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Decision-Based Learning as an Approach for Teaching Statistics in a Peruvian University[1]

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Many students find learning statistics difficult, especially novice learners. Instructors also struggle to teach statistics due to many challenges, such as students' misconceptions, lack of math skills, negative attitudes, and deficient instructional methods. A new pedagogical approach called Decision-Based Learning (DBL) has been developed to help instructors and students; however there are limited studies about teachers' and students' experiences with this method, particularly in international settings. For this project, a group of Peruvian university professors were trained to use DBL. This qualitative study sought to understand the experiences of one Peruvian statistics instructor and her students implementing DBL pedagogy and software. The DBL software was created to help instructors easily implement DBL. Findings identify specific benefits and challenges participants faced when using DBL. Benefits included the growth of students' confidence in solving statistical problems and instructor satisfaction. Challenges included time-consuming instructor initial preparation and students' learning transfer issues.

Keywords: decision-based learning, statistical thinking, conditional knowledge, critical thinking, intelligent tutoring system

INTRODUCTION

Statistics is a necessary tool for making decisions in many fields of human activity. Thus, most university programs require at least one introductory statistics class to help

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students develop statistical thinking to make informed decisions (Carver et al., 2016). Experts use statistical thinking to solve statistical problems. Statistical thinking allows learners to recognize the essential characteristics of a statistics problem, choose the best procedures to solve a problem, and understand why choosing these procedures is the best course of action. However, instructors struggle to find the best way to teach statistical thinking to novice students and have called for more pedagogical approaches that help instructors teach novices to think like experts (Garfield et al., 2015). A new pedagogical approach called Decision-Based Learning (DBL) has been developed to help instructors teach conditional knowledge in the domain of statistics—or in other words, statistical thinking (Plummer et al., 2017). DBL provides students with immediate feedback, enabling students to learn from their mistakes. As Garfield et al. (2015) suggested, when teaching statistical thinking, it is essential "to foster an atmosphere in which it is safe for learners to make mistakes and express their partial understanding" (p. 329). DBL provides a safe atmosphere for students to develop statistical thinking and learn from their mistakes.

LITERATURE REVIEW

Challenges and Solutions Explored to Teaching and Learning Statistics

Many scholars have identified common challenges in learning statistics, especially for novice learners, such as negative attitudes, misconceptions, and errors (Sanchez, 2023, Trassi et al., 2022). Common errors are mostly related to flawed statistical thinking and reasoning in probabilities, sampling distributions, and significance tests (Sanchez, 2023). These challenges can lead to student anxiety and poor teaching techniques that can negatively affect1 students' performance (Trassi et al., 2022).

Many active learning approaches have been implemented to improve student learning. These learning approaches include problem-based learning (Sari et al., 2021), inquiry-based learning (Laursen et al., 2014), metacognitive learning strategies (Hargrobe & Nietfeld, 2015), and collaborative learning (Yaacob et al., 2021), among others. Despite the existing methodologies, instructors have called for more active learning approaches to teach statistical thinking.

Decision-based Learning to Teach Statistical Thinking

DBL is a new pedagogy designed to help instructors teach expert thinking, especially conditional knowledge, in many domains. In the domain of statistics, this conditional knowledge is referred to as statistical thinking (Plummer et al., 2020). DBL introduces concepts through a problem-solving approach supported by a decision tree model with decision points to help students solve a problem in a structured manner (Sansom et al., 2019). This structured manner emulates experts' steps when they solve a problem.

To implement DBL, statistics instructors created a model of how experts solve statistical problems, called the Expert-Decision Model (EDM, see Figure 1). An EDM focuses on teaching students how to make decisions to solve real problems (Plummer et al., 2017). Instruction is presented to students through a problem with many successive decision points. To facilitate the creation of EDMs, researchers at <removed for blind review> university created a DBL software. EDMS can be created without the software,

however, the software facilitates EDM creation and implementation. DBL have been implemented successfully in statistics (Plummer et al., 2017; Vogeler et al., 2022), math (Plummer et al., 2022), religion (Plummer et al., 2020), chemistry (Sansom et al., 2019), in multiple subject areas in a Peruvian university (Cardenas et al., 2020), writing (Pixton, 2023), and physiology (Tesseyman et al., 2023).

