Development of an Educational Case Study to Explore Target Value Design

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Abstract

Case studies have been developed and used in teaching and training for more than 100 years. They have widely been used in business and law schools. The use of case studies has become popular in engineering and construction education with evidence of tens of papers reporting the efficacy of the case study method published in the proceedings of the American Society of Engineering Education (ASEE) annual conferences. The Associated General Contractors (AGC) Education and Research Foundation (AGCERF) started the development of construction case studies for educational purposes in 2011 and has published 16 of them, including various construction topics from ethics to mobile technology. A multitude of "how to write a teaching case study" guidelines are available, including in construction education. However, literature that provides insights into developing a specific case study in construction engineering and management is scarce. To fill this knowledge gap, this paper presents the dynamics of developing an educational case study to explore the implementation of target value design (TVD). This case study was developed for engineering and construction management students to formulate, discuss, and decide on strategies, actions, and solutions to provide the best value to the project owner when implementing TVD. This work-in-progress paper focuses on the pilot test when developing the case study. Pre-class engagement, in-class collaborative learning strategies and post-class comprehensive student feedback in addition to instructor's observation and reflection were employed in the pilot test – an important step in developing an effective educational case study.

Introduction

The utilization of case studies in educational settings, tracing back over a century, represents a significant evolution in pedagogical methods. Harrison et al. [1] provide a comprehensive overview of this evolution, highlighting the methodological development and flexibility of case study research. Their work underscores the adaptability of case studies in providing in-depth understanding across various disciplines, particularly social sciences, education, business, law, and health, to address a wide range of research questions. Following this trend, engineering and construction education have increasingly used case studies to enhance student learning.

Extensive research has shown the effectiveness of using case studies in engineering and construction education. The literature discussed components that constitute a successful case study as well as offered how to write case studies. However, while pilot testing is an essential step in developing a case study, previous studies appear to be silent in offering a comprehensive pilot testing framework. The goal of this work-in-progress paper is to present a pilot test conducted to produce an educational case study in construction engineering and management (CEM).

Background

An extensive search conducted on SCOPUS reveals that the American Society of Engineering Education (ASEE) proceedings have published 717 case studies from 1983 to 2023. Notably, the

last decade has seen 333 case study publications, underscoring a significant uptick in interest and research in this area. The results, as depicted in Figure 1 below, illustrate a steady and consistent increase in case study publications year over year. This expansion signifies a recognition of the case study method's efficacy in fostering deep learning experiences.

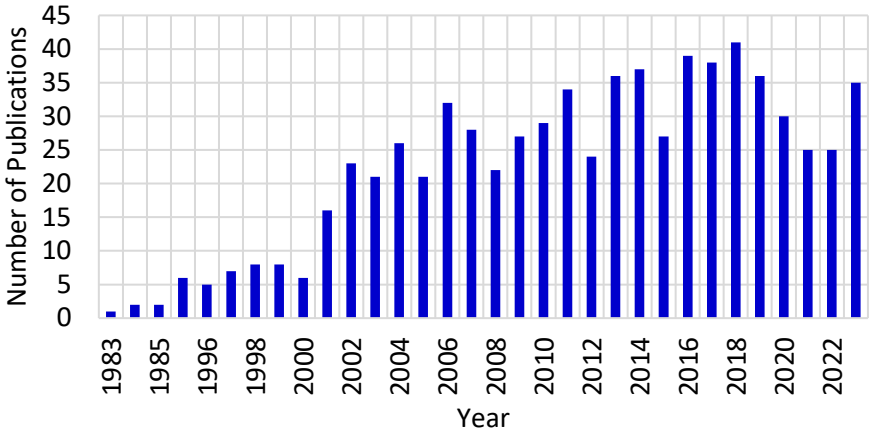

Figure 1. Case Study Publications in ASEE Proceedings by Year from 1983 to 2023

That said, it must be acknowledged that there are different types of publications that use the descriptor "case study." For example, in peer-reviewed journal articles and conference proceedings, the term may be used to passively report on metrics, outcomes, and lessons learned from an actual project. However, there is another type of publication that is also flying under the "case study" banner. This type of case study is typically created and used by academic professional programs such as the Harvard Business School. While inspired by actual projects, professional school case studies are generally designed to mentally situate students into modified, semi-fictitious storylines to help them imagine they are facing a specific dilemma. An informed facilitator in a classroom setting then interactively challenges the students to figure out how to resolve the dilemma. The research in this paper engages students in this latter type of case study.

