguity in the lack of specific response, as this may indicate a wide range of possible emotions (extreme satisfaction, feeling of hopelessness, or extreme frustration) but there is no way to confirm the respondents' perceptions from the available data.

Physical Environment

Students encountered both positive and negative experiences related to the physical environment that affected classroom learning. They expressed appreciation for classroom layout and amenities that provided optimum experience in terms of the visual, auditory, and technical requirements of the course. They expressed frustration over sub-standard resources, such as lack of seating, due to large class sizes. Several students specifically indicated frustration over the inability to find seats because of the presence of students who are not registered in the class ("*seats were hard to find especially when students from other instructors' classes came so to get a seat you'd have to arrive half an hour early*").

Table 5. Emergent theme: Physical Environment

Code	Description
Thermal environment	Level of comfort of the temperature of the room
Classroom layout	Physical arrangement of the room
Classroom amenities	Technologies available to students in the classroom
Seating availability	Availability of seats for students
Desks and seating	Quality of desks and chairs in the classroom
Acoustics	Quality of sound in the room and the ability to hear the instructor from any point in the room
Visibility	The ability to see material being presented (writings on the board, visual aids, visual presentations) from any point in the room, due to either physical layout or lighting
Physical distance	Comments on the physical distance of the building where the room is located relative to other points in the classroom
External factors	Factors from outside the classroom that affect learning inside the classroom (e.g. noise pollution from outside the classroom)

Furthermore, student perceptions confirmed the views expressed by faculty in the pilot study [11], albeit with slight differences. Both students and faculty cared about conceptual understanding (*"My instructor taught me how to think"*) and a desire for students to actively engage in the course and the course material ("*I should have paid more attention in class"; "I should do more practice problems"*). Both students and faculty also consider the ideal learning experience to involve facilitating learning that leads to conceptual understanding, supported by timely, targeted and quality feedback, where available resources (i.e., office hours, use of technology) are maximized. However, while students recognize the effort of specific instructors to provide them with a positive learning experience, the path to success in Mechanics courses continues to be riddled with difficulty, due to the nature of the topics covered in the course and the skills and effort necessary to learn them. Students also confirmed the observation shared by faculty regarding the tendency of some resources, such as WileyPLUS, an online homework and study utility associated with the textbook that is ideally meant to improve the learning experience for large classes, to be ineffective because the quality of the interaction between the learner and the instructor is low or non-existent, and the feedback received by the student is not meaningful.

Implications and Future Work

The key findings of this study were:

(1) Students shared positive experiences that they associated with instructors who design and facilitate learning environments that encouraged self-regulated learning and conceptual understanding, and engaged in quality interaction with their students.

(2) Students shared negative experiences that they associated with diminished opportunities to be behaviorally and cognitively engaged in the course material, and to receive meaningful feedback in a timely manner.

We summarize the ideal student learning experience in a large Mechanics class, based only on the data analyzed for this study, as an environment where the instructor serves as the *facilitator of learning* and provides *quality interaction* to students; where students need to engage in *self-regulated learning*; and where learning and engagement is affected by the resources and amenities available in the *physical environment* where classroom learning takes place.

These findings are anecdotally and intuitively predictable, and have been documented in past literature (e.g. Cuseo, 2007)[5]. We find value, however, in producing data-supported evidence of these student perceptions specifically for Mechanics courses taught in large classes, and look forward to their use in efforts to revitalize feedback loops in large engineering classes. For example, the emergent codes and themes that were generated in this study may be used to build a database and develop a way to automate the processing of SPOT data available to Mechanics faculty so that it can be used practically and meaningfully. When used in this manner, these findings have important implications in the design of future Mechanics course offerings, specifically in terms of making decisions regarding learning activities, supplementary resources and homework utilities, opportunities to interact and provide meaningful feedback to students, and classroom infrastructure given the reality of having to teach these course in large classes. The opportunity to use these findings for course design purposes apply both to individual instructors and to the department. It opens the possibility of sharing strategies for facilitating learning among instructors, coordinated at the department level.

We note further that qualitatively analyzing student responses to open-ended questions in SPOT surveys is a lengthy and tedious process. Another finding from the analysis indicated that emergent codes and themes related to *facilitator of learning, quality of interaction*, and *self-regulated learning* align with, and indicate student preference for, strategies suggested by the MUSIC Model of Academic Motivation. The MUSIC Model was developed from the analysis, evaluation, and synthesis of research and theories on academic motivation, and is composed of five components: *empowerment, usefulness, success, interest,* and *caring* [23]. Each of the codes generated during analysis could be attributed to, or impacted by, one or more of the five principles of the MUSIC model. Future work should, therefore, harness this potential and explore the possibility of using the codebook generated by this study and the MUSIC model to design a replicable process to meaningfully analyze and present student responses to SPOT surveys, as well as provide strategies for improving student motivation and engagement. There is also an opportunity for further analyses to correlate numeric responses to Likert-scale items against responses to open-ended questions and to consider writing questions to follow-up on findings for inclusion in succeeding SPOT surveys.