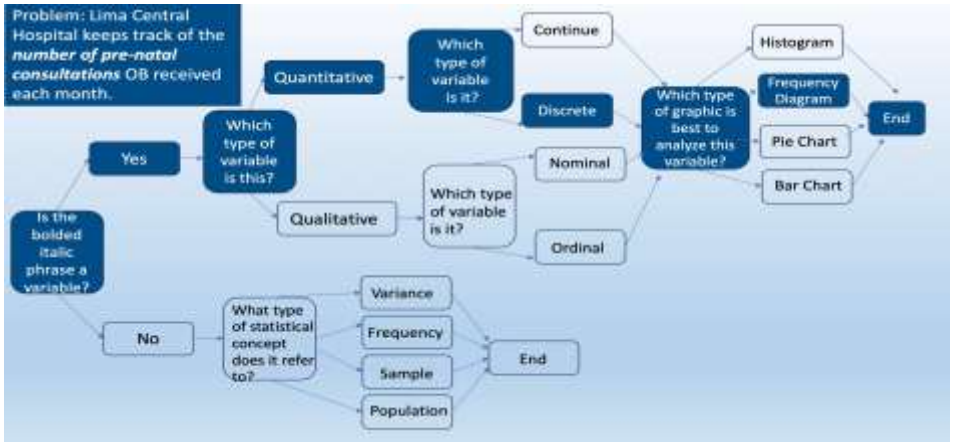

Figure 1
Variable identification and classification through a statistical DBL Model. The shaded options depict the correct path

Several DBL empirical studies in the United States have shown DBL to positively impact student performance and engagement. DBL was tested during three semesters in graduate statistics courses. Significant improvements were observed in students' abilities to choose and explain statistical methods, with lasting effects even four months after the course (Vogeler et al., 2022). Students who learned with DBL and used the DBL software in a chemistry class got better grades compared to students who didn't have DBL (Sansom et al., 2019). Further, students who took DBL math courses scored higher on test scores than those who did not take DBL math courses (Plummer et al., 2022). A qualitative study was conducted in a religious class. A presentation with the DBL model was used to assign pre-class homework. Students reported a more experiential learning experience, though some usability concerns were noted. Overall, the study results indicated DBL could enhance students' engagement and understanding of class topics (Plummer et al., 2020). Recently, DBL was implemented in a physiology nursing class. The study found that DBL enhanced student self-efficacy and provided a positive learning experience (Tesseyman et al., 2023). Also, DBL homework was used as a pre-class assignment in a writing class. There was a statistically significant difference in post-test performance between students who received DBL treatment and those who were given lecture treatment. Internationally, 104 professors from different subjects attended a DBL training at a Peruvian university. Cardenas et al. (2020) explored the DBL implementation experience of 42 of these professors. Peruvian instructors agreed that DBL helped their students understand course content better and feel more engaged.

The mentioned studies show that DBL can positively impact student performance. Despite few studies on DBL implementation and effectiveness, research outside of the U.S. on how DBL is used to teach statistics remains unexplored. Therefore, knowledge from this study will seek to understand DBL implementation in a Peruvian classroom. This study sought to answer the following research questions: (1) What is the experience of a Peruvian statistics instructor implementing and using DBL pedagogy and software in her classroom? (2) What are the students' experiences of learning introductory statistics using DBL pedagogy and software?

METHOD

This qualitative study used a Gadamerian-based hermeneutic approach (Farooq, 2018). In this approach, researchers and participants collaborated to gain a common understanding of the phenomenon. Researchers contributed to this understanding in three different ways: (1) using their previous and evolving knowledge of the phenomenon to interpret the data, (2) being receptive to new ways to understand the phenomenon, and (3) engaging in the hermeneutic circle to understand and interpret the data (Taeger & Yanchar, 2019). The hermeneutic circle is the process of understanding a text by referencing its parts and understanding them by reference to the whole. (Farooq, 2018).

