



A COGNITIVE APPROACH TO ASSESSING THE MATERIALS IN PROBLEM-BASED LEARNING ENVIRONMENTS

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ABSTRACT

Aim/Purpose	The purpose of this paper is to develop and evaluate a debiasing-based approach to assessing the learning materials in problem-based learning (PBL) environments.
Background	Research in cognitive debiasing suggests nine debiasing strategies improve decision-making. Given the large number of decisions made in semester-long, problem-based learning projects, multiple tools and techniques help students make decisions. However, instructors may struggle to identify the specific tools or techniques that could be modified to best improve students' decision-making in the project. Furthermore, a structured approach for identifying these modifications is lacking. Such an approach would match the debiasing strategies with the tools and techniques.
Methodology	This debiasing framework for the PBL environment is developed through a study of debiasing literature and applied within an e-commerce course using the Model for Improvement, continuous improvement process, as an illustrative case to show its potential. In addition, a survey of the students, archival information, and participant observation provided feedback on the debiasing framework and its ability to assess the tools and techniques within the PBL environment.
Contribution	This paper demonstrates how debiasing theory can be used within a continuous improvement process for PBL courses. By focusing on a cognitive debiasing-based approach, this debiasing framework helps instructors 1) identify what tools and techniques to change in an PBL environment, and 2) assess which tools and techniques failed to debias the students adequately, providing potential changes for future cycles.

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Findings	Using the debiasing framework in an e-commerce course with significant PBL elements provides evidence that this framework can be used within IS courses and more broadly. In this particular case, the change identified in a prior cycle proved effective and additional issues were identified for improvement.
Recommendations for Practitioners	With the growing usage of semester-long PBL projects in business schools, instructors need to ensure that their design of the projects incorporates techniques that improve student learning and decision making. This approach provides a means for assessing the quality of that design.
Recommendations for Researchers	This study uses debiasing theory to improve course techniques. Researchers interested in assessment, course improvement, and program improvement should incorporate debiasing theory within PBL environments or other types of decision-making scenarios.
Impact on Society	Increased awareness of cognitive biases can help instructors, students, and professionals make better decisions and recommendations. By developing a framework for evaluating cognitive debiasing strategies, we help instructors improve projects that prepare students for complex and multifaceted real-world projects.
Future Research	The approach could be applied to multiple contexts, within other courses, and more widely within information systems to extend this research. The framework might also be refined to make it more concise, integrated with assessment, or usable in more contexts.
Limitations	The framework was applied in a single illustrative case, potentially limiting its generalizability.
Keywords	cognitive biases, problem-based learning, e-commerce, debiasing, PDSA, continuous improvement

INTRODUCTION

Problem-based learning (PBL) has gained increasing attention in information systems education (Mykytyn et al., 2008). Through PBL, students learn about a subject by working on real-world, open-ended problems. The problems usually involve higher-order thinking, requiring students to rearrange, interrelate, and extend new information with information in memory (Lewis & Smith, 1993). These projects have shown success in improving critical thinking skills (Nargundkar et al., 2014). In information systems (IS), PBL projects have helped students cope with uncertainty in agile systems development, plan an IT-based innovation, conduct predictive analytics, and write papers on expert systems (Cheong, 2008; Guthrie, 2010; Taipalus et al., 2018; Yazici, 2020).

Since PBL projects focus on higher-order thinking, pedagogical techniques used within the PBL environment should improve student choices, judgments, and reasoning. Unfortunately, students' decision-making skills are hampered by cognitive biases (Behimehr & Jamali, 2020; Bhardwaj et al., 2018; Novianggie & Asandimitra, 2019). Cognitive biases are systemic errors in reasoning that follow predictable patterns. In particular, Tversky and Kahneman (1974) found that biases are an inevitable consequence of using heuristics in decision-making.

Biases manifest themselves across many decisions and fields, including IS (Calikli & Bener, 2015; Flieschmann et al., 2014; Mohanani, 2016; Mohanani et al., 2018). For example, research in requirements determination has found biases in satisficing, reasoning, recall, variety and complexity of requirements, communication, motivation, and observation (Browne & Ramesh, 2002; Mohanani et al., 2018). Even decision support systems designed to overcome biases inadvertently introduce different biases (Chen & Koufaris, 2015). Yet various techniques have been shown to reduce bias in students,

such as using educational videos, facilitating group discussion, and writing reflective statements (Rusmana et al., 2020).

After conducting a scientometric survey of the biases studied in IS Research, Fleischmann et al. concluded, “While previous research on perception and decision biases has already led to valuable contributions in IS, there is still considerable potential for further research regarding social, memory and interest biases” (Fleischmann et al., 2014, p. 1). Another recent article documenting a comprehensive survey and synthesis of bias research in Software Engineering found a “scarcity of research on mitigation techniques and poor theoretical foundations in understanding and interpreting cognitive biases” (Mohanani et al., 2018, p. 1). They called for the development of comprehensive debiasing approaches that could be applied “in specific contexts to see what’s practically important” (Mohanani et al., 2018, p. 17).

Thus, while PBL theory promises an approach to education that focuses on higher-order thinking, students bring many and varying biases to the course. This creates an inherent conflict between using higher-order thinking and overcoming biases introduced with high-order thinking, whether social, memory, and interest biases or otherwise. An instructor attempting to improve student outcomes must mitigate those biases through the design of the PBL environment. Yet, the literature is largely silent on how to verify if the techniques used in the PBL environment are debiasing student thoughts. What is needed is a cognitive approach to assessing the various techniques used in the project that considers the interaction of instructional materials with the students.

