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Benefits and Challenges of Implementing Case-based Instruction: A Student Perspective*

AMAN YADAV
Educational Psychology and Educational Technology, Michigan State University, East Lansing, MI 48824. USA.
E-mail: ayadav@msu.edu

CHRISTY BOZIC
College of Engineering and Applied Science, University of Colorado Boulder, CO 80303. USA. E-mail: christy.bozic@colorado.edu

SARAH GRETTER
Educational Psychology and Educational Technology, Michigan State University, East Lansing, MI 48824. USA.
E-mail: sgretter@msu.edu

ERIC NAUMAN
School of Mechanical Engineering, Purdue University, West Lafayette, IN 47907, USA. E-mail: enauman@purdue.edu

Case-based instruction has been found to increase student engagement and motivation in engineering classrooms. However, there is a lack of qualitative in-depth examination of student perceptions of the use of cases in engineering. The current study examined undergraduate engineering students' perceptions of implementing case studies in a mechanical engineering course, what aspects of case studies were beneficial and what aspects were challenging. Twenty-seven students enrolled in an undergraduate mechanical engineering course were interviewed using a semi-structured protocol. The interview protocol asked students about their experiences when learning from cases in the course. The interviews were transcribed and coded to develop categories and themes related to student views about cases. The interviews produced a rich set of qualitative data, which suggested that students found cases to be beneficial with regards to allowing them to see real world application of course concepts. Students also reported some challenging aspects of learning from cases, such as frustrations with the ill-structured nature of cases and the inefficient use of class time when using cases. Cases offer a potential mechanism to engage students in the classroom, but face resistance and challenges. Hence, it becomes important for instructors to carefully engage students in the case study approach.

Keywords: case-based instruction; qualitative interview

1. Introduction

Engineers in the 21st century are increasingly required to demonstrate skills that go beyond technical knowledge and skills and also require them to have interdisciplinary breadth, being able to communicate, work in teams, and have an understanding of global and societal contexts [1–2]. Additionally, this engineer must develop the information-seeking skills necessary to research and propose solutions to solve real-world problems [3]. *The National Academy of Engineers* has developed a set of characteristics the future engineer will have to possess to be a competitive force within the field [4]. These characteristics include strong analytical reasoning, critical thinking, managing complexity, self-directed learning, communication, business and management skills, leadership, ethics, and cultural awareness [5]. This new type of engineer needs the competencies of a "T Shaped professional" with both discipline specific in-depth domain knowledge as well as boundary crossing competencies to be able to problem solve and work across domains [5]. To achieve this, engineers should not only have deep knowledge in their engineering discipline but also build a broad knowledge base in the adjacent areas of business, entrepreneurship, and innovation during their undergraduate education.

A 21st century engineer cannot be created by a traditional engineering education curriculum that relies on the deductive teaching approaches beginning first with "theories and abstractions and then progresses to applications of those theories" [1, p. 21]. These new expectations for engineers call for educators to change tightly sequenced and highly technical curricula, which are rooted in a paradigm from the 1960s [1]. Instead, engineering educators need to use inductive pedagogical approaches, such as problem-based learning and case-based instruction (CBI) to develop a wide array of skills for students, such as teamwork, critical thinking, and cultural awareness in addition to the requisite technical knowledge [6]. Recently, case-based instruction has been highlighted as a possible way to allow engineering educators to expose their students to the complexities of real world engineering problems while engaging them in the curriculum [7–9].

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1.1 Case-based instruction

Case-based instruction (CBI) involves using case studies with the overarching goal of providing students with the opportunity to apply complex concepts to solve applied, real-world problems [10]. Using case studies to allow students to experience how professionals solve problems encountered in the field has a long history dating back to the 1870s when Christopher Langdell, a law professor, used actual legal cases to teach law [7]. The cases allow students to analyze intricate situations and promote complex decision-making through vicarious learning experiences within the safe learning confines of the classroom [11]. Within the context of STEM disciplines, case studies are typically real (or realistic) incidents that promote problem-solving skills by engaging students in solving practical problems and applying their theoretical knowledge [12–14]. The authentic problem solving and student-centered nature of case-based instruction has been found to significantly increase student engagement as well as attendance rates in the classroom [9, 15].