Table 1
Five steps of Fleming's Gadamerian hermeneutic methodology

Fleming's Steps	Our Steps in this study
Define a research question	We defined two research questions
Document the pre-understanding of the phenomenon	We kept a reflective journal to document our understanding of DBL
Dialogue with participants to understand their experiences	The lead researcher conducted 15 interviews, to understand participants' experiences.
Analyze the text to understand the phenomenon better	The lead researcher transcribed and analyzed the interviews, which are described below.
Establish trustworthiness	Trustworthiness is described below under the appropriate heading

Description of the Decision-Based Learning Statistics Course

This study was conducted from January to May 2022 at a Peruvian public university in southeastern Peru. It focused on a statistics course supported by DBL pedagogy and software. The instructor who taught this course was part of a faculty group from different disciplines who received prior DBL training (Cardenas et al., 2020).

The statistics class was taught online weekly in a three-hour block in the fall of 2021. The DBL software facilitated the creation of EDMs. Like other DBL instructors (Cardenas, 2020; Sansom et al., 2019), this Peruvian instructor decided to use the DBL methodology and software to teach students to recognize essential parts of a statistical problem, which is the first critical step to solving a problem (Garfield et al., 2015).

Description of the Decision-Based Learning Instruction

During the first two weeks of the semester, the instructor relied on the DBL software to teach students to recognize, classify, and choose the best graphic to represent a variable.

The DBL software (Conate) is a commercial software developed specifically to assist with the implementation of decision-based learning and is available at https://conateinc.com/. The instructor guided the students through each decision point. Students completed homework in the software.

After the first two weeks of class, the instructor introduced new topics weekly using a concise presentation with "Just-Enough, Just-in-Time" instruction, a recommended DBL strategy. Immediately after this introduction, Dr. Luna presented students with a statistical problem and asked learners to identify the relevant features of the problem. The instructor guided students through the process.

Participants

A statistics professor and six undergraduate students from Peru participated in this study. The instructor, Dr. Luna, has taught statistics for over 20 years and teaches introductory statistics courses to 250 undergraduate students each semester. We invited Professor Luna to participate in this study because she had consistently implemented DBL in her classroom. We followed convenient and purposive sampling techniques to select student participants from those from her class who responded to our email invitation. Equal numbers of males and females were selected based on the following: participants took DBL statistics in fall 2021, had internet access, and agreed to a Zoom interview. In line with other studies (Taeger & Yanchar, 2019), the sample size was determined to help us gain a deeper understanding of the phenomenon.

Table 2
Participants information

Pseudonym	Age	Gender	Pre-statistics exposure
Diego	18	Male	Yes
Pedro	19	Male	No
Edward	19	Male	Yes
Lizbeth	18	Female	Yes
Selya	19	Female	Yes
Marie	20	Female	Yes

Data Collection

Data collection relied on two individual, semi-structured interviews with each student and three interviews with the instructor. Also, the instructor provided us with the following artifacts: the class syllabus, EDMs, and just-enough, just-in-time PowerPoint instruction. These artifacts helped us understand the instructor's DBL implementation. Interviews lasted 45 minutes to one hour and were conducted in Spanish via Zoom.

Trustworthiness

Trustworthiness of the qualitative analysis (Stahl & King, 2020) was accomplished in five different ways. First, we kept a reflexive journal where we wrote our initial and evolving pre-understanding of DBL. Second, we provided rich reports of the phenomenon and included participants' direct quotes. Third, we conducted a negative case analysis to find data contradicting our themes and conclusions. Fourth, we completed member checking and sent participants an email with our final interview

analysis. Lastly, we triangulated our data using information from the interviews, research field notes, and artifacts.

FINDINGS

The authors and participants engaged in a dialogue to better understand DBL. Themes were developed based solely on the participants' interviews. Table 3 below summarizes the themes we developed after interacting with the data.

Table 3
Decision-based learning themes and sub-themes

Theme 1: DBL Benefits	
	Sub-theme 1: Students' Benefits
	Sub-theme 2: Instructor's Benefits
Theme 2: DBL Challenges	
	Sub-theme 3: Outside of the Classroom Challenges
	Sub-them 4: Inside of the Classroom Challenges

Decision-based Learning Benefits

Since the instructor used a variety of teaching strategies to teach introductory statistics, we selected the benefits that participants most frequently mentioned and those that were more closely connected to DBL.

Students' Benefits

Immediate Feedback and Support: Most of the students appreciated the immediate feedback and support they received in class through DBL instruction and after class through the Conate software used by the professor to teach DBL.

In class, the instructor presented a statistics problem and invited students to identify its features. For instance, Marie mentioned one positive aspect of her in-class experience:

> Something that helped me was that when the professor was explaining if you participated, the professor guided you at that very moment. You did it with the professor helping you, and that is a practical way of learning. I think that helps you not be afraid to make a decision you probably thought was wrong. [Marie, November 24, 2021]

Marie's comment suggested that the guidance and support received from the instructor helped her not to be afraid of using the DBL model. Diego also found the professor's support beneficial. He commented how this support helped him "solve statistics problems by being guided to think correctly." He emphasized, "this is what I liked the most." This guidance is a distinctive feature of the DBL approach that is crucial for a successful DBL implementation.

In class, when students did not know what decision to take, the instructor supported the students by presenting the previously taught PowerPoint instruction. Then, the students read the instructions and tried again to identify the problem features. Edward mentioned how this instruction helped him to "remember the topic" learned and to "recognize" the solution "more easily." He described the just-enough, just-in-time PowerPoint

instruction as follows: “In my opinion, it was easy to understand these slides. It was not a matter of filling in all the slides with a lot of information; instead, they had practical and simplified information.” Edward received support to navigate the DBL model through the concise instruction available when he needed it.

However, not all students’ experiences in the classroom were identical. Despite the in-class feedback and support, some students were reluctant to participate and found it difficult to adapt to this way of teaching. Lizbeth remembered that the professor presented problems to solve from day one. This student found it complicated to identify the variables of a problem without feeling overwhelmed. Lizbeth felt intimidated to participate in class for fear of making mistakes in front of her classmates. She described her feelings like this: “I was afraid of being wrong or giving the wrong answer because I wasn't sure what I was going to say.” This participant's experience suggests that some students might need extra help adjusting to a new teaching method.

After class, students received immediate feedback through the Conate software, which they considered very beneficial. This feedback enabled students to identify and correct misunderstandings. When participants chose the wrong path to solve a DBL problem, they received an error message that blocked progress until the right decision was made. Selya commented, “I found it excellent to go back to the question, see the error, and answer correctly. It was very useful.” Upon identifying their mistakes, students read the just-enough, just-in-time instructions embedded in the software to help them make the right decisions. This instruction contained concise information that helped students to choose the right path. Access to this concise instruction was crucial for Edward:

> In my case, I recognized the solution to the problems; it became easier for me because I did not have to look in my books or my notebook. I did not have to spend a lot of time looking at my class notes. Instead, it was right there [in the PowerPoint slides]. After it [the error message] told me where I was wrong, I was able to look at the information there and solve it again. And I liked that. [Edward, November 27, 2021]

Edward emphasized how this concise instruction helped him to minimize the time required to correct his mistakes when solving statistical problems.

*Confidence Growth***:** The second benefit that student participants noted was the growth of their confidence in solving statistical problems. Most of the participants reported their confidence increased after taking this class. These students initially expressed little confidence in solving statistical problems because they felt they lacked the mathematical skills needed to learn statistics. For instance, Marie commented, “In the beginning, I wasn't very confident because it was a course related to numbers. I told myself that it was going to be difficult. I thought that I was going to fail.” Many participants expressed the same feelings as Marie.

However, students’ confidence grew by the end of the course. Participants gained the confidence to identify the relevant features of a statistics problem and solve it. Selya noted how her confidence grew and highlighted this positive change:

> In the beginning, I did not feel very qualified since I knew something very basic. I hadn't learned much, but after taking this course, it's different because I've learned new names, variables, exercises, and ways to solve problems. It is very different now. [Selya, December 2, 2021]

In summary, most of the student participants reported that the learning activities and support received positively promoted their understanding and learning of statistics.