The Associated General Contractors' America Education and Research Foundation (AGCERF) [2] has been instrumental in funding a series of case studies for use in college and university programs. These case studies, which cover a spectrum of topics including ethics, lean practices, and sustainable construction are pivotal in fostering critical thinking and decision-making skills among students. As of 2022, the foundation has published 16 case studies, each presenting complex, real-world issues without clear-cut solutions, thereby encouraging robust student engagement through discussion and analysis. The AGCERF's contribution to construction education through these case studies is significant. By covering a broad spectrum of topics, they not only enhance the learning experience but also prepare students for the complexities and dynamic nature of the construction industry.

While the use of case studies as a teaching tool is well-established in various disciplines, the specific application in the field of CEM presents a distinct set of challenges and opportunities. The existing literature offers a multitude of guidelines on "how to write a teaching case study,"

emphasizing general pedagogical approaches and strategies suitable for diverse fields ranging from business to healthcare [3], [4], [5]. These resources often describe the principles of effective case study design, such as developing real-world scenarios, fostering critical thinking, and promoting active learning environments. However, there is a noticeable gap in literature specifically tailored to the unique needs of construction engineering and management education. This gap is evident in the lack of detailed guidance on incorporating modern construction technologies, regulatory aspects, and specific project management approaches in educational case studies [6].

The CEM discipline is characterized by its emphasis on practical problem-solving, project management, technical proficiency, and the need to address the rapidly evolving technological and regulatory landscapes of the construction industry [7]. Collaboration is the nature of construction projects, which often involve diverse stakeholders like architects, engineers, contractors, and clients, each with unique viewpoints [8]. Effective CEM case studies should therefore not only present technical and managerial challenges but also focus on stakeholder management, interdisciplinary teamwork, and conflict resolution [9]. Addressing this gap is not merely a matter of adapting existing methodologies but requires a nuanced understanding of the construction industry and its educational requirements. Therefore, this paper aims to contribute to this under-explored area by presenting a detailed process of developing a case study in the context of implementing Target Value Design (TVD) in a construction project, thereby enriching the literature and offering practical insights for educators in the CEM field.

TVD represents a paradigm shift in construction project management, integrating cost as a fundamental design criterion rather than an afterthought [10]. At its core, TVD is rooted in Lean Construction principles, focusing on aligning design and development with a pre-set target cost [11]. This approach fosters a collaborative environment where architects, engineers, and contractors work together from the project's inception, ensuring that design solutions meet both financial limits and functional needs. The application of TVD in construction and engineering education is crucial, as it equips students with modern skills in cost management and collaborative problem-solving, essential for the current landscape of construction project management.

In the development of our case study's testing questions, our approach was twofold. Firstly, we drew inspiration and adopted questions from a range of existing research to ensure a robust and academically sound framework. This involved adopting and adapting question structures from various sources such as [12], who provided a foundational perspective on construction case studies, [13] whose work in digital ethics curriculum development offered insights into complex problem-solving, [14] who explored the integration of public policy in engineering education, as well as the practical guidelines from the Boston University Center for Teaching & Learning [15]. Additionally, the approach by Head et al. [16] in applying case studies to teach structural analysis and design was also influential. Secondly, complementing these borrowed structures, our research team engaged in thorough discussions to develop original questions. This dual strategy ensured that our case study not only aligned with established educational practices but also addressed unique aspects relevant to our specific research focus.

While there is considerable emphasis on the development and design of case studies, the literature reveals a lack of research focusing on systematic testing and evaluation of these educational tools in CEM. Testing case studies is not just a quality assurance measure; it is a pedagogical necessity that ensures the case studies are effective in enhancing student learning and engagement [17] [18]. This involves assessing the clarity of the case, its relevance to industry scenarios, and its ability to prompt thoughtful discussion and critical analysis among students [19]. Moreover, because the construction industry is unique and constantly changing, especially in its technologies and project management methods, it's important to regularly update and revise case studies. This can be done effectively only through detailed testing and strong feedback processes.