Such an assessment would be best situated within a process of continuous improvement (Ivey et al., 2017). Through continuous improvement, instructors would improve instructional materials over time to help students achieve better decisions systemically. This leads us to our research question:

What type of cognitive approach can systematically assess the effectiveness of tools and techniques in order to improve students’ decision-making in an Information Systems (IS) course with a semester-long PBL project?

The next section provides the conceptual and theoretical background on debiasing and the different strategies used to improve decision-making to answer this research question. From this literature, a debiasing framework is proposed that layers debiasing strategies on project techniques. The debiasing framework is situated within the continuous improvement Model for Improvement as a technique for evaluating project techniques. The following section presents the methodology for implementing and evaluating the framework within an illustrative case. Specifics of how it was used in an e-commerce course with a semester-long PBL project identified strong and weak parts of the project, suggesting modifications in future iterations. Lastly, a discussion of the findings indicates that the framework proved a reliable source for improving the semester-long PBL project.

CONCEPTUALIZATION AND THEORETICAL BACKGROUND

This section provides a literature review and conceptualizes the proposed process to identify and mitigate potential problems in a PBL environment. Literature from cognitive biases and debiasing is examined and provides the foundation for application to IS education.

BIASES AND DEBIASING

Bias is a well-known flaw in human decision-making. For example, we have long known that humans are particularly susceptible to over- and under-estimating numeric probabilities (Kahneman & Tversky, 1979; Tversky & Kahneman, 1974). This is particularly problematic in business decisions because small mistakes in probability estimates when dealing with millions of customers can significantly impact revenue and customer retention. These biases are also insidious because most people are unaware that they have a bias and act as if they do not. Even managers cognizant of potential

biases still revert to heuristics and rules of thumb to make decisions in fast-paced environments, such as when firefighter commanders make decisions without considering alternatives (Kahneman, 2011).

Three broad categories of biases impact cognition – psychophysically-based errors, association-based errors, and strategy-based errors (Arkes, 1991). Psychophysically-based errors refer to biases that emerge from the relationship between stimuli (physical reality) and the resulting sensations and perceptions. These types of biases exhibit a mismatch between what is perceived and what exists. The prototypical example of this type of bias would be when a reference point, like the first item that is observed, influences later observations. Psychophysically-based errors include statistical biases (e.g., base rate fallacy and correlation/causation fallacy), adjustment biases (e.g., anchoring bias and reference point bias), and presentation biases (e.g., framing bias and scale bias).

Association-based errors refer to errors of judgment caused by instantaneous associations within memory. These types of errors are caused by mistakes in remembering the past or misapplying memories to current situations. Association-based errors include memory biases (e.g., hindsight bias and recall bias) and confidence biases (e.g., confirmation bias and overconfidence bias).

Strategy-based errors refer to errors in applying a suboptimal cognitive strategy to a problem. Sometimes, more complex strategies may produce slightly better accuracy, but at a cost. Decision-makers may optimize with a less complex strategy if the time saved results in a minimal loss in accuracy. In some cases, the decision-maker does not know about more accurate strategies, so they depend on flawed or poorly-calibrated strategies that produce systematic errors (Larrick, 2004). Strategy-based errors include motivational biases (e.g., escalation bias and loss aversion) and situational biases (e.g., attenuation bias and in-group bias).

DEBIASING STRATEGIES

Fortunately, there are strategies to overcome biases. Debiasing is the attempt to reduce bias in decision-making. Debiasing strategies may include techniques, methods, tools, or interventions that impact the behavior of the individual directly or change the tasks to mitigate bias indirectly. Many debiasing strategies show evidence of successfully debiasing a problem domain (Arkes, 1991; Fischhoff, 1982; Larrick, 2004; Morewedge et al., 2015). However, decision-makers may exhibit multiple biases, and when decision-makers are on a team, each team member may exhibit different biases. Thus, a singular debiasing strategy is unlikely to be sufficient for improving the overall PBL project. Instead, a debiasing *approach* that incorporates multiple debiasing tools and techniques is needed.

Debiasing strategies have been the subject of research for several decades. Through a review of literature, several frameworks for categorizing debiasing strategies were identified (Arnott, 2006; Cleaves, 1987; Fischhoff, 1982; Kaufmann et al., 2009; Larrick, 2004). Across these frameworks, nine similar debiasing strategies were observed (see Table 1), though all nine did not exist in any one of the frameworks. Some of these debiasing strategies focus on the decision maker's behavior, such as taking different perspectives, decomposing the decision task, creating awareness of own biases, learning about the task domain, and requiring consensus (in group situations). Other debiasing strategies focus on the task, such as raising the stakes, limiting how changes in the domain impact the decision, reducing environmental complexity, and changing the task instructions. Each of these strategies is briefly described in Table 1.

When decomposing the decision task, the decision process is broken down into smaller, distinct decision tasks which better align with the decision maker's cognitive capabilities (Kaufmann et al., 2010). By focusing on the structure of the decision, decision-makers can better assess how to deploy their effort and decision strategies (Cleaves, 1987; Fischhoff, 1982; Kaufmann et al., 2009). Furthermore, decomposition has been shown to decrease errors in probability estimation (Buyukkurt & Buyukkurt, 1991).