Instructor Benefits

Instructor Satisfaction: The instructor expressed her satisfaction in implementing the DBL approach and in adapting her teaching to DBL:

> Before knowing DBL, I had always taught step by step. But I did not or had not seen it from the point of view that they could make decisions, and I could ask questions about those decisions. . . And now I love DBL. [Dr. Luna, December 4, 2021]

Like other DBL instructors (Sansom et al., 2019), the Peruvian instructor's comments showed her DBL path from being unaware of her expert decision-making process to being aware of her decisions to solve statistical problems. She showed excitement in changing her way of teaching and use of DBL.

Also, the instructor talked about her satisfaction with how much her students' were learning and with her experience teaching statistics with DBL. When the statistics professor initially implemented the DBL pedagogy, she conducted an experiment with her students to learn about the DBL's impact on students' performance. She had three student groups and only implemented the DBL approach to two groups. The two groups also completed their homework on the DBL software. Then the instructor evaluated the three groups just as she had done in the past. The instructor commented, concerning her students' results, "When I took the test, those who had learned with DBL did better than those who had not used it. Why? Because they had the support [DBL]." After these positive results, the instructor decided to continue using DBL.

Furthermore, she found after surveying students that their satisfaction increased after learning with a DBL approach. "I asked them [her students], and they answered that it is nice, interesting, educational, practical, pleasant, and friendly." Knowing that her students enjoyed DBL increased Dr. Luna's satisfaction with this DBL. Another example shared by the instructor showed that students' satisfaction applied to those who started her statistics course already hating statistics.

> I think it's working for me [teaching with DBL] because there were Social Sciences students who at some point told me that they didn't like it [statistics] and were afraid of the course. But at the end of the course, they were very grateful, and one student told me: "I'm happy because I did learn. I like it." And it was the person who hated the course at the beginning. [Dr. Luna, November 21, 2021]

The instructor's satisfaction with DBL stemmed from her students' positive learning results and satisfaction with the class setup.

Tutoring Assistant: The instructor reported that DBL became her tutoring assistant by helping students work independently. With the DBL software, students could review, practice, and complete their homework independently. The instructor stated, "If they did not understand in class, they could review again at home because they immediately had access to the instruction." During the students' independent learning, they received automatic feedback and the just-enough, just-in-time instruction embedded in the software. The professor highlighted how the DBL homework has been helpful for her class, saying, "It does help me so that the students practice and consolidate what we have already seen in class and that I cannot personally review with them."

In addition, the instructor perceived a timesaving benefit. Students were able to review the problem feature identification topic independently, saving the instructor's class time:

> It helps me because I don't need to be repeating the same thing over and over when students do not understand. I don't have to teach them everything again, such as how to discover, how to define, and how to identify variables. And you know that is time-consuming. Instead, they could do it independently when they can, and I don't need to be present because I don't have time. [Dr. Luna, December 4, 2021]

In other words, DBL saved her time and acted in a similar way to a tutoring assistant.

Decision-Based Learning Challenges

The participants also shared challenges they faced when implementing the DBL approach. Our discussion will include critical challenges outside and inside the classroom that impacted DBL's success. The outside-of-the-classroom challenges occurred before or after the class started. Inside-of-the-classroom challenges occurred from the beginning of the semester to the end in the classroom setting.

Outside of the Classroom Challenges

Instructor Initial Preparation: An instructor who wants to implement the DBL approach will need to follow the process of creating "an Expert Decision Model (EDM), just-enough just-in-time instruction, and a well-populated bank of conditionally organized problems or scenarios" (Swan et al., 2020, p. 5). This process of creating a DBL model and its supporting materials can be time-consuming (Wentworth et al., 2021). Dr. Luna reported adapting and creating the EDM model took her "a whole semester" and that "it's been a long, really long time to get ready."

Her first attempt at implementing DBL required extra support from a DBL consultant to organize the material. Despite these challenges, the statistics instructor plans to continue implementing the DBL approach and extend the topics to be taught. She said, "The model is interesting. I love it, and when one already learns, I think it will be much better because I'm already improving in the model, and it is growing." Dr. Luna recognized the challenges attached to adopting the DBL approach. However, she seemed to be convinced to adopt this methodology fully.