Case studies in STEM classrooms have been common in medical and biological sciences to prepare students for professional practice and connect complex theory to practical application in a controlled, risk-free environment [16–17]. For example, Dori, Tal, and Tsaishu [18] implemented case-based instruction in a biotechnology course for non-science majors and found that case studies significantly improved students' knowledge, understanding, and higher order thinking skills related to biotechnology. While previous research has suggested benefits of cases in improving student outcomes and engagement, Yadav and colleagues [19] examined science faculty's perceptions of case-based learning. Not surprisingly, the authors found that faculty reported case studies having a positive impact on students' learning, critical thinking, and motivation. However, faculty reported that a number of barriers existed to incorporating case-based instruction in their courses, including increased amount of preparation time, lack of appropriate learning assessments, and a paucity of relevant case study examples. Additionally, faculty experienced student resistance to case-based learning, which might have been as a result of unfamiliarity with learning from cases.

1.2 Case-based instruction in engineering

Within the context of engineering education, cases have been used in Chemical and Civil engineering since 1950s [20]. Fuchs [21] defined an engineering case as a "written account of an engineering job as it was actually done, or of an engineering problem as it was actually encountered. [And the case presents] not only quantitative relations amenable to computations, but other more subtle factors such as the interactions of people, the malevolence of inanimate objects, and the pressures of time and resources under which engineers work." Vesper further argued that cases in engineering are designed to "illustrate the art of engineering [and] help students, through practice, to cultivate judgment and an appreciation of what is involved in that attribute" [20, p. 56]. The learning experiences from engineering cases allow students to experience authentic problems and take risks to propose solutions under the guidance of an instructor within the safe confines of the classroom.

While risk-taking has been viewed as a desired attribute of creative and innovative engineers, often employers punish engineers for on-the-job failure and engineers face punitive consequences [22]. So case-based instruction offers one approach to prepare engineering students to search for creative solutions free from the risk of failures [23]. In spite of the use of case studies in engineering since the 1950s there is limited in-depth examination of the influence of case studies on student engagement, learning, and motivation [24]. A majority of the research on case studies in engineering has examined student perceptions using surveys and questionnaires. For example, Vesper and Adams [25] evaluated faculty and student perceptions of the case method and educational value they associate with case studies. The authors reported that both faculty and students found the case method to be valuable in allowing students to see how and what engineers do. On the other hand, traditional lecture in engineering courses conveyed knowledge of engineering theories as well as developing skills in manipulating and solving mathematical models. More recently, Raju and Sankar [3] used a questionnaire to evaluate student impressions of case study approach in a senior level undergraduate mechanical engineering design course. The authors reported that the students found cases to be useful, attractive, clear, and challenging while providing them with opportunity to transfer theory to practice. In another study, Yadav and colleagues [26] found that students reported that cases were engaging, increased their enthusiasm, and helped them understand relevance to real world issues; however, cases were not better at helping them understand the course concepts and nor did cases make them feel comfortable with complex ideas.

Overall, this research on case-based instruction has found that students report case studies to be applicable to real-life issues [3, 24, 27], engaging [26, 28], promote creative thinking [27], and develop life long learning skills [29]. While the research on case-based instruction—especially student percep-

tions—is growing, we have few in-depth qualitative studies on student experiences with case studies. Given the incompatible findings (students find case studies useful, but not when it comes to learning), it is imperative to conduct qualitative in-depth exploration of student views about learning from case studies. The use of qualitative research provides appropriate methods to address this gap as the focus on the *nature* of student experiences from case studies, and *why* students find case studies to be challenging [30]. Furthermore, qualitative inquiry can make significant contributions within engineering education by providing rich, descriptive information on benefits and challenges students face from case-based instruction [31]. The goal of the current study is to better understand how CBI as a pedagogical practice engages engineering students and how they learn from cases [1].