In addition, the process of testing a case study is itself a pedagogical exercise that contributes to the teaching and learning experience [20]. Using components such as pre-class engagement, in-class discussion and engagement, and post-class comprehensive feedback in this course serves a dual purpose: it not only aids in gathering data for the testing process but also plays a key role in enhancing the way the case is taught [21]. Pre-class engagement ensures that students are prepared and have a baseline understanding of the case study content, enabling more effective in-class discussions. In-class discussion and engagement allow for the application of theoretical knowledge in a simulated practical environment, fostering collaborative problem-solving and critical thinking skills. Finally, post-class comprehensive feedback is vital for gauging the effectiveness of the case study, providing insights into areas of improvement, and understanding the students' learning outcomes. All three components not only guarantee the effectiveness of our teaching methods but also assist in data collection for ongoing improvements.

Developing an Educational Case Study of Implementing Target Value Design

The case study was the implementation of TVD in a new healthcare campus in Florida. The major components of the new healthcare campus included: A 284,000 SF hospital, 92,000 SF medical office building (MOB), 7,000 SF commons building, and a new 450-space parking garage. While inspired by an actual case, names and details in were changed when presented to the students for educational purposes.

The case study development team included four academics from two institutions and two industry professionals from construction management / general contracting (CM/GC) firm. Collectively, the team had expertise and experience in applying TVD, lean construction, case study methodology, and pilot testing.

With the collaborative effort of the development team from academia and industry, five dilemmas in implementing TVD were outlined in the case study to challenge students. They included:

- Dilemma 1 – Cost Management: Recognizing and dealing with financial constraints;
- Dilemma 2 – Scope Management: Dealing with multiple and sometimes conflicting stakeholder needs;
- Dilemma 3 – Change Management: Dealing with uncertainty from changing circumstances;

- Dilemma 4 – Team Management: Motivating stakeholders to work collaboratively;
- Dilemma 5 – Stakeholder Engagement: Creating Buy-in with Stakeholders

The remaining of this paper is to present the pilot test and its insights when developing the TVD case study.

Pilot Testing of the Educational Case Study

After the case study was drafted, the first pilot test was conducted in two sections of project planning classes with a total of 65 students in Fall 2023 and took two contact hours for each section. It is a required class for civil engineering and environmental engineering majors. Figure 2 presents the process of pilot-testing this educational case study. The case study development team divided the roles of its members who primarily responsible for drafting the case study from those who conducted the pilot test as instructors. The following subsections summarize the pedagogical practices used before, during and after classes in engaging students to the case study and obtaining their feedback.