Technological Barriers: Due to the COVID-19 pandemic, the course was taught in an online format, and both students and instructors faced difficulty due to a slow internet connection and participants' computers not being properly equipped. These challenges

interfered with the successful implementation of DBL. Marie described how she got disconnected a couple of times from her online class and how it affected her:

> Since the class was virtual, sometimes the internet failed a bit, and I got lost. It happened to me that I missed a part of the problem resolution, so I didn't understand; I was trying to understand it, and it was hard for me. [Marie, November 24, 2021]

Having trouble connecting to the internet caused Marie to have difficulties learning how to solve statistical problems. Edward also noted that he had difficulty accessing the DBL just-enough just-in-time instructions inside the software when he needed them. His slow internet connection contributed to this problem. Edward stated,

> When we were redirected to the feedback, the process was a bit long because you clicked and went to another page to load the PDF or PPT... It took too much time. It took a minute, but if it were a fast internet, it would do it in 10 seconds.

The instructor had similar internet problems. She said, "At home, I had an internet that was not very fast, it was slow, and that was a problem." As part of the technological challenges faced, participants also had difficulties with computers not properly equipped or without access to computer labs. The instructor commented, "Initially, there were no computer labs at this university, and we didn't have internet either." Thus, students could not access the DBL software at the university. In addition, her statistics department did not provide computers to instructors. She had to use her own laptop that was not equipped properly.

Students faced similar equipment difficulties, as illustrated by Lizbeth's experience: "It was a problem with my computer that does not have much capacity, so I always had to reset it." As suggested by participants' quotes, these technological challenges negatively influenced participants' experiences implementing DBL.

Inside of the Classroom Challenges

Insufficient Time: The instructor had two main constraints, (a) insufficient time for instruction and (b) insufficient time for student-teacher interaction. The university cut in half the instruction hours to teach statistics from six hours to three hours per week without reducing the class credits and statistics topics that needed to be covered. Thus, the instructor felt she did not have sufficient time to cover each topic more deeply.

Because of the insufficient time for instruction, the instructor moved fast from one topic to another without giving students time to internalize the new statistical knowledge introduced. Lizbeth talked about her experience learning about variable recognition with the DBL model: "I think the method was fine, but sometimes as the professor went very fast, … if we missed something the thread of everything was cut and you got lost. I thought that was complicated." Diego expressed similar feelings: "I would have liked the course to take more time because the problem was always time, and the content was a lot to cover." Also, the instructor admitted that she would have liked to spend more time on each unit, especially on variable recognition. Dr. Luna emphasized that the time she was able to dedicate to the course content was limited.

In interviews, most of the students expressed dissatisfaction with the small number of in-class problems presented (another problem due to the insufficient time for instruction). Also, participants felt that there were insufficient homework problems on the DBL software. The instructor used the DBL software as a homework strategy. Diego highlighted how "in the first weeks," the instructor left students "a variety of problems" for homework about the process in statistics of identifying a variable. However, as the semester progressed, students weren't assigned more problems. Even though the students needed to practice problem identification all semester long. Students pointed out how they would have liked to continue practicing and completing their homework in the software. Edward expressed his feelings about the discontinued use of this strategy. He stated, "I liked it [DBL software homework] a lot, and I was sorry not to continue using it."

The insufficient time affected Dr. Luna's ability to interact with students leading to the insufficient time for student-teacher interaction constraint. The instructor considered that because the instruction time was limited and she had a big group of students, she could not spend a lot of class time answering additional students' questions. She said, "we had to advance" to cover all the class topics. Dr' Luna attempted to answer some students' questions, but she referred students many times to the DBL model. "I said, go to the DBL [software] because I have already taught you how to use it."

Because of this lack of time, students perceived a lack of teacher accessibility. As Pedro stated, "The accessibility of the professor in the middle of classes was scarce, and asking questions outside of the class hours was also a bit difficult." Diego expressed his frustration when his group needed help identifying the features of a problem. He stated, "we could not ask the professor" since teacher accessibility was limited. To sum up, all the outside-of-the-classroom challenges presented above negatively influenced the DBL implementation success, as reported by the participants.

