



The Impact of problem-based learning versus structured online tutorials on students' database design acquisition in a physical education distance learning course

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Abstract

The purpose of this study was to compare two instructional approaches, problem-based learning and structured online tutorials, for teaching the intricacies of relational database design within a web-based class at the Democritus University of Thrace. Fifty-four (54) third-year undergraduate Physical Education students, between the ages of 20-21 years old, were randomly assigned into two teaching method groups: a problem-based learning group consisting of 27 students and a structured online tutorial group with 27 students. The teaching, practical exercises (activities), and tests spanned six consecutive weeks. Participants received five 90-minute instructional sessions for learning relational databases (LibreOffice Base 6.4). At the end of the experimental process, students were given a knowledge test as a final measurement. Independent sample t-test analysis was conducted to examine the hypothesis that students who receive web-based problem-based learning will have higher knowledge achievement than students in the structured online tutorials group. The analysis revealed that both methods, problem-based learning and structured online tutorials, could be effective for teaching relational database design, although students engaged in PBL activities outperformed those receiving structured online tutorials in the posttest. To fully understand the underlying reasons behind this discrepancy, additional studies are warranted.

Keywords: Problem-based learning, structured online tutorial, distance learning, database, physical education

Introduction

The landscape of higher education for undergraduate students and the format of available courses have undergone significant transformations due to the widespread impact of the COVID-19 global pandemic. As we shift from hastily implemented remote courses to more refined and effective online learning experiences, it is crucial to approach this transition with careful consideration and empirical insights (Foo, Cheung & Chu, 2021) [2]. McCue (2018) [1] predicts that the global eLearning market will reach \$325 billion by 2025, highlighting the growing significance of web-based courses. Consequently, there is a pressing need to focus on understanding the methods through which concepts are taught and absorbed in the online learning environment as the prevalence of such courses continues to rise.

An effective approach employed for teaching concepts involves the use of structured tutorials. A structured online tutorial is characterized as a web-based platform that delivers direct instruction through tutorials or practice problems (Kirkpatrick & Cuban, 1998) [3]. This format allows students to progress through web-based lessons at their own pace, choosing specific topics for learning. Immediate feedback is integrated into these programs, enabling students to assess their comprehension and proficiency levels in real-time (Harsası & Sutawijaya, 2018) [4].

Another effective strategy for teaching concepts is Problem-Based Learning (PBL). PBL is an instructional approach specifically designed to cultivate group problem-solving skills (Sayyah, Shirbandi, Saki-Malehi & Rahim, 2017) [5]. In this method, students collaborate in groups and are presented with a "real-world" problem to solve. The instructor takes on the role of a facilitator, offering guidance and resources to students while minimizing direct

instruction. Students, in turn, engage in information gathering, hypothesis formulation, and solution generation (Salvador *et al.*, 2023) [6]. The key aspect of PBL is that students themselves identify the necessary skills and locate resources to acquire these skills, working collectively to arrive at solutions (Barell, 2007) [7]. These resources may encompass websites, tutorials, textbooks, reference books, and expert advice.

Previous studies indicate that students participating in Problem-Based Learning (PBