Assessing students' perceptions of learning at undergraduate sophomore level in mechanical engineering curriculum

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Abstract

While studies report problem-based learning promotes deeper learning in STEM curriculum at the undergraduate level, some researchers note students have difficulty transitioning to this new style of learning. The purpose of this study was to assess students' perceptions of classroom strategies in mechanical engineering courses. Fifty-three mechanical engineering students in sophomore level courses took an electronic survey with forced choice and open response items. Results indicated that students perceived that they learn best from practical class sessions, demonstrations, studying on their own, doing homework, and watching actions. The majority of students did not perceive listening to multimedia presentations, conducting labs, or completing design projects as best learning strategies for themselves. These findings may be valuable in that students' perceptions of best classroom practices do not support previous literature on how students develop conceptual understanding through problem-based learning.

Keywords

Perceptions; active learning; mechanical engineering

Introduction

Studies have shown that only 20% of students may follow a lecturer in an average undergraduate mathematics lecture.[1] Meanwhile, active learning in the STEM curriculum has been highly cited as contributing positively to student learning.[2] Active learning can be manifested in problem-based learning, which has been shown to promote collaborative learning, reinforcement and integration of topics, and development and translation of skills to solving more realistic problems.[3,4] Furthermore, a review by Dr. Hanna reported active learning techniques could help better prepare students for the workplace upon graduation.[5]

While studies report problem-based learning promotes deeper learning in STEM curriculum at the undergraduate level, there are substantial problems that need to be overcome with transitioning to this new style. These can include dealing with large student group sizes, with increased diversity among students, and altered study patterns.[1] With regards to the latter, some researchers note students have difficulty transitioning to this new style of learning.[6] Courses in STEM are taught differently based upon the department, course content, and individual teaching style. Students develop mastery through conceptual development, integration of new knowledge with existing knowledge and skills, and the application of component skills in relevant contexts.[7] Thus, teachers are encouraged to adapt active learning strategies into their STEM curriculum.

However, to adjust to a new teaching style, students need guidance on getting started and on the development of expertise in this domain, which includes the use of requisite knowledge and skills in formal and informal contexts with minimal support from a cognitive tutor.[6] One way to ease the transition will be to identify how students perceive that they learn best and why by using pedagogical and cognitive research.

Currently, students in the Department of Mechanical Engineering at the University of Delaware are introduced to some active learning strategies in their first year. One such strategy is cooperative (or team-based) learning, which has been shown to provide positive outcomes for achievement, productivity, relationships, and psychological health.[8] At the freshman level, cooperative learning is brought into the statics course where students conduct a design project in groups using simple materials (i.e. PVC piping) to build a chariot which holds the weight of an average person. Active learning becomes more integrated into their curriculum with subsequent years, leading up to a capstone senior design course in their fourth year. While students may adjust to active learning strategies by their fourth year, the nature of students' perceptions of effective learning practices at the sophomore level are unclear. This is especially important as these experiences are typically on of the first encounters with active learning for many. This understanding can help guide mechanical engineering professors in recognizing students' perceptions, and therefore, their attitudes and beliefs, which can inform the development of strategies to smooth the transition to active learning, so as to maximize the benefit of this teaching style. Thus, the purpose of this study was to first assess students' perceptions of classroom strategies in mechanical engineering courses at the sophomore level.

Methods

Approximately 150 students in sophomore level mechanical engineering courses at the University of Delaware were invited to participate in an electronic survey with forced choice and open response items via e-mail. Of those invited to participate, 53 mechanical engineering students in sophomore level courses took the electronic survey. This study was exempt under the University of Delaware Institutional Review Board.

The survey questions were deployed via Google Forms. No student was compelled to complete the survey as a requirement of the course, and there was no time limit in which to respond. The questions were chosen with the help of the assistant director for Center for Teaching and Assessment of Learning at the university. The last two questions were adapted from two questions in the VARK®-Learn questionnaire, which was developed to assess learning styles and provide study strategies for students.[9] The questions and forced choice answers are listed below:

1. When considering your experience in Mechanical Engineering classes, how do you learn best…
[Mark the options that apply most to you]

- ☐ Lecture
- ☐ Design projects
- ☐ Discussion (working with groups to solve problems)
- ☐ Labs
- ☐ Homework

- ☐ Studying on your own
- ☐ Other:

Briefly explain why you think the methods you chose above work for you....