Table 1. Debiasing strategies in literature

DEBIASING STRATEGIES	FISCHHOFF (1982)	CLEAVES (1987)	LARRICK (2004)	ARNOTT (2006)	KAUFMANN ET AL (2009)
Taking different perspectives	Consider alternative situations		Consider the opposite		Taking different perspectives
Decomposing decision task	Decompose problem	Decomposition			Decomposing decision task
Creating awareness of decision biases	Search for discrepant information	Focusing	Training in biases	Warn the decision-maker of potential bias. Describe the nature of the bias	Creating awareness of decision biases
Learning about task domain	Make knowledge explicit Train extensively Clarifying instructions	Training	Training	Provide training	
Requiring Consensus	Rely on substantive experts	Consensus interaction Consensus weighting	Group decision making		
Raising the stakes	Raise stakes	Logic challenges	Incentives Accountability		
Limiting how changes in domain impact the decision					Reducing dynamism of a decision-making environment
Reducing environmental complexity	Discourage second-guessing Ask fewer questions	Visual props Scoring rules	Analytic tools and models		Reduce decision task's environmental complexity
Changing task instructions	Clarify instructions/ stimuli Use familiar response modes	Response mode changes			

In taking different perspectives, the decision-maker attempts to see a decision task from different points of view, whether those perspectives are of various stakeholders or playing devil's advocate (Fischhoff, 1982; Kaufmann et al., 2009; Larrick, 2004). A simple but powerful strategy is to encourage decision-makers to look at the problem from multiple perspectives. This helps the decision-maker avoid the pitfalls associated with biased thinking that can reveal itself when a person makes a quick and reactionary decision based on incomplete or erroneous information (Hogarth, 2001). Thus, encouraging the decision-maker to consider multiple perspectives results in a more broadly considered solution and has been shown to be effective at debiasing (Larrick, 2004; Pronin et al., 2002).

Multiple research efforts identified creating awareness of one's own biases as a strategy for reducing biases (Arnott, 2006; Cleaves, 1987; Fischhoff, 1982; Kaufmann et al., 2009; Larrick, 2004). With this strategy, education about types of biases and their manifestations helps the decision-maker identify areas to be extra careful with their thinking. While evidence exists that awareness of biases helps decision-makers improve the quality of their judgments, it also suggests that it only works for certain biases (Welsh et al., 2007).

In learning about the task domain, the decision-maker becomes aware of key decisions and best practices to avoid biases (Arnott, 2006; Cleaves, 1987; Fischhoff, 1982; Larrick, 2004). These interventions can take the form of providing better knowledge and relevant training to improve the skills and techniques needed to effectively debias the individual (Lilienfeld et al., 2009; Soll et al., 2015). For example, financial analysts exhibit greater tendencies toward confirmation bias while forecasting financial market reactions to major IT investment decisions when they have less knowledge of Information Technology (IT). However, as a financial analyst gains IT competence, they mitigate much of that bias (Legoux et al., 2014).

In requiring a consensus, decision-makers are forced to justify their thoughts sufficiently to convince others. In addition, the act of consensus-building places checks on individual biases through feedback from others and the hope that they do not all share the same biases (Cleaves, 1987; Fischhoff, 1982; Larrick, 2004).

In raising the stakes, decision-makers find motivation in doing well because they perceive their decision will have important implications (Cleaves, 1987; Fischhoff, 1982; Larrick, 2004). This motivation impacts the care a decision-maker takes while thinking about the decision task. However, Arkes (1991) argued that psychophysically-based and association-based errors are not likely to be impacted by simple incentives to do well because of the automatic nature of those errors. But strategy-based errors could be reduced by holding decision-makers accountable for their decisions (Larrick, 2004).

In limiting how changes in domain impact a decision, decision-makers decrease their dependence on rapidly changing environmental factors that are required for specific decision tasks (Kaufmann et al., 2009).

Whether through models, visuals, frameworks, or tools, reducing the environmental complexity helps the decision-maker to better frame the decision for clearer thinking (Cleaves, 1987; Fischhoff, 1982; Kaufmann et al., 2009; Larrick, 2004).

Another strategy to debias is to change the instructions for the task. Sometimes, simply re-wording task instructions can yield significant reductions in the decision maker's bias (Cleaves, 1987; Fischhoff, 1982). These changes in instructions can "nudge" the subject in a positive direction (Kenyon & Beaulac, 2014). Thaler et al. (2012) posit that a "nudge" is a strategy that frames the options in a way that encourages the subject to make better choices.

FRAMEWORK FOR DEBIASING

It is important to note that no one tool or technique can satisfy all types of debiasing strategies. Nor is a single debiasing strategy applicable to all tools and techniques. For example, requiring peer

evaluations in an assignment may raise the stakes but may not directly help with learning the task domain. It is a combination of tools and techniques that facilitate debiasing and mitigating as many potential biases as possible across the teams. Through modifications to the techniques and tools, each of the debiasing strategies can be integrated within the project to improve decision-making and hence the outcomes. This observation leads us to propose the framework shown in Table 2. Each tool or technique is evaluated against each debiasing strategy to determine if it satisfies at least one debiasing strategy. This approach allows us to look at the project as a whole, identifying gaps in the debiasing strategies employed. If none of the techniques decompose a decision task, there is an opportunity to improve. Alternatively, if one of the techniques fails to impact any debiasing technique meaningfully, perhaps the technique needs to be improved. This framework is embedded within the continuous improvement process discussed below.