2. Research problem

The aim of our qualitative study was to examine students' perceptions of implementing case studies in a mechanical engineering course, what aspects of case studies were beneficial and what aspects were challenging. Specifically, we investigated the following research questions: (a) What do students believe to be benefits of learning from case studies? (b) What do students believe are challenges to learning from case studies?

3. Method

3.1 Participants

Twenty-seven students enrolled in a mechanical engineering course at a large Midwestern university participated in the study. Participants' average age was 19.64 years and included 10 females and 17 males. Majority of the participants (N = 22) were sophomores with two juniors, one senior, one freshman, and one classified as other. Participants included twenty-four Caucasian, two Asian, and one African-American. Eleven students were mechanical engineering majors, five were industrial engineering, six were biomedical engineering, two were electrical engineering, one was agriculture & biomedical engineering, and two did not identify a major. The participants were volunteers and were paid for their time.

3.2 Materials

3.2.1 Interview

The participants were interviewed at the end of the course using a semi-structured interview protocol. During the interview participants were asked about their opinions of the course in general as well as their thoughts on the lecture-based and case study approaches used in a basic mechanics course. The course covered a number of topics including friction, vector operations, distributed forces, and also covered applications from structural and machine elements, such as frames, and trusses. The course objectives focused on developing students' understanding of *static equilibrium* and *Newton's laws of motion* and how to apply them to engineering systems as well as understand *kinematics and kinetics for particles.* The course also focused on helping students learn a systematic approach to *problem solving* and foster effective mathematical and graphical *communication skills*. The case studies exposed students to these constructs using examples from automotive industry, bridge design, lasers, and dams, especially as they related to the United States, Germany, India, China, and Mexico. During the interview, participants were asked to discuss the relevance of case studies to what they were learning in the course, their future career as engineers, and the improvement of their technical skills. Finally, participants were asked about some challenges of using case studies in their course.

3.3 Procedure

The participants used case studies as a part of their sophomore level mechanical engineering course. The course, ME 270 (Basic Mechanics I), focused primarily on applications of statics to particles, rigid bodies, structures, and the dynamics of particles. The authors utilized both traditional lecture approach as well as case studies in the course. The traditional lecture involved students reading the relevant chapters before the class and the instructor using a traditional lecture approach during the class time. The case study approach, on the other hand, involved students reading the case studies before the class; the instructor, then, led a class discussion surrounding the case study highlighting the relevant course concepts. Towards the end of the course, the first author recruited students for the interview study during class time announcing that we were interested in their thoughts on how the course was structured. In order to make students feel comfortable, they were made aware that participation will not have any impact on their course grade and that the instructor would not have access to their data and all identifying information would be removed before any information was shared after the course grade had been assigned. Twenty-seven students volunteered to participate in the study and were paid for their time. At the end of the course, students met the researchers (not the course instructor) for semi-structured interviews, which lasted approximately 40 minutes. Participants completed a background demographic questionnaire. They also

signed an informed consent form, which was approved by Institutional Review Board. The interviews were tape-recorded.

3.4 Data analysis

The participant interviews were transcribed and imported as text file into a qualitative analysis software nVivo (Version 2.0, Melbourne, Australia). Two researchers (first and third author) met weekly to begin coding the interviews for a detailed line-by-line coding "to generate initial categories and to suggest relationship among categories" [32, p. 57]. The interviews were examined multiple times by two researchers for emerging themes and patterns. The joint coding allowed the researchers to pose questions about participants' views and develop a "shared interpretation and understanding of the phenomenon being studied" [33, p. 382]. Specifically, the researchers looked for the students' perception of benefits of using case studies in engineering education and the challenges they faced when learning from case studies. Initial coding of the interviews generated 52 themes, which were collapsed and categorized into two overarching categories—benefits of cases and challenges of using case studies. The *benefits of cases* overarching category had 19 themes, which were further collapsed into five main themes. This was an iterative process with themes and keywords being continually merged using nVivo, until both researchers were satisfied that themes could not be further collapsed. Based on the work of Weston et al. [33], we established reliability during the coding process by independently applying codes to ten percent of the transcripts and if the agreement was high (eighty percent or better), we deemed the codes to be robust. In case there were discrepancies in the coding process, the researchers discussed the codes until a consensus was formed or the codes were redefined. For the purpose of the reliability, another rater also coded the transcripts using the coding scheme and the inter-rater agreement was 91.66%.