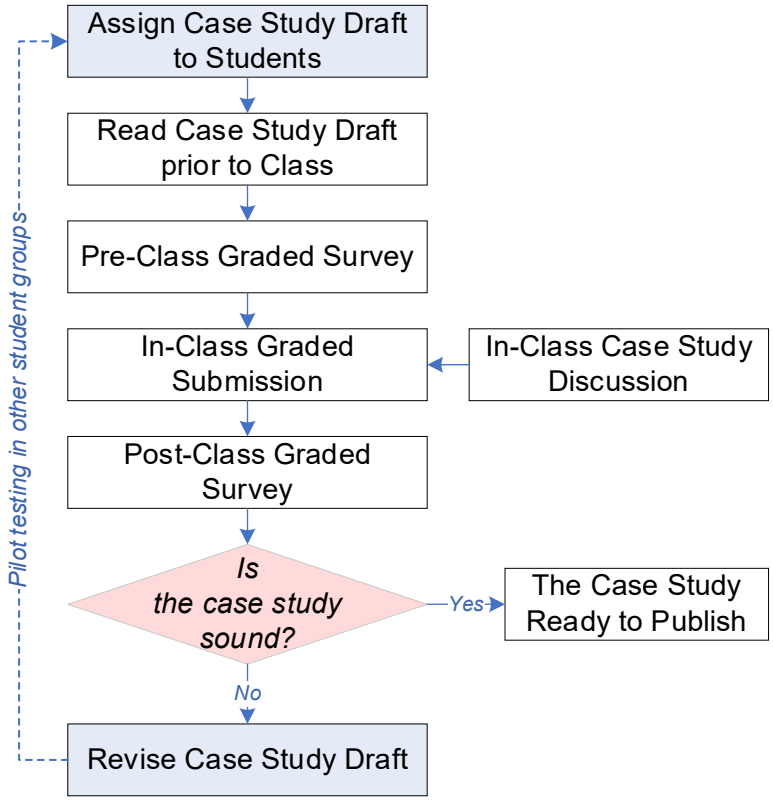

Figure 2. Pilot Test Process of the TVD Case Study

Pre-Class Engagement

Prior to the class sessions, the instructor made the case study draft available to students through the learning management system (LMS). The students were asked to read the case study draft and complete a low stake pre-class graded survey prior to the class start. The goal of this graded survey was to ensure the students read or at least skim through the case study draft and to acquire

the students' knowledge and experience about the concepts related to TVD. The questions in this graded survey included:

- What is your major?
- What is your current knowledge of project delivery methods, such as Design-Bid-Build, Design-Build, Integrated Project Delivery, etc.? Please briefly describe your understanding of these methods.
- Do you have experience with any of the project delivery methods mentioned previously (Design-Bid-Build, Design-Build, Integrated Project Delivery, etc.)? If yes, please specify which method(s) and describe your experience. If no, just type "I don't have any."
- Have you ever heard of the "Target Value Design" or "Choosing by Advantage" [CBA] methods? If yes, what do you know about them? Please share any insights or experiences you have regarding these methods. If no, just type "I don't know."
- Read and summarize this document [case study draft] in less than 100 words. Focus on answering these questions:
    - What is this document about?
    - Where is the project?
    - Who are the main stakeholders in the project?
    - What are the main problems in the project?
    - What do they need?

In total, 58 out of 65 students (89.2%) of students responded to this pre-class survey, including 45 civil engineering students and 13 environmental engineering students. Fifty-seven (57) students had basic knowledge of the project delivery methods and mostly indicated that they learned from the current class in earlier of the semester. Twelve students had experience at least one of the project delivery methods while they worked as interns or full-time employees. Five students had engineering interns but were not exposed much to the delivery methods. Most of students (55 out of 58, 94.8%) students did not know TVD and its tools such as CBAs. Two laterally defined or interpreted from the meaning of their words. One heard these terms several times in their workplace, cited "countless problems in constructability of engineering designs" but they seemed not to understand the TVD concepts. The feedback from this pre-class survey helped the instructor understand the current background of the students to provide the level of detail necessary for students to have meaningful discussion, analysis and decisions when dealt with the dilemmas of the TVD case study.

The last question in the pre-class graded survey made sure students read or scanned through the case study draft. Most of students provided a brief and good summary of the case study while only one student appeared not to read or know what was asked for. Nevertheless, a quite detailed notes (PowerPoint slides, Worksheet, etc.) with sufficient information from the case study were presented to students during these "pilot-test" classes which is discussed in the next section.

In-Class Discussion and Engagement

Cooperative learning strategies were used in the pilot-test classes. Some variations of Think-Pair-Share and Think-Group-Share were used for each dilemma. A dilemma and additional contextual background were presented, followed by open-ended question(s). Students individually thought about the question and typed individual response to the question. As

indicated by the literature, the extra writing/typing step was to ensure each student engaged and to help students reflect on their own work. The students were then either paired or placed in small groups to share their response and reasoning behind their response. Some questions were required the students to work collaboratively in small groups to come up with a group answer. Finally, the instructor expanded into a whole-class discussion. The following demonstrate how these cooperative learning approaches used in Dilemma 1 and Dilemma 3.