Learning Transfer Issues: The second inside-of-the-classroom challenge that negatively influenced students' experiences was learning transfer issues. Most participants talked about their struggles to apply the knowledge learned with DBL to the authentic end-of-the-year statistic group project assignment. Also, some students struggled to apply the DBL model structure to in-class statistical problems presented by the instructor.

Participants reported that during class time, the instructor invited them to use the DBL structure to identify the variables in a problem but "without referencing [to] the decision model" (Plummer et al., 2022, p. 6). According to Plummer et al. (2022), this instructor invitation is an important step to help students become independent from the DBL scaffolding. Professor Luna expected the students to have practiced at home and to know how to find the right path to identify the main features of a problem.

Despite having the in-class support of the instructor to follow the DBL path, some students struggled to apply the model on their own. For example, Lizbeth stated that she felt "confused" and "insecure" when she had to identify the variables in a problem in class. She explained that she got lost as soon as the instructor presented statistical problems that the student considered different from previous problems. Similarly, Selya remembered that it was "difficult" to follow the DBL model structure because "as you

move forward, you have to create your options [follow the DBL path].” It shocked Selya that after the second class, the instructor invited students to participate and analyze a statistical problem on their own using the DBL model. Both participants' comments suggest they struggled to transfer what they learned from the DBL model to solve in-class statistical problems.

This was not true for all students, as Marie expressed: “She [the instructor] made us make our own decisions and follow the path, which worked well for us. It was very nice.” Also, Pedro explained how initially it was “a bit frustrating” for him to apply the DBL model to solve in-class statistical problems. However, he mentioned that he “adapted over time.” Pedro was able to apply the DBL model to in-class problems. He highlighted, “it was no longer so complicated.” From participants' comments, it can be inferred that some students had a less complicated time transferring what they had learned with DBL to in-class statistical problems.

As noted before, Dr. Luna used DBL combined with group projects to help her students apply their problem feature identification skills learned through DBL. She presented her students with “ill-defined problems not accounted for by the decision model” (Plummer et al., 2022, p. 6) to challenge students to use their new knowledge and develop their statistical thinking. She said, “On the first day of classes, I told them they were going to develop a research project in groups.” Presenting students with ill-defined problems is the last step in the DBL learning process (Plummer et al., 2022). However, students struggled the most when completing this step. For example, Lizbeth’s group had difficulties identifying the problem variables correctly. She noted that in her group, “there was confusion about the variables.” Lizbeth emphasized how her group didn’t see the similarities between the previous in-class and homework problems and the project problem. Pedro had similar impressions. He declared:

> It shocked me a bit because I wondered if I had seen an example similar to this [group project problem] or not. I was looking in my previous notes if I had one to compare them, and, well, I couldn't find much of a relationship, so that was what shocked me the most. [Pedro, November 29, 2021]

Lizbeth and Pedro struggled to transfer their DBL knowledge about variable identification to the group project because it required them to solve a more complex statistical problem independently. Different reasons were given by students as to why they had difficulty identifying problem features in the group project. Marie commented that the group project problems were difficult in comparison with the other homework they had. Marie said, “She [the instructor] taught us the easiest but left us the most difficult. It was a bit tricky to resolve it.” Thus, some participants had difficulty solving the group project assignments and transferring what they had learned from the DBL model.

DISCUSSION

Analysis of the participants’ interviews showed that they perceived several benefits and challenges when adopting DBL, which were reflected in the themes presented in this study. Despite the Peruvian participants' unique experiences, these study findings can be

useful for researchers and instructors looking for ways to use and improve the DBL pedagogy.

In this study, we identified different benefits of using DBL for students and instructors alike. One student benefit was that students started this introductory statistics class with low confidence in solving statistical problems, but their confidence grew by the end of the semester. Five of the six student participants self-reported that the DBL learning activities of the course positively promoted their statistical knowledge while boosting their confidence. McGrath et al. (2015) found that one strategy to enhance students' statistical confidence is to use a combination of effective teaching methods. Dr. Luna used different teaching strategies, such as real data problems, computational tools, DBL, and group project methods. Thus, in combination with other methodologies, DBL seems to be a feasible means of increasing novice statistics students' confidence.