4. Results

4.1 Interview

The interview data is organized under two overarching categories based on the research questions: the benefits of and challenges of using cases.

4.1.1 Student perspectives on benefits of cases

The interview data exhibited that students thought that case studies offered several benefits, including improved problem solving, conceptual understanding, and increased motivation to learn. The five themes on benefits of cases that emerged from the data are discussed below.

Improved problem-solving capability. Students reported that cases improved their problem-solving abilities, which includes understanding how to work through complex problems. Students reported feeling more independent and able to think through and solve problems. Students noted that they felt more prepared for future work in the field. For example, one student stated,

> The [lecture] problems were all well-defined for the class ya know it was one way how you solve them . . . when we did the case studies, there was more than one way to solve them and we could solve them our own way. You could say I think its this way and someone else [in the group] could say I think it should be done this way and still come to an answer that was the same or was still right even though they were approached differently, whereas during the lecture part you needed to do it the professors way to get the answer right.

Another student echoed similar thoughts, namely that case studies allowed them to see the complexity of engineering problems and improved their ability to work through ambiguous problems.

> [With case studies], you have to visualize it differently because it is not always laid out perfectly for you they don't give you all the answers and you have to think about it more conceptually and with different mathematics and the numbers aren't always nice and you have to get used to calculating different things . . . When you get a problem usually in the book they work out perfectly, but in the real world it doesn't ever end up like that and so case studies gave us the opportunity to realize that even if its not a beautiful answer that it could be right.

Students also thought that the case studies improved problem solving because it allowed them to connect different concepts together rather than solving problems that were based on isolated concepts. One student stated,

> It's [case studies] applicable to real life, and you start seeing what you are going to be doing in the workforce, more than just the concepts. You have the concepts, and now you are starting to pull them together. You learn how you won't get all of the examples, but you will start taking something here and something there. It will help you with the whole problem solving, and you kind of get an idea of what's going on.

Students also remarked that the use of case studies allowed them to go beyond rote memorization and allowed them to expand their thinking. For example, one student stated that the case study approach in the class "get me thinking out of the box whereas a lot of my classes right now are rote memorization" and the other classes were "pretty easy" due to memorization and utilization of formulas. He further stated that a case study "makes me think more—I like the fact that it makes me think more."

Improved conceptual understanding. Students also reported that case studies allowed them to develop a deeper understanding of concepts. One student elaborated,

> Yeah I definitely think that doing them (case studies) helped me understand the concepts better. It's one thing to understand the concept; it's another thing to be able to manipulate it and apply it. I think that the homework and case studies do a good job in taking baby steps to get to the point where you can be given the information and use it to the maximum amount.

Students reported that case studies were beneficial for understanding because they allowed them to apply the course concepts, find relevant information, and helped bridge the gap between course content and practical application. For example, another student stated:

> Cases helped us understand the material, and once you understand and see the application of it, your understanding gets better and you're like oh now I know why I'm doing this and it makes a little more sense . . . once you learn the application of it [concepts] you understand what the [math] equation means.. you understand it in a broader sense than just knowing the equation.

Another student reiterated that cases improved understanding because they built on different concepts, stating "the concepts also build off of each other so you don't learn one thing and then just forget about it, you continue it through the whole class." In summary, students reported that cases allowed them to see beyond superficial aspects of the problem and to delve deeper into the issues presented in the case, which increased their understanding.