Table 2. Framework for assessing project techniques compared to debiasing strategies

DEBIASING STRATEGIES	PROJECT TECHNIQUES				
	Technique 1	Technique 2	Technique 3	Technique 4	Technique 5
Taking different perspectives		X			
Decomposing decision task		X			X
Creating awareness of decision biases			X		
Learning about task domain				X	
Requiring consensus	X				
Raising the stakes	X				
Limiting how changes in domain impact the decision			X		
Reducing environmental complexity				X	
Change the task instructions		X			

METHOD

A case study design in an e-commerce course allowed us to provide an illustrative case that demonstrates how the debiasing framework could be used within a continuous improvement cycle. The course was required for the Management Information Systems program of an Association to Advance Collegiate Schools of Business (AACSB) accredited college in the United States. The course contained a PBL project that lasted the entire semester (sixteen weeks) and included a variety of techniques, including reading the textbook, participating in discussions, observing, completing focused worksheets, writing peer reviews, receiving feedback, working in teams, writing a final report, and interacting with real businesses.

CONTINUOUS IMPROVEMENT PROCESS

The purpose of a continuous improvement process is to assess the tools, techniques, and outcomes, searching for ways to improve each over time. One of the strengths of using a continuous improvement process in this context is that the debiasing strategy, changing the task instructions, is embedded within. Thus, every iteration of the continuous improvement cycle provides another opportunity to improve the task instructions. In education, continuous improvement processes can be used at the university, college, program, and course level (Drake, 2012; Temponi, 2005) and is an integral part of AACSB accreditation (Claybaugh et al., 2020).

Model for improvement

In this case study, we use the Model for Improvement, which combines three fundamental questions with the Plan-Do-Study-Act (PDSA) cycle (Langley et al., 2009), to frame the continuous improvement process. Those three fundamental questions are “What are we trying to accomplish?”, “How will we know that a change is an improvement?”, and “What change can we make that will result in improvement?” The PDSA cycle includes: 1) *Plan*: plan a change to the PBL environment; 2) *Do*: implement the change to the PBL environment; 3) *Study*: observe and analyze the results of the change; and 4) *Act*: adopt the change or abandon the change (see Figure 1).

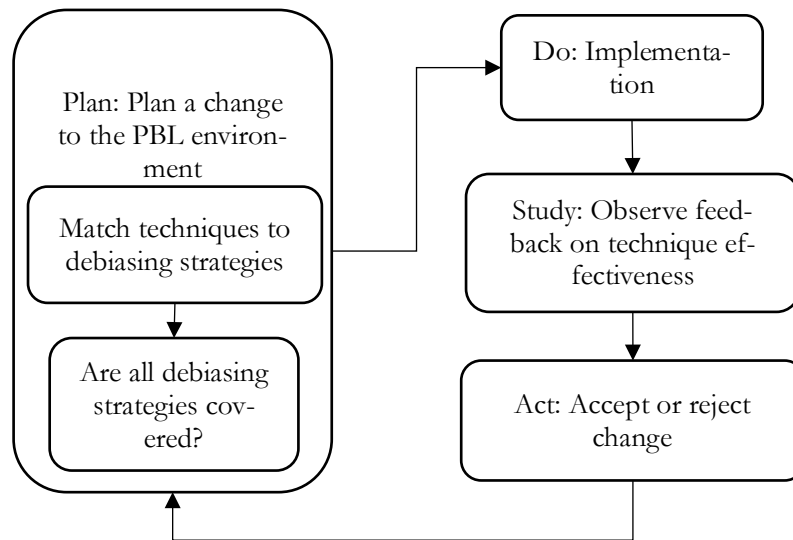


Figure 1. The PDCA continuous improvement process for debiasing (adapted from Langley et al., 2009)

What are we trying to accomplish? As stated above, the goal is to improve the decision-making of students within PBL projects. These improvements consist of modifications to the techniques and tools used throughout the project. Similar to the IS security concept of Defense-in-depth (Kuipers & Fabro, 2006), which attempts to limit threats to information systems through a combination of security protocols, tools, and techniques, PBL projects should attempt to limit bias in students through a combination of techniques and tools. Because PBL projects require complex analysis and decision-making throughout the project, many psychophysical-based, association-based, and strategy-based biases as discussed above, may impact the project.

How will we know that a change is an improvement? There are several ways to determine improvements in decision-making. In one option, we could assess the bias used by students before and after the change. A second option is to compare the outcomes of the projects to look for systemic bias.

Finally, a third option could ask students to self-report how a technique impacted their decision-making. We consider these three means of assessment below.

The first means of assessing improvements is problematic because an individual student may exhibit any number of biases. While a change in a technique may limit one bias, it may not be the bias or set of biases a particular student possesses. Perhaps worse, a change in a technique may introduce new biases that were not checked earlier.

The second means of assessing improvements require a more subjective and time-intensive approach. The instructor (or external expert) would have to evaluate the outcomes and have a clear idea of the best solution. To do that well, they would essentially have to do the project themselves. This type of assessment would become very time-prohibitive as it goes above and beyond the typical expectations. Furthermore, instructors need to be careful not to input their own biases into the assessment process.

The third approach to assessing the techniques is to ask the students if a technique helped them debias their thinking. While undergraduate students may not be experts on biases, they have sufficient reflective ability to identify when a technique helps or hurts their problem solving (Kitchener, 1983). Built into the debiasing framework, this last approach shows promise in the “Study” phase of the Model for Improvement. After completion of the project, the student would be asked to assess the effectiveness of each technique at accomplishing each of the debiasing strategies. While some techniques and tools are predicted to improve specific debiasing strategies, surprising relationships may emerge from student responses. For example, an instructor may expect that reading the textbook provides the most significant impact on learning the task domain, but students may perceive working on a deliverable within the project as to where the real learning occurs. Alternatively, students may perceive that the learning mostly happens while working with their group. Thus, a comprehensive assessment would ask about the effectiveness of each technique and tool in helping with each debiasing strategy.