> Dilemma 1: "In recent years, Topnotch Health and many other healthcare systems have experienced rapidly increasing labor, materials, energy, transportation and construction costs of building hospitals as well as the rising costs of doing business for their health care operations. The owner's representative expressed that '*health care systems and hospitals cannot simply raise or adjust [their] prices in response to external pressures like an airline, hotel, restaurant, theme park or grocery store can*.'
>
> The owner needs to build this hospital but is concerned if they will ultimately be able to afford the first cost and then create a reasonably profitable operation that can be sustained. In fact, the two owner's proposed healthcare sites in Melbourne and Palm Bay also located in this coastal region of Florida have been paused to be reevaluated. You are in charge and have been asked to bring stakeholders together to see if it's possible to design and build a hospital that works with their business model and is affordable. The market cost for healthcare facilities in this area is $950 per SF. The owner's business model shows they can only afford $760 per SF – this is the allowable cost per SF. The allowable cost is a drop of 20% from the market cost.
>
> - Question 1a. Should this project be paused as the other proposed healthcare campuses in Melbourne and Palm Bay?
> - Question 1b. What do you recommend should be done to meet allowable costs?
> - Question 1c. What are the possible outcomes emerging from your recommendations?"

Think-Write-Pair-Share was used in Dilemma 1. Table 1 shows three sample responses (unedited, out of 52 responses) of individual "Think-Write".

Table 1. Sample individual, unedited answers to Dilemma 1's questions

#	Response to Question 1a	Response to Question 1b	Response to Question 1c
1	"*no because it is in close proximity to the one that is always shutting down because of weather issues*"	"*change wants for project and see what can be taken out like size of parking garage etx [sic]*"	"*more jobs more sustainable medical studies and care*"
2	"*it can be paused while more stakeholders are obtained, or continue the project and it will be less state of the art*."	"*Gain more stakeholders, cut unnecessary costs*."	"*Donors and stakeholders may wonder why the project needs more money, but is cutting costs. With more stakeholders, there will be more wants*."

3	"*Yes, in terms of cost management, you would want to pause the project on the owner's side*."	"*Cut aesthetics, obtain more donors and investors*."	"*It will be cheaper, you will have more funding, it will delay the start of the project, but the project will get finished*."

After students shared with their peers (in pairs or in small groups), the instructor called several pairs or all groups to share with the whole class. At the end, the instructor offered some responses based on class discussion: (1) recommend Target Value Design to the owner; (2) determine the owner's allowable cost based on their business case; (3) work with the owner to determine their conditions of satisfaction (CoS); and (4) identify owner needs versus wants.

> Dilemma 3: "Disagreements among stakeholders about how to select a specific design alternative, given varying needs and stakeholders are commonplace in any construction project. In this case, the project architect is very protective of the building's exterior look. A variety of exterior wall assemblies are available in the market. Examples are Tilt with Thin Brick, concrete masonry unit (CMU)/Brick Cavity, CMU/Split-Face Cavity, Metal Stud/Brick Cavity, Metal Stud/Split-Face Cavity, Prefab Sto Panel, Metal Stud/Metal Panel Rainscreen, Glass Curtainwall and Storefront/Punched Opening.
>
> - Question 3a. In choosing among exterior wall systems for the hospital façades which of the following three factors is the most important one – economics, safety, or aesthetics?
> - Question 3b. Which exterior wall system should you recommend for the hospital façades?"

The instructor provided the analyses of three exterior wall assemblies, namely tilt with thin brick, CMU/brick cavity, and metal stud/metal panel rainscreen, with this dilemma. These analyses were simplified from the real-world ones provided by the industry professionals from the CM/GC firm. While the similar cooperative learning strategy was used in Question 3a as in those of Dilemma 1, a small group activity was used to practice building consensus and addressing Question 3b. The student group applied the Choosing by Advantages (CBA) [22] to select exterior wall systems after the instructors introduced CBA – an approach to support key decisions in TVD. The students used pen/pencil, blank CBA table, sticky notes (same color), and a piece of tape (Figure 3). Figure 4 displays a sample group work in completing the CBA table.