Real-world application. Students felt that the case studies allowed them to see the real-world application of the concepts being discussed in the class. Specifically, they discussed that case studies helped to make the material more realistic by creating problems embedded in real situations. One student expressed this idea, stating:

> I would assume the goal [of case studies] is to make the problem relevant to what you could do in a career just crunching equations and stuff even for engineers does get a little boring where this can be like hey this is something you will use when you graduate and it gives it a real-world aspect to it.

The case method illustrated examples and utilizations of course material. Cases helped students realize the meaning behind what they learned. Another student remarked:

> I like them [case studies] combined because in lecture you learn just standard 2 + 2 = 4 type thing. But then using the case study you can kind of relate it to something in real life that you would actually use it for. It's not like Calculus where they do this triple integral, and you have no idea what you are doing it for. You can see what it's used for.

Specifically, students seemed to express that real-world problems do not often have clear-cut answers. Case studies aided students in understanding how to work with complex problems in a risk-free environment, as it allowed them to solve problems that do not have an easy straightforward answer. Case studies introduce students to the complexities of real-world situations whereas typical classroom questions and problems are simplified. The following quotes illustrate this discussion,

> When you get a problem, usually in the book, it works out perfectly, and it's like, 'Oh, two pi, excellent!' But in the real world it doesn't ever end up like that. And so case studies gave us the opportunity to realize that even if it's not a beautiful answer that it could be right. They are an idea of a real-world problem, and it just helps you get thinking more abstractly. Because real-world problems are not as simple . . . Case studies help to show you how many possible complexities there are to something because things are never as simple as what we actually do in class . . . Case studies give you the bigger picture, and they show why engineering is necessary, which I think is a good thing.

In addition to allowing them to see the application of course concepts to real work, students also felt that case studies were beneficial in preparing them for future work within the field of engineering by exposing them to real-life problems. One student stated,

> Because as you go through you are constantly working with different like exact problems that help you specify and just kinda it's a more hands on approach. It gets you prepared for the field earlier . . . to give you some experience before you actually [enter the field].. in case you don't have internships and things like just to kinda give you experience with actual problems you may encounter when you go out into the business world after you graduate.

Another student shared a similar sentiment stating, "I guess I would say the goal is to prepare us for real world situations sorta thing because not everything is as cut and dry as it is in the textbooks." Clearly, students see that there are benefits to case studies in the classroom as it allows them to see that what they are learning in the classroom applies to what they might do with real world problems, as one student highlighted, "to help you when you do go to out in the job force doing full blown problems to help you understanding how what you learning in the classroom applies to the problems".

Increased interest and engagement. Students not only saw the benefits of cases as applied to the real world, they also discussed how they were more engaged during the class, and how cases, by providing relevance to mundane problems, gave learning a

purpose. Students felt that the cases increased their motivation to learn by showing how it can be used in the future and breaking up the monotony of day-to-day lectures. One student stated,

> I think it's nice because it's kinda a break like case studies are a break from your typical lecture. And so they are more interesting and our professor gets really excited when he starts talking about stuff, so it's always interesting. It's better than just ya know a standard sit down and take notes lecture. [Our professor] gets really excited about some stuff and he'll just go off on like these small tangents about like dams breaking and um he'll tell us these stories and its more interesting than this is how you measure the force on a dam. So, in that sense it's exciting.

Another student reported that cases made the class engaging because cases were "entertaining and they give you a break from just grinding out the material and learning all these concepts and learning that you actually do use these in the real field instead of just non-useful things." This real world application of concepts being learned during the class grabbed students' attention, which helped [their learning] by providing "a good break from the monotony of the book problems."

Global perspective. Finally, given that our case studies situated the engineering problems in both local as well as global contexts allowed students to view engineering as a more global enterprise. The following comment highlights this idea:

> Well, the case study did help . . . a lot of the case studies were kind of the global perspective in which you're looking at different things from around the world. That helped apply it to different projects around the world or just real-life situations.