2. If you were to teach high school students the basics of Statics, how would you teach the course to make sure that they learned the material?
[Mark the options that apply most to you]

- ☐ Present a lecture using PowerPoint
- ☐ Present a lecture using the chalkboard
- ☐ Give them a problem to solve in groups
- ☐ Provide an in-class demonstration of the concepts
- ☐ Use hands-on activities (e.g. labs, projects)
- ☐ Other:

Briefly explain why you chose those teaching methods....

Are the teaching methods you chose the same way that you learned statics?

3. Do you prefer a teacher or a presenter who uses
[from the vark-learn.com questionnaire[9]]

- ☐ question and answer, talk, group discussion, or guest speakers
- ☐ diagrams, charts, or graphs
- ☐ demonstrations, models or practical sessions
- ☐ handouts, books, or readings
- ☐ Other:

4. You are trying to learn to plot a fast fourier transform in Matlab and you have been told to use a specific youtube tutorial to do so. There is a person speaking, some lists and words describing what to do and some diagrams. You would learn most from:
[from the vark-learn.com questionnaire[9]]

- ☐ listening
- ☐ seeing the diagrams
- ☐ reading the words
- ☐ watching the actions

Results

With regard to survey item 1, results from the 52 responses indicated that students perceived they learned best in mechanical engineering courses by doing homework (65.4%), attending discussions (53.8%), studying on their own (53.8%) and lectures (50%) (Figure 1). Design projects (30.8%) and labs (13.5%) were perceived as effective by a minority of students. The three responses (5.8%) for the written in "Other" option include: getting extra help during the TA's office hours, textbook, studying written examples.

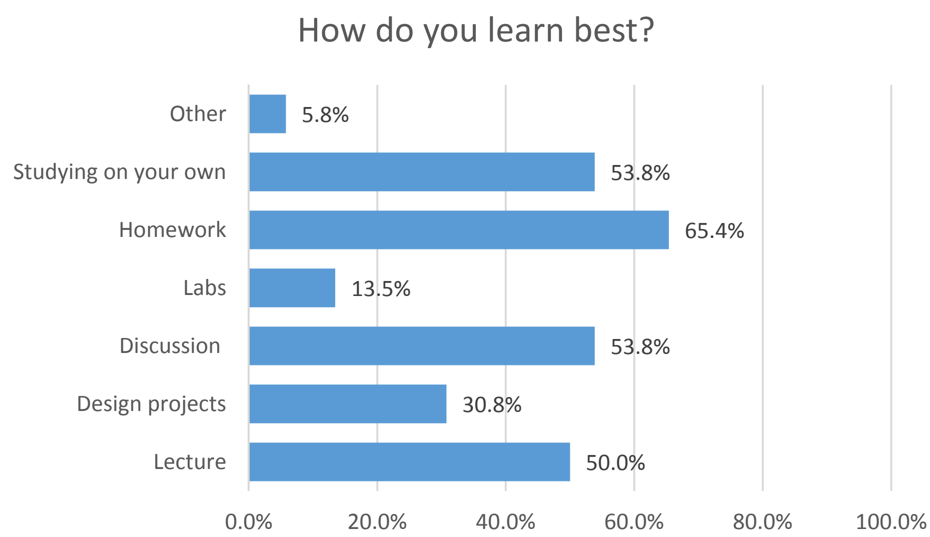

Figure 1. Student responses (n = 52) to a fixed choice answer question on how they believe they learn best.