Before beginning the PDSA cycle, the last question to ask is: What change can we make that will result in improvement? The identified change is then integrated into the “Plan” phase of the PDSA cycle. According to the debiasing framework, at least one technique or tool should satisfy each debiasing strategy. If one is lacking, that helps identify a potential change. We highlight one cycle of the PDSA below.

PDSA - PROJECT PLANNING

In the planning phase, the course instructor identified nine techniques used in the project. Three were general classroom activities – reading the textbook, participating in classroom discussion, and observing examples of other analyses. The other six techniques were specific to the project – completing worksheets, writing peer reviews, reading and thinking about feedback from others, working in groups, interacting with the business sponsor, and writing the final report.

Reading, participating and observing

The first three techniques focused on helping students learn about the task domain. Students were required to read a chapter before attending class, where a short quiz was provided to help encourage them to take the text seriously. After the required reading, the instructor led a discussion of the chapter contents focusing on how they might be applied in businesses. Students were also provided with examples of previous student reports, selected for demonstrating best practices. Lastly, the students also observed examples during the peer review process.

Completing the worksheets

A series of worksheets were designed to progressively focus the students’ attention on specific aspects of the e-commerce domain, helping them to decompose the initiative, reducing the complexity

of the initiative by focusing on critical areas, and helping them to consider different perspectives. Each worksheet focused on a separate stakeholder perspective, progressing through the critical decisions made by a manager, a user, a marketing professional, and an information technology (IT) professional.

Students described the business and key decisions in the e-commerce strategy in the manager worksheet, including website goals and key performance indicators. In the user experience worksheet, students described the typical users, their goals, and how well the online initiative helped them accomplish their goals and included cross-platform checks, link analyses, and social media analyses. Next, students defined the major marketing promotions conducted for the different sales funnel stages for their customers in the marketing worksheet. Special emphasis was given to search engine optimization and social media engagement because of their integral role in many digital marketing efforts. The last worksheet challenged students to identify and describe the tools and technologies used to develop the website, the platform for hosting the website, the domain names and connectivity technologies used to share the website and security issues with any of these steps.

Writing peer reviews

Students were assigned two peers' analyses to review from different groups. Peer review days occurred after the analyses were completed. Students received the analyses and a document with guided questions to help the reviewer. After an hour of writing their reviews, students returned a copy of the peer reviews to the reviewee and to the instructor. To encourage quality reviews, the instructor graded the peer reviews.

The purpose of the peer review is three-fold. First, it provided reviewers with multiple examples of approaches to the analysis, creating awareness of potential biases in their own approach to the analyses. Second, it gave the reviewers a chance to observe other examples of other student work, helping them to consider different perspectives. Third, because the peer reviews were graded, it raised the stakes of reviewers to write higher quality reviews with meaningful suggestions.

Reading feedback provided by others

Students received feedback from both their peers in terms of the peer review and from the instructor. Groups were asked to include the feedback from the peer reviews in an updated analysis submitted for the instructor to grade. The instructor also provided detailed comments and suggestions for improvement on the analysis and report.

The feedback from peers and the instructor provided different perspectives on the analysis for the students to consider. The submission for a grade helped raise the stakes. The feedback from both the peers and the instructor helped identify potential decision biases in thinking through the analysis.

Working in groups

The project required some work individually and some in groups. Collecting data from the project sponsor was done as a group. Each of the analyses was completed on an individual basis to ensure the students were familiar with the e-commerce initiative, developed the same conceptual understanding of e-commerce, and had decomposed the project initiative individually. While writing the recommendation report, groups were required to work together to synthesize their understanding, forming a consensus on the initiative's current state and prioritizing potential improvements.

Writing the final report

Writing the final report helped synthesize everything the students observed. The final report started with an executive summary, specifying the recommendations. The report then provided the reasons for these recommendations. A class workshop detailed how to justify recommendations with logic, expert opinion, and quantitative evidence. Finally, the report ended with a plan for revision to the

business's digital initiatives. The four analyses were included as appendixes. Finished reports averaged over 30 pages.

Due to the integrative nature of the report, students would likely continue learning about the task domain in the process of writing it. The report also required a group effort, requiring a consensus in identifying potential improvements. Lastly, because the report was graded, it raised the stakes to do it well.

Interacting with real business

Real businesses were used in the analysis. These businesses were primarily small local companies. Working with real businesses helped students take the experience seriously, raising the stakes to do well because of the real-world impact of their work (Bradford, 2005).

Identify potential change

In the cycle prior to this one, the textbook was identified as an area for potential improvement. In this cycle, a new textbook was adopted (Drake, 2019). The textbook organized chapters by different stakeholders in the e-commerce domain. Chapters 3-6 progressively focused on the manager, the user, the marketing professional, and the IT professional, respectively. Each of these chapters included a case study at the end analyzing an existing business to provide an example of what the analysis could look like.

Some of the task-based debiasing strategies could be integrated directly into the project design and were not directly observable by students. For example, changing task instructions was an inherent aspect of the project design. Similarly, the instructor chose to work with small organizations to reduce the environmental complexity that many larger organizations experience. The remaining seven debiasing strategies were correlated with the appropriate techniques we predicted would help debias the decisions to create the framework (Table 3).