Another student also discussed how the cases gave them exposure to technological approaches other countries use to address engineering problems, stating,

> We learned a lot about what's going on in [other] countries, what are the technical advances, what technology are they using there as opposed to just what we are using here, so it kinda gave you that different aspect of what other people were doing.

The cases also allowed students to become more aware of global events and that different areas of the world have different needs. For example one student commented,

> The case studies help you to see that these kinds of things are going to be needed here in this country, but not in this country. We have to think about those kinds of constraints when we are designing for different places.

Even though students reported a number of benefits of case studies that increased their engagement in the course and seeing the real world application of course concepts, they also reported some challenges of learning through the cases.

4.1.2 Student perspectives on challenges of learning from cases

This section discusses students' views on the demands of learning from case-based instruction. It should be noted that even though students discussed these as challenges, instructors might find them to be a positive impact of cases, given that students are not always the best judges of their own learning. For example, some students reported frustration with not being able to find the correct solution to the case study problems. One student stated, "with the case study its harder to find what's the correct answer and how do I get there." Similarly, another student discussed that cases didn't always have one right solution to the problem as compared to ones in the textbook. She said,

> not always having the answers. A lot of the times the answers are in the book and you can just solve it and your like all right I got the right answers. Case studies its you may have gotten the right answer you may have not you have to know exactly what you are doing . . . you have to have confidence in what you are calculating.

Another challenge that students identified was that cases required more work as compared to traditional problems. For example, one student said "case studies that would require more work whereas if I just had a bunch of equations I could just like try it do it another one another one another one." The additional work required was because students had to seek information from outside sources. One student described,

> The equation type problems is what you are doing in the homework all the time, but then it would also be kinda difficult because with [this] class you don't expect to come in and do all kinds of like research and stuff on a type of problem, so I think it would be kinda difficult and would kinda throw you back a little bit.

Students discussed that the need to find additional information to work on problems presented in cases took more time than it was worth. For example, one student stated,

> I probably would have would have taken more time and for me time is money like it like I'm on so many different things that I'm trying to be the most efficient I think lecture is the most time efficient method.

Another student highlighted a similar sentiment that cases were not an efficient use of time, stating,

> If that's [use of cases] the most efficient use of the time 'coz if I was learning about how to build three types of dams [during traditional lecture] in the time it took us to do one case study. To me that [traditional lecture] would have been more effective.

5. Discussion

Results from this study suggested that students found the use of cases allowed them to view the relevance of course concepts in relation to real world engineering applications, increased their engagement and interest in the course overall, and assisted in the development of their problem solving and conceptual understanding of the topics. Additionally, students reported that the cases expanded their global perspective on engineering problems and how other countries address them. These results provide an in-depth examination of students' perceptions of cases and support prior research on what students view as benefits of using case-based instruction. For example, Yadav and colleagues [24] also found that students who learned from cases found them to be thought-provoking and relevant to learning about the course concepts while adding realism to the course. Additionally, students in Yadav et al. [26] reported that cases allowed them to form a deeper understanding of course ideas and to better synthesize those ideas and information. In another study, Raju and Sankar [3] used a Likert-scale survey to examine students' perceptions of cases. The authors reported that students found that while cases were meaningful and relevant to the course topics, they also allowed them to learn difficult concepts and transfer theory to practice.

Given that student experiences, including quality teaching, are a key factor in retention of undergraduate students in engineering disciplines, case studies offer a promising approach to engage students in the content. Seymour and Hewitt [34] reported that students cite poor teaching as one of the main reasons to switch or drop out of engineering disciplines. More recently, Litzler and Young [35] used the Project to Assess Climate in Engineering (PACE) survey to examine the role of student experiences and characteristics in attrition in undergraduate engineering. Results from the survey led to identifying three groups of students: Committed, Committed with Ambivalence, and At-Risk of Attrition. A key finding from this study was that students with the lowest risk of attrition had a sense of community and collaboration with their peers, experienced high quality of teaching, and also saw the value of engineering to society. The authors argued that students who are either ambivalent towards engineering or are at-risk of dropping out might benefit from a curriculum focused on social applications of engineering that would allow students to see how engineering is related to other disciplines.