Figure 3. Group discussed and assigned values of the advantages

Decision: Select Exterior wall		Alternatives					
Factors and Criteria		Tilt w/ Thin Brick		CMU/ Brick Cavity		Metal Stud/ Metal Panel	
Schedule	Attributes	10 wks		12 wks		4 wks	
Earlier Finish	Advantages	2 wks Sooner	4	—		8 wks Sooner	8
Weather Proof	Attributes	Good		Best		Better	
Better weather Proof	Advantages	—		Best	10	Better	9
Exterior Maintenance	Attributes	Best		Best		Best	
Better Maintenance	Advantages						
Insulation Quality	Attributes	R-18		R-25		R-24	
More insulated	Advantages	—		7 higher R	6	6 higher R	5
Local Trade Availability	Attributes	2		4		15	
Better Accessibility	Advantages	—		2 more trade	2	13 more trade	5
Material Availability	Attributes	Best		Best		Best	
More Material options	Advantages						
Historical Performance	Attributes	Good		Best		Good	
Better Historical Performance	Advantages	—		Best	8	—	
Project Safety	Attributes	Good		Good		Best	
Better Project Safety	Advantages	—		—		Best	10
Total importance			4		26		37
Unit Cost $/SF		$67		$77		$91	

Figure 4. Group building consensus and selecting exterior wall using CBA

Through the in-class discussion, the instructor also observed and reflected for improving the case study. The case study with multiple dilemmas and cooperative learning strategies took more than the two-hour class time. The case study would be improved to either reduce the number of dilemmas or make dilemmas somewhat not so much rely on one another. This would provide flexibility for instructors using the case study in one class session or two class sessions as well as choosing dilemmas to be discussed in their classes. The instructor noted that students were confused with some terms such as "buy-in" in Dilemma 5 – Creating Buy-in with Stakeholders.

Post-Class Comprehensive Feedback

A post-class graded survey was created in the LMS and consisted of 17 questions, 13 open-ended and four 5-point Likert scale questions. More open-ended questions were used to find meaningful insights to improve the case study. Open-ended questions such as "*Which concepts were the most challenging to understand, and would you benefit from additional examples to help clarify them?*" helped the case study development team understand how the case study background and information can be improved to allow students to address the dilemmas. Other open-ended questions such as "*In terms of overall readability and tone of the case study, how did you find it?*" helps the team in improving the clarity in writing and structure of the case study. Figure 5 shows the word cloud of student feedback to this question. Most of students (98%, 49 out of 50 responses) were very positive about the readability of the case study draft. This somewhat shows in the word cloud (Figure 5). Only 2% (one out of 50 responses) was not very positive: "*Kind of dry. The infromation [sic] was good and the examples were clear but it was not the most captivating*."

Figure 5. Word cloud of student feedback to overall readability and tone of the case study