Table 3. Debiasing strategies-techniques framework for e-commerce analysis project

DEBIASING STRATEGIES	PROJECT TECHNIQUES/TOOLS								
	Reading the textbook	Participating in class	Observing other examples	Completing the worksheets	Writing peer reviews	Reading feedback by others	Working in groups	Interacting with real business	Writing final report
Taking different perspectives	X				X	X			
Decomposing decision task				X					
Creating awareness of decision biases					X	X			
Learning about task domain	X	X	X						X

DEBIASING STRATEGIES	PROJECT TECHNIQUES/TOOLS								
	Reading the textbook	Participating in class	Observing other examples	Completing the worksheets	Writing peer reviews	Reading feedback by others	Working in groups	Interacting with real business	Writing final report
Requiring consensus							X		X
Raising the stakes					X	X		X	X
Reducing environmental complexity				X					

PDSA - PROJECT DOING

The project consisted of a semester-long assignment completed by a team of students. During the project, they analyzed a business’s web, social, and mobile initiatives and synthesized critical areas in need of improvement. The primary deliverable was a report listing a series of recommendations and justifications based on the business context. This project evolved as a collaborative effort between several e-commerce and business domain experts to identify important areas of e-commerce that needed attention.

Approximately one month before the beginning of the course, local businesses were contacted with interest in the project. Some requirements for inclusion in the project included at least one year of history as a business, containing a website with appropriate complexity, and no plans for major website updates during the course term. Furthermore, organizations from different industries and using different technologies were selected to enhance the variety of learning opportunities. The instructor contacted the selected organization to welcome them, establish expectations, and confirm the primary contact information (hereafter called the project sponsor).

Students groups were instructed to select a business to analyze from the provided list, contact the project sponsor and request an interview. The students were also provided some priming questions to help them start the discussion and request additional documentation, such as the web analytic reports, Facebook usage reports, disaster recovery plans, and sales figures.

The course followed traditional “tell”, “show”, “do”, and “review” (Merrill, 2002) principles of instruction in a weekly cycle. After the course and project introduction, the weekly cycles began. At the beginning of a week, students read a chapter (tell) in the textbook and came to class prepared to take a quiz on those topics. After the quiz, the instructor led a discussion of the chapter topics and provided examples of using those ideas to analyze a business (show). Then students were given worksheets to complete, with approximately 30 minutes to get started and ask questions of the instructor (do). The students had until the next class period to complete the worksheet on their own. In the next class, the instructor discussed significant issues with the worksheet. The students then completed the peer reviews (review). The following week a new chapter was covered, and the process continued.

After the coverage of the four perspectives and completion of the four corresponding analyses, the students updated their analyses based on feedback from peers, business interaction, and class discussion. The instructor then reviewed and graded the analyses, offering extensive feedback. Meanwhile, the groups started working on recommendations for improvement. A workshop provided help to

students in identifying recommendations and prioritizing them by essential business criteria. The groups prepared a rough draft that the instructor graded and returned with feedback. The groups then took one last effort to improve their report, submitting a final draft that was presented to the project sponsor.

The PBL environment was implemented in two sections of the same course. There was a total of 28 students between the two sections, of whom 15 agreed to participate in the study for extra credit. They worked in eight different groups (not all group members agreed to participate in the study). In one group, none of the students agreed to participate in this study even though they finished the course. Therefore, this group was omitted from the analysis. Each of the groups worked with a different business (see Table 4). All names are anonymized.

Table 4. Group members and projects

GROUP	GROUP MEMBERS	PROJECT	DESCRIPTION OF BUSINESS
A	Alex, Alice, and Alfred	AgriRetailer	Rural farm equipment retailer
B	Barbara, Beth, and Brittany	BarAndStage	Entertainment stage and bar
C	Charles and Cindy	ConcreteManu	Specialized concrete manufacturer
D	David and Daniel	DentalRetailer	Dental equipment manufacturer and retailer
E	Ella, Erin, and Eric	EnCasaSalsa	Homemade salsa producer
F	Frank	Farm	Sweet potato farm
G	Gwen	GoLocalTavern	Local sports tavern

PDSA - PROJECT STUDYING

Data were collected through participant observation throughout the semester, archival material, and a survey of the students. One of the authors of this paper was the course instructor, implementing the project in the course, managing discussions, and providing feedback. The observations of this instructor were validated by the second author of this paper, checking for bias according to case study best practices (Yin, 2009). Any issues discovered by the second author were discussed and incorporated within the final draft of this manuscript. Archival material was collected in terms of the course deliverables and email conversations with students. After obtaining IRB approval, the survey of students captured their perceptions of the effectiveness of the different techniques.

The survey of students asked about the effectiveness of the different techniques in identifying problems and suggesting solutions. Each question was explicitly developed for this study and took the form “How effective was [project technique] at helping you do the following? – [List of debiasing strategies].” The rating ranged from Not at all Effective, to Extremely Effective, with five possible choices using a Likert-type scale. Each project technique and tool was worded as a verb phrase. Instead of saying “Worksheets,” the survey said, “Completing the worksheets”. This was done to activate the memory of doing cognitive work with the tool.

The debiasing strategies were worded to make sense in the context of the project. For example, instead of “learn about the task domain,” the survey said, “learn about e-commerce domain”. Instead of “reduce environmental complexity,” the survey said, “reduce the complexity of the e-commerce initiative.” As mentioned above, changing the task instructions was embedded into the course design, so students could not adequately determine its effectiveness. Thus, this debiasing strategy was not included in the survey. The survey also asked an open-ended question for suggestions to improve the project. Results from the survey are reported in Table 5.