References

[1] J. Grohs, M. Soledad, D. Knight, and S. Case, “Understanding the Effects of Transferring In Statics Credit on Performance in Future Mechanics Courses,” 2016.

[2] R. L. Geiger, “The Ten Generations of American Higher Education,” in *American Higher Education in the Twenty-first Century: Social, Political, and Economic Challenges*, P. G. Altbach, R. O. Berdahl, and P. J. Gumport, Eds. Baltimore, MD: Johns Hopkins University Press, 1999.

[3] M. Parry, “‘Supersizing’ the College Classroom: How One Instructor Teaches 2,670 Students,” *The Chronicle of Higher Education*, 29-Apr-2012.

[4] National Science Board, “Science and Engineering Indicators 2014,” National Science Foundation, 2014.

[5] J. Cuseo, “The empirical case against large class size: adverse effects on the teaching, learning, and retention of first-year students,” *J. Fac. Dev.*, vol. 21, no. 1, pp. 5–21, 2007.

[6] S. M. Lord and J. C. Chen, “Curriculum Design in the Middle Years,” in *Cambridge handbook of engineering education research*, New York, NY: Cambridge University Press, 2014, pp. 181–195.

[7] C. Mulryan-Kyne, “Teaching large classes at college and university level: challenges and opportunities,” *Teach. High. Educ.*, vol. 15, no. 2, pp. 175–185, Apr. 2010.

[8] E. Carbone, “Students Behaving Badly in Large Classes,” *New Dir. Teach. Learn.*, vol. 1999, no. 77, pp. 35–43, 1999.

[9] G. Gibbs and A. Jenkins, *Teaching large classes in higher education: how to maintain quality with reduced resources*. London: Kogan Page, 1992.

[10] E. Carbone and J. Greenberg, “Teaching Large Classes: Unpacking the Problem and Responding Creatively,” in *To Improve the Academy*, vol. 17, M. Kaplan, Ed. Stillwater, OK: New Forums Press and the Professional and Organizational Development Network in Higher Education, 1998, pp. 311–326.

[11] M. Soledad and J. Grohs, “Understanding Faculty Experiences in Teaching Large Classes: A Pilot Study on Faculty Perceptions of Teacher-Student Interaction in Foundational Engineering Courses,” in *The 2nd Annual Teaching Large Classes Conference*, 2016.

[12] E. Blair and K. Valdez Noel, “Improving higher education practice through student evaluation systems: is the student voice being heard?,” *Assess. Eval. High. Educ.*, vol. 39, no. 7, pp. 879–894, Nov. 2014.

[13] H. G. Cheng and M. R. Phillips, “Secondary analysis of existing data: opportunities and implementation,” *Shanghai Arch. Psychiatry*, vol. 26, no. 6, p. 371, Dec. 2014.

[14] H.-F. Hsieh and S. E. Shannon, “Three approaches to qualitative content analysis,” *Qual. Health Res.*, vol. 15, no. 9, pp. 1277–1288, 2005.

[15] J. W. Creswell, *Qualitative Inquiry and Research Design: Choosing Among Five Approaches*. SAGE, 2012.

[16] D. R. Krathwohl, *Methods of educational and social science research*. Longman, 1993.

[17] J. Saldana, *The Coding Manual for Qualitative Researchers*. SAGE Publications, 2009.
[18] M. B. Miles, A. M. Huberman, and J. Saldaña, *Qualitative data analysis: A methods sourcebook*, 3rd ed. Thousand Oaks, California: SAGE Publications, Incorporated, 2013.
[19] J. A. Leydens, B. M. Moskal, and M. J. Pavelich, “Qualitative Methods Used in the Assessment of Engineering Education,” *J. Eng. Educ. Wash.*, vol. 93, no. 1, p. 65+, Jan. 2004.
[20] N. Golafshani, “Understanding reliability and validity in qualitative research,” *Qual. Rep.*, vol. 8, no. 4, pp. 597–606, 2003.
[21] J. E. Ormrod, *Human Learning*, 6th ed. Pearson Education Inc., 2012.
[22] R. B. Barr and J. Tagg, “From Teaching to Learning: A New Paradigm for Undergraduate Education,” *Change*, vol. 27, no. 6, pp. 12–25, Nov. 1995.
[23] B. D. Jones, “Motivating Students to Engage in Learning: The MUSIC Model of Academic Motivation.,” *Int. J. Teach. Learn. High. Educ.*, vol. 21, no. 2, pp. 272–285, 2009.