Cases offer a natural bridge to such a curriculum by situating students' learning in a meaningful context [7], making engineering relevant to modern life [36], connecting theory to practice [12], and engaging them in the course content [26]. Results from our study suggest that cases have the potential to engage all students in the curriculum and to increase their interest by highlighting the real world application of engineering. Furthermore, cases provide an opportunity for instructors to not only provide active learning opportunities, but to also incorporate other key skills, such as collaboration and communication in the classroom [12]. The collaborative nature of problem solving in cases provides students with a lens into how engineers work and also increases the participation and retention of traditionally under-represented minorities and women [37].

In addition to discussing the benefits of cases, students also discussed some potential challenges of learning from cases. While students identified obstacles to learning through case studies, engineering educators may view these student challenges as important skills for the engineering enterprise. For example, students reported that cases were challenging because they had to do additional research when relevant information required to address the case study problem was not readily available. While students viewed this as a challenge, information-seeking and complex problem solving are highly desirable skills in engineering. A survey of industry professionals rated working on complex engineering problems that often involve the ability to learn and understand new information as one of the important attributes of an engineer [38]. Cases provide one possible solution to exposing students to the ill-structured nature of engineering, where problem solving often requires engineers to work with sketchy information. Raju and Sankar argued that cases equip students with tools to deal with issues when "limited information is normally available in many decision-making scenarios and the engineers have to obtain more relevant information through research, contacts, and experience" [3, p. 206].

Students also discussed that cases took more time than traditional lecture and might not have been an efficient use of classroom time. This is not surprising given that previous research has found that engineering students who are experiencing case-based instruction for the first time view that cases take the time away from learning and that the material that needs to be learned is not covered in the class [24]. Faculty have also reported an initial resistance to cases because students prefer a traditional lecture, which covers more content and gives students a false sense of security of "learning" [19]. However, recent studies have shown that cases are significantly better at improving engineering students' conceptual understanding as compared to a traditional lecture

approach [26]. Researchers have argued that even though instructors might implement inductive teaching approaches, such as case-based instruction, the course assessments still use traditional plug and chug questions [15]. The students, thus, feel that they are wasting time and not "learning" the materials necessary to take quizzes and tests. Instructors interested in implementing cases should be cautious about using traditional assessment mechanisms and should focus more on a process of learning that reflects the student-centered approach of case-based instruction.

Given the benefits of case-based instruction in engineering education, it important for instructors to carefully incorporate the case study approach. Previous research on case-based instruction in engineering has suggested that students find cases to engaging [24, 39], but faculty face a number of challenges including student resistance as students feel that not enough content is being covered [26]. However, this is not surprising given that "implementing engaged learning approaches has challenges, including significant educational socialization of faculty and students accustomed to less active, more traditional instructional method" [1, p. 22]. Both faculty and students need to become comfortable with teaching and learning from cases. One strategy to address student concerns about cases might be to invite former students to share their experiences of learning from cases [15]. For example, past students could discuss the initial frustrations that come with students being in charge of their own learning when using cases; however, they could explain that those early demands of learning from cases would be beneficial in their future careers as engineers. There are a number of resources available for faculty interested in incorporating cases in their curriculum, such as the National Center for Case Study Teaching in Science (http://www.sciencecases.org). Davis and Yadav [7] provide an in-depth examination of case-based instruction within engineering contexts, including key issues for faculty to consider when developing engineering cases and/or implementing engineering cases in the classroom.