Some selected responses are below (with their fixed choices in parentheses):

"Actual application of material is invaluable." (Homework)

"Classes are all theory so the real learning happens in homework and working in groups" (Discussion, Homework)

"If you teach yourself something you don't know it because someone told you, you know it because you figured it out on your own" (Studying on your own)

"I need to learn the basic methods and concepts in lectures, and apply those when I do my homework. I need time to practice and figure out problems by myself. I think I am productive when I am alone." (Lecture, Homework, studying on own)

"Working with others helps you observe how other people think about problem. If their methods are useful then you can use them when you go to solve a problem." (Discussion, Lab, Homework, Studying on your own)

"The hands on approach allows for the lessons from lecture to be more applicable" (Design Projects, Discussion, Labs)

"I learn better by physically doing the work then I do sitting and listening to someone tell me how to do it." (Design projects, Homework)

With regard to survey item 2 (n = 52), when asked how they would teach high school students a statics course, students reported that they would lecture using a chalkboard (63.5%), give the class a group problem (51.9%), conduct in-class demonstrations (63.5%), and hands-on activities (46.2%) (Figure 2). Only 12 students said they would lecture statics using a multimedia presentation software (23.1%). Of the four responses (7.7%) for the written in "Other" option, three specified: giving students a worksheet, doing problems with the class, and doing practice problems in lecture.

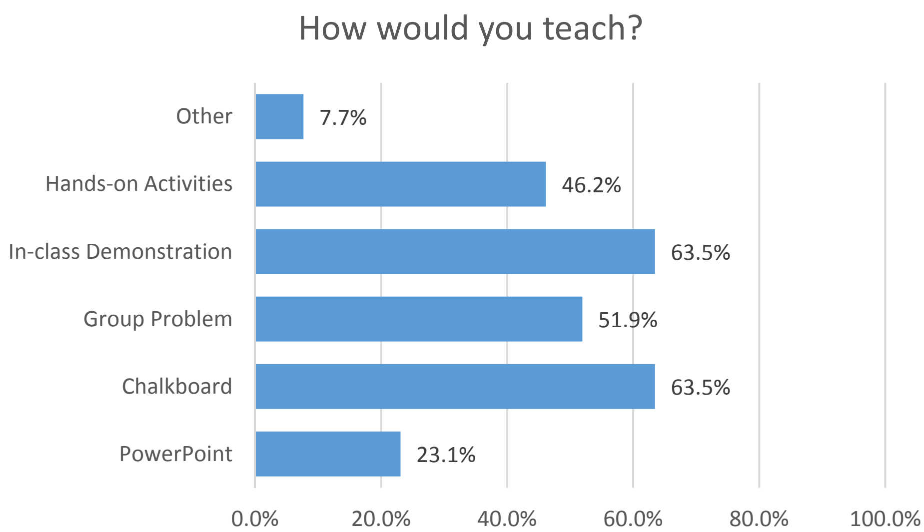

Figure 2. Student responses (n = 52) to a fixed choice answer question on what teaching strategies they would use to teach high school students a statics course.

Some selected responses are below (with their fixed choices in parentheses):

“Statics is a field where you need to know the fundamentals, and using a chalkboard will keep the pace of the class.” (Chalkboard, Hands-on activities)

“I'm a visual learner and like to watch the problems being done.” (Chalkboard, Hands-on activities)

“Lecture gets the concept down. A demonstration makes it real, making it easier for the kids to understand it. A problem helps kids understand how to work with the knowledge. The lab would then let them apply that knowledge, hopefully solidifying it.” (Chalkboard, Group problem, In-class demonstration, Hands-on activities)

“Power Point so the material is clear and concise and in class demonstration in order to relate the material to something students already know i.e real life” (Powerpoint, In-class demonstrations)

“Kids don't learn well at all through powerpoints because they get super bored. To really teach statics, or any critical thinking and math based topic, the teacher needs to do an example problem and then have the students do other problems on their own.” (Group problem, In-class demonstration, Hands-on activities)

“Many students in high school refuse to accept concepts if they don't agree with the physics or see it practically. Demonstrations and hands-on activities would be a much easier way to persuade them to understand.” (In-class demonstrations, Hands-on activities)

Interestingly, 58.7% of students (n = 46) reported the options they chose were used in their Statics course.