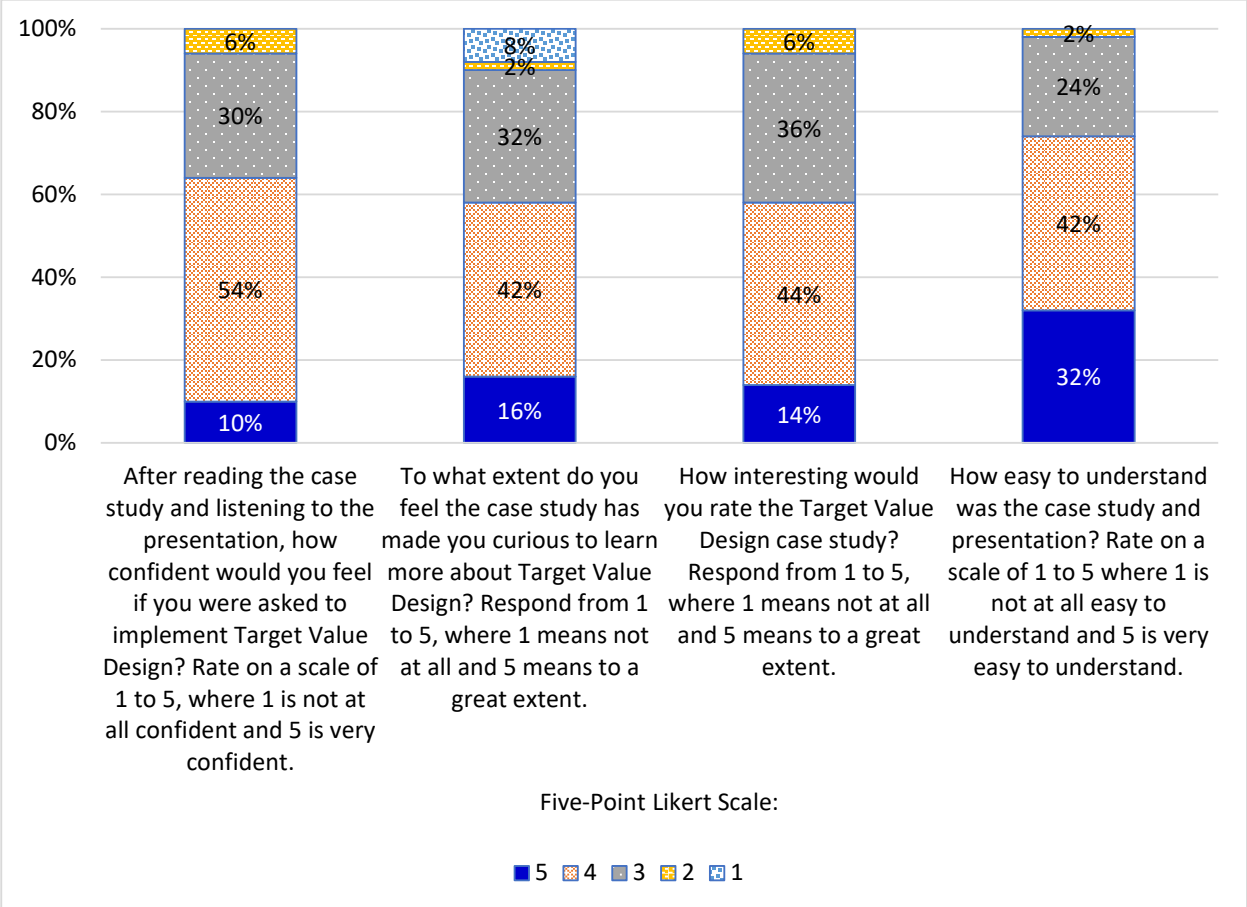

Figure 6. Student feedback on the four closed questions in the post-class graded survey

Figure 6 summarizes 50 student responses on the four 5-point Likert scale questions in the post-class graded survey. The responses were very positive across the four questions. The highest-level response ("5") of the understandability of the case study (the last question shown in Figure 6) was more than double that of the first three questions (10% - 16%). This indicated that the

writing and presentation of the case study itself was highly effective in the views of the students participated in the pilot test. The first three questions depend on many other factors such as teaching effectiveness and students' learning ability and interests. Noticeably, this pilot test was the first time the case study was introduced to students. TVD and the case study were first taught by the instructor who had two and half years of teaching experience.

Conclusions

This work-in-progress paper is to explore the development and pilot testing of an educational case study on TVD. Appropriate pilot testing is an essential step to improve an educational case study and allows it to be used effectively by other educators and trainers other than the case study drafter. The process and insights of the pilot test for the TVD case study presented in this work-in-progress paper shed some light on developing a through framework of testing educational case study prior to wider uses. The case study development team strategically divided roles to make sure an effective pilot testing in place. From the students' activities and feedback as well as instructor's observation and reflection, the first pilot test showed that the case study draft was generally easy to understand and interesting. It also indicated that the balance between technical details including terminologies versus application in the case study could be the area for improvement. The dilemmas would be flexible for instructors to introduce the case study in one class session or two class sessions by choosing some or all of the dilemmas to be discussed in their classes. The insights gained from this pilot test will guide further refinement of the case study, ensuring that it not only meets educational goals but also enhances student learning. Future research will focus on conducting additional pilot tests with diverse student populations (e.g., civil engineering, environmental engineering, construction management) to further validate the case study's effectiveness across different educational settings.

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