Table 5. Average effectiveness scores of PBL techniques on each debiasing strategy

DEBIASING STRATEGIES	PROJECT TECHNIQUES									
	<i>Reading the textbook</i>	<i>Participating in class</i>	<i>Observing examples</i>	<i>Completing the worksheets</i>	<i>Writing the peer reviews</i>	<i>Reading about feedback</i>	<i>Working in groups</i>	<i>Interacting with business sponsor</i>	<i>Writing the final report</i>	<i>Average across techniques</i>
Take different perspectives	3.3	3.7	4.0	3.9	4.0	4.0	3.5	2.9	3.7	3.7
Decompose the problem	3.5	3.9	3.9	4.3	3.8	3.8	3.1	2.9	4.0	3.7
Create awareness of biases	3.1	3.1	3.7	3.7	3.7	3.9	3.0	2.3	3.7	3.4
Learn about e-commerce	3.7	3.8	3.7	3.9	3.4	3.5	2.9	2.5	4.0	3.5
Build consensus	3.2	3.4	3.6	3.9	3.5	3.7	3.3	2.9	3.8	3.4
Raise the stakes	3.3	3.6	3.7	3.7	3.6	3.9	3.5	2.8	3.7	3.5
Reduce complexity	3.4	3.7	3.5	3.6	3.4	3.4	2.9	2.5	3.3	3.3
Average across strategies	3.3	3.6	3.7	3.9	3.6	3.7	3.2	2.8	3.7	

Since the textbook was new in this cycle, we focus on analyzing it first. The average effectiveness of the textbook across debiasing strategies was 3.3. While certainly not the highest-rated technique, it demonstrated an improvement over the previous cycle. Next, we looked at the two expected impacts of the textbook – learning the task domain and taking different perspectives. For learning the task domain, the textbook scored an average of 3.7, the highest debiasing strategy for the textbook. However, taking different perspectives averaged only 3.3, which matched the average for all other textbook scores. We use this information in the Act stage of the cycle, discussed below.

We continued studying the results by looking at the debiasing strategies. Taking different perspectives and decomposing the problem rated the most effectively implemented debiasing strategies, whereas reducing complexity was rated the lowest. Completing the worksheets, writing the peer reviews, observing examples, and reading and thinking about feedback had the greatest impact on taking different perspectives. For decomposing the problem, students rated completing the worksheets as the most effective, followed by writing the report, observing examples, participating in and observing class discussion. Reading and thinking about the feedback from others had the biggest impact on raising the stakes. The technique that most helped students learn about the domain was writing the

final report. This was surprising because it was dependent on most of the preceding activities. Perhaps this final effort helped students integrate the concepts so that they became more meaningful (Drake, 2012).

For creating awareness of the student's biases, the techniques rated most effective were reading and thinking about feedback from others. However, completing the worksheets proved more effective for building consensus. This result seems odd because the worksheets were individual assignments initially, but the students combined the worksheets in the final report. A possible explanation is that completing it individually at first and then as a team required them to reconcile their differing views and have a productive debate, thus allowing for better consensus building.

The two techniques that were perceived as least effective across all debiasing strategies were interacting with the business sponsor and working in a group. There were two business sponsors that were slow to respond or did not respond at all to student inquiries. Group A worked with farming equipment retailer, AgriRetailer. The students and the instructor sent several messages to the owner of AgriRetailer but did not receive a callback. Group A members could complete the project by making assumptions on some parts of the analyses, such as business goals and objectives. But without firsthand knowledge of the business's actual goals, some of their recommendations were largely conjecture. Thus, it was unsurprising that Alex, Alice, and Alfred considered interacting directly with the business to be not at all effective. Group D also struggled with DentalRetailer. As Daniel put it in his open-ended response: "For our sponsor, it felt like they were doing us a favor to take a few minutes out of their busy day." This feeling was reflected by both Daniel's and David's rating of interacting directly with the business as slightly effective or not at all effective.

Group work has a notorious history in higher education in general and IS courses (Dunaway, 2013). This project was not immune to that. The groups were kept small (3-4 members), and students were told that group member assessment impacted individual grades to limit social loafing. However, several groups had problems that may have led to lower ratings of effectiveness in group work. In group E, Eric became unresponsive during much of the project, although he provided a burst of effort near the end. Unsurprisingly, Eric considered working in a group as not at all effective for any debiasing strategy. Whether Eric felt that way because of a bias coming into the project or an outcome of the project is uncertain. However, his two group mates, Ella and Erin, worked well together and found the group work effective at debiasing, even without Eric's input. Similarly, Gwen worked within a dysfunctional group that led to a major argument on the last day of the project. She rated the effectiveness of group work as ineffective.

On the other hand, Frank, who struggled with some of the individual aspects of the project, rated working in a group as the only extremely effective technique across all debiasing strategies. This high rating suggests that the group work provided Frank with the greatest clarity in his thinking.

Students asked about potential changes to the project with the open-ended question had this to say:

Alice said: *"The class is great overall. I have enjoyed looking at a real business and digging into the impact a website can have on a business. And it is good to think about how a group can influence decisions of a business."*

Alex suggested: *"I think seeing an example of e-commerce in action would be beneficial. Knowing how an e-commerce site works on the backend and being able to interact with it would be interesting. This could be a dummy site that allows students to simulate buying and selling."*

Ella said: *"The examples in class were really helpful and made it easier to put the concepts into perspective. I think that continuing to incorporate more diverse examples would make it easier for students to better understand e-commerce"*

Not everyone felt comfortable with their knowledge during the project. For example, Alfred said:

"I liked the case study in the chapters but I still didn't feel like I knew enough to recommend professional solutions for the business."

But whether Alfred felt this way because of a lack of perceived self-efficacy or because of inadequate debiasing is difficult to judge. The open-ended questions validated the results of the survey, with no inconsistencies observed.

PDSA - PROJECT ACTING

Students rated the newly adopted textbook as moderately effective overall. They also rated Reading the textbook's effectiveness in helping them learn the e-commerce domain well, suggesting that it met its primary goal. However, it did not show much effectiveness in helping students take different perspectives, despite our expectations.