With regard to survey item 3 (n = 51), a large proportion of students preferred a teacher who used demos, models, and practical sessions (80.4%) compared to group discussion and guest speakers (45.1%), diagrams and graphs (21.6%), and handouts and reading (15.7%). The three responses (5.9%) for the written in “Other” option specified they preferred a teacher who does: question and answer, group discussion, and provides worksheets/practice problems; uses reference material and equations; and a professor who lets them learn on their own.

With regard to survey item 4 (n = 52), when asked how they would obtain information from watching a video tutorial, most participants would watch the actions (86.5%) while listening (34.6%), decoding the diagrams (53.8%), and reading the words (23.1%) were less preferred.

Discussion

A voluntary electronic survey from sophomore mechanical engineering undergraduate students reported that most students perceive they learn best from practical class sessions, demonstrations, and watching actions and not from listening to multimedia presentations or conducting labs. These findings may be valuable in that students’ perceptions of best classroom practices do not fully support previous literature on how students develop conceptual understanding through problem-based learning.

An important cognitive principle in transferring learning to situations outside of class or in a new environment is that people learn new concepts through relevant, contextualized examples.[10] In this way, lab exercises and design projects can be very valuable in translating knowledge to “real” life and furthermore, in developing life-long learners. However, the majority of students did not perceive these as most valuable practices for achieving their best learning. In further explaining their answer, a student noted test problems appear close to homework problems. However, while being able to practice solving homework problems does promote the cognitive principle of practicing to learn new facts[10], if the student is memorizing problems in order to pass the exam, this may be closer to superficial learning than deep learning that facilitates transfer of conceptual knowledge and skills to novel contexts.[7]

The majority of students reported that the way they would teach a fundamental engineering course is similar to the way they were taught and commented that they believed this to be the way that works best for them personally. However, educators cannot assume that their personal preferred learning style will accommodate every student. Because of the range of learning styles and topics covered in engineering, this discipline may benefit most from a “fluid” teaching model where group work, lecture, individual work, and hands-on activities are highly integrated. Furthermore, if students are partial to teaching the way they were taught, and evidence supports active learning promotes deep learning in the classroom, our results show support for introducing active learning at earlier grade levels in school.

Based on the third and fourth survey items, adapted from the VARK®-learn questionnaire, more than 80% of students who responded to the survey prefer demos, models, and practical sessions as well as watching the actions while learning. This would suggest many mechanical engineering students at the sophomore level may prefer visual and kinesthetic learning styles. Interestingly, responses from these two questions do not fully support the responses to the first two questions posed in this survey, as many students did not find they learned best from such kinesthetic learning strategies as labs or design projects. Further investigation into this discrepancy in students' perceptions of learning will be required before conclusions are drawn from this finding.

While this survey was useful, there were several limitations to this study. One limitation was the small sample size and data collected. For example, the students' experience with active learning in high school courses was not recorded and may have been beneficial in reasoning particular students' preferences in learning. Furthermore, it is unclear how many non-traditional students (e.g. transfer students, students returning from delayed enrollment postsecondary education, part-time students, etc.) responded to this survey. Finally, while responses from 53 students were recorded, there are approximately 150 students in the University of Delaware's mechanical engineering program at the sophomore level. Therefore, this survey cannot be generalized across the entire population, or other similar populations, but rather only the subset who volunteered to participate in this particular study.

In conclusion, students at the undergraduate sophomore level in mechanical engineering curriculum may not be cognizant of the learning strategies which work best for them. While students reported they learned best from studying on their own, doing homework, and attending lecture, the survey revealed the majority of students could benefit from active learning strategies, like performing practical labs and completing design projects. These findings may be valuable in that students' perceptions of best classroom practices do not support previous literature on how students develop conceptual understanding through problem-based learning. Professors in the mechanical engineering departments can benefit by assessing their students learning strategies and informing students of the cognitive benefits of active learning in the classroom.

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Dr. Higginson is an Associate Professor in the Departments of Mechanical Engineering and Biomedical Engineering at the University of Delaware. The fundamental objective of her research group is to improve the understanding of muscle coordination for normal and pathological movements through coupled experimental and simulation studies. In recognition of her contributions, Dr. Higginson was awarded the College of Engineering Outstanding Junior Faculty Award in 2014 and the Excellence in Teaching Award in 2015.

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