5.1 Limitations and directions for future research

This study had some limitations that should be kept in mind when considering the findings. One of the limitations was that the data was collected from only one course where case studies were implemented, which limits the generalizability of the results. Furthermore, this was the first time case studies were implemented in the course, which might have also led to some unforeseen challenges of putting cases into practice. Another limitation of the study was the self-reported nature of the qualitative interviews, which might produce response bias results as participants say what they think the interviewer wants to hear. While precautions were taken to minimize the influence of these limitations, future research needs to be conducted in other settings and also supplement interview data by observing student experiences during the implementation of the case studies.

The qualitative results from this study provide an in-depth understanding of students' perspectives on learning from case studies. Future research could extend the current study by examining engineering faculty's implementation of cases and their views on teaching with cases. A meticulous examination of engineering faculty implementing cases would provide us with a knowledge base of what obstacles they face and possibly develop ways to address them. Students in the current study reported that traditional lecture was a better use of the time than cases; hence, researchers should examine whether a blended lecture and case approach would alleviate students' concerns while allowing instructors to provide some necessary background knowledge on the course topics.

6. Conclusion

This study examined undergraduate engineering students' perceptions of implementing case studies in a mechanical engineering course. Incorporating qualitative research methodologies, the results from this study provide an in-depth examination of students' perceptions of cases and elaborate upon the prior quantitative research on what students view as benefits of using case-based instruction. Furthermore, results from this study extend prior research by examining what students view as challenges of learning from cases. Results suggested that students found cases to be beneficial in allowing them to view relevance of course concepts in relation to real world situations, increased their interest and engagement in the course, as well as develop their problem solving and conceptual understanding of the topics. Additionally, students reported that the cases expanded their views and perceptions on the role of engineering from a global perspective. Not only did the students in our study viewed cases as engaging, they also reported that cases allowed them to see issues from multiple perspectives as the course concepts built upon each other. While students reported benefits from the use of cases, participants in this study identified some potential challenges of case-based instruction in engineering education. It is interesting to note that the obstacles students identified might not be viewed as such by engineering educators, but rather as important skills for the engineering enterprise. For example, stu-

dents reported that cases were challenging because they had to search for additional information given that all the information required to address issues in the case was not readily available. Additionally, students reported that traditional lecture approach was a more efficient use of class time as case studies took more time. In summary, the findings from this study suggest that cases are well suited to engage students and allow them to see the connection of abstract concepts to real world problems; however, engineering educators need to carefully embed cases in the classroom to allow students time to adjust to the ambiguous nature of solving ill-structured problems.

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Aman Yadav, Ph.D., is an Associate Professor in Educational Psychology and Educational Technology at Michigan State University. In addition to a Ph.D. in Educational Psychology and Educational Technology, he holds a Bachelors and a Masters in Electrical Engineering. Dr. Yadav's research focuses on computational thinking, computer science education, and problem-based learning. He teaches courses on research methodology, learning theories, cognition, and computing technologies at the undergraduate and graduate level.

Christy Bozic, Ph.D., is a Professor of Practice in Engineering Management at the University of Colorado Boulder. She holds a Ph.D. in Curriculum and Instruction, an M.B.A. in Marketing, and a Bachelors degree in Industrial Engineering Technology. Dr. Bozic builds upon her extensive industry experience to develop undergraduate curriculum to better prepare undergraduate engineers for careers in business and engineering management. Her research focuses on case-based instruction in engineering and engineering entrepreneurship.

Sarah Gretter is a doctoral student in the Educational Psychology and Educational Technology program at Michigan State University. Her research focuses on the implementation of media and information literacy in educational settings, along with teacher training in media and information literacy through pedagogical case studies. In addition, she works as a graduate research assistant on a project involving the professional development of computer science teachers.

Eric Nauman, Ph.D., is a Professor of Mechanical Engineering, Biomedical Engineering, and Basic Medical Sciences at Purdue University. He has received the Willis Tacker Prize for teaching in Biomedical Engineering, the Harry Solberg Award for teaching in Mechanical Engineering, and the A. A. Potter Award for teaching in the College of Engineering. His research focuses on Traumatic Brain Injury, Regenerative Therapies, and the Implementation of Novel Teaching Methods.