Fortunately, this PBL project uses other techniques that emphasize taking different perspectives. Because these other techniques continued to score well for taking different perspectives, the danger from the textbook not scoring highly reduces the concern of bias in that area. Specifically, observing examples, Completing the worksheets, Writing peer reviews, and Reading feedback from others all scored highly in effectiveness in helping students consider different perspectives. Furthermore, adopting a new textbook would not necessarily address this result. Few e-commerce textbooks explicitly adopt different perspectives, one of the reasons the instructor selected this textbook in the first place. Furthermore, changing a course textbook is time-intensive. Considering all of the above, the textbook change is accepted for future cycles.

NEXT CYCLE

Upon reviewing the other techniques, any with low ratings were considered for change in the next cycle. As mentioned above, the two weakest techniques were Interacting with business sponsor and Working in groups. Each of those can be good candidates to change in the next iteration of the course. For interaction with the business sponsor, students noted a lack of commitment by some sponsors throughout the project. The instructor could establish better expectations with the project sponsors. For example, they might suggest that a regular weekly meeting should be held between the students and the project sponsors to ensure greater engagement. By establishing this expectation upfront, project sponsors can hopefully plan for regular interaction and develop more buy-in to the project.

Group project-based learning is common in business education, with a growing focus on consulting-oriented projects (Heriot et al., 2008). However, poor group dynamics can lead to negative experiences. Research has shown that five elements ensure positive, cooperative achievement within groups – positive interdependence, individual accountability, face-to-face promotional interaction, social skills, and group processing (Johnson & Johnson, 1989). While the current course structure incorporates some of those elements, it could build positive interdependence by assigning complementary roles and encouraging better social skills in team decision-making and conflict management.

DISCUSSION AND CONCLUSION

This paper presents a continuous improvement process with a cognitive approach applicable to PBL projects in IS courses. While continuous improvement of courses is not a new concept, the cognitive approach focusing on debiasing strategies is. Building on research in cognitive debiasing, a framework was developed that compares project techniques to debiasing strategies to determine how effective those techniques are at improving student decision-making. Implementation of the framework within an e-commerce course suggests that it was largely effective. While there was considerable variation in effectiveness ratings, all students found some value in the techniques. The project showed that multiple techniques might interrelate and impact debiasing strategies multiple times, helping to ensure that each student had various means to debias their thinking. For example, expectations for the new textbook included helping students take different perspectives. However, the evidence did not show

support for this. Fortunately, other techniques helped students to take different perspectives. This cross-fertilization of techniques helps limit the weaknesses of any one technique.

Furthermore, the framework provided evidence that a change to the course was effective while simultaneously suggesting weaknesses in the current design to be fixed in future cycles. The adopted textbook proved effective at helping students learn the domain. However, the lack of effectiveness in interacting with a business sponsor and working in a group both proved problematic.

Lastly, the mixed methods approach used in the case helped illustrate the effectiveness of the framework. The survey provided evidence *that* there was a problem with a technique, however, the archival material and participant observation helped pinpoint *why* there was a problem.

APPLICATION TO OTHER COURSES

Findings from this paper suggest that this approach can be adapted for other IS courses using PBL projects, and the collection of techniques and tools used in PBL environments can be assessed based on their ability to help students with each debiasing strategy effectively. Furthermore, by asking students to rate the effectiveness of these techniques and tools across the debiasing strategies, instructors can gain insight into which changes were effective, which techniques fail to meet their potential, or which debiasing strategies were not being utilized.

Instructors seeking to implement this process should adjust the assessment accordingly. As noted in the case above, changing the task instructions may not be directly observable to the students if the instructor did so during the project plan phase. However, there may be cases where changing the task instructions is an integral part of the project. Similarly, projects that are individual-based may not have components that require consensus; thus, removing that debiasing strategy from evaluation would make sense.

LIMITATIONS

Illustrative cases provide evidence that something is feasible by providing one or two instances of an event. While the case in this study provided evidence that the framework was feasible in an e-commerce course, it was singular in design and needs further replication. Future research should replicate this framework in other courses with PBL environments.

The proposed framework focuses only on reducing cognitive biases. This is not intended to minimize the focus on other skills and competencies. PBL environments may have other competencies they want to assess, such as knowledge, communication skills, or ethical principles. Expanding the list of competencies to include in a PBL assessment would likely improve a PBL environment in multiple dimensions, cycle after cycle.

CONCLUSION

PBL projects are increasingly used in Information Systems (IS) courses. Because PBL projects require higher-order thinking, evaluating such a project should entail checks on the effectiveness of the techniques and tools for debiasing in terms of cognition. This study proposes a continuous improvement process for such an assessment, asking the student to identify how effective the project techniques were at implementing different debiasing strategies. These strategies include taking multiple perspectives, creating awareness of biases, decomposing the task domain, learning about the task domain, requiring consensus on decisions, reducing environmental complexity, changing the instructions, and raising the stakes.

The evaluation framework was applied in an e-commerce course PBL project. It evaluated student perceptions on techniques including reading a textbook, completing worksheets, writing peer reviews, observing examples, participating in class, reading feedback, working in groups, interacting with a business sponsor, and writing a report. The ratings from students suggested that a change in the

textbook was effective and further suggested two techniques that needed improvements in future cycles; working with groups and interacting with a business sponsor. Findings from this research indicate that the proposed evaluation framework would be a valuable tool in IS courses using PBL projects to assess changes to courses and find weaknesses in their current implementation.

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