As a second benefit, students mentioned that DBL's immediate feedback and support enabled them to recognize, rectify, and learn from their mistakes. Students appreciated the DBL scaffolding. Scaffolding is considered an important educational approach especially for solving statistical problems where educators provide support to learners as they absorb and acquire a new skill (Garfield et al., 2015). Both perceived student benefits mentioned by participants, immediate feedback and support and confidence growth, are closely related. Statistics researchers have found a positive relationship between feedback and confidence (Maqsoo & Ceravolo, 2019). DBL provides students with high qualitative feedback that could help students increase their confidence in solving statistical problems.

One instructor benefit reported in this study is in line with those reported by other instructors (Cardenas et al., 2020; Wentworth et al., 2021). Dr. Luna reported a higher level of satisfaction when teaching with DBL, as well as higher student satisfaction. According to previous research, the instructional technique used, and student satisfaction are positively related. Student satisfaction is enhanced when the teaching method used is a learner-centered pedagogy, and the learner receives high levels of feedback (Murillo-Zamorano et al., 2019). Participants in this study reported positive experiences with the DBL method, suggesting that this teaching approach can increase satisfaction with statistics teaching and learning.

Data from participants' interviews indicated that while using the DBL methodology may benefit instructors and students, some associated challenges can be faced. Participants faced outside and inside-of-the-classroom challenges. Challenges outside the classroom included the instructor's time-consuming initial preparation, and technological challenges. Implementing DBL initially requires instructors to spend more time creating material. Dr. Luna spent a considerable amount of time developing DBL material. This process was a struggle because it was time-consuming. These findings suggest that instructors might need additional support when implementing DBL. The kind of support instructors receive might enhance their ability to adopt and integrate DBL smoothly. Participants also expressed frustration with some technological challenges they faced. These technological challenges may reduce student engagement and affect student learning outcomes (Aguilera-Herminda et al., 2021).

In addition to the challenges mentioned above, students also faced challenges inside the classroom, such as insufficient time and learning transfer issues. The instructor lacks the time to discuss each topic in depth and present more practical examples. Students felt they didn't have time to learn a topic before the instructor moved on to another topic. Also, most students complained about the little interaction they had with the instructor. Students would have liked the teacher to spend more time answering students' questions and presenting more practical examples. The lack of student-teacher interaction and insufficient time in class affected students' ability to transfer their DBL knowledge to the group project. Participants' accounts suggested that they perceived the DBL transfer as too much and too fast because they didn't have enough time to practice and internalize the model. Overcoming outside and inside the classroom challenges is crucial for the success of DBL adoption and implementation because these challenges have a direct impact on the effectiveness and sustainability of this approach.

CONCLUSION AND RECOMMENDATIONS

Overall, this study found that DBL pedagogy and software had positive effects on instructors' and students' experiences in teaching and learning statistics. Also, instructors and students encountered some challenges that, once overcome, could make DBL a more valuable approach. Three strategies are proposed to address DBL's challenges. First, to avoid instructors spending a lot of time preparing DBL material, an open-source bank of already prepared DBL material might be created. Using open-source DBL material not only saves instructors valuable time but also promotes collaboration and knowledge sharing among educators. Future research could be conducted on creating an open-source DBL bank of resources and testing its effectiveness in reducing instructors' time spent creating DBL materials. Second, providing students with enough DBL problems to master the topics presented is essential to ensuring effective knowledge transfer. To achieve this objective, instructors should expose students to enough DBL problems. One way to do this is assigning more DBL problems through the DBL software. We recommend replicating this study, focusing on presenting students with more DBL problems to practice to enable them to internalize the DBL model faster. Third, Peruvian students wanted more interaction with the instructor, but Dr. Luna lacked time. Creating online discussion boards can increase student-teacher interaction. Students can use these boards to support each other, ask questions, and reinforce their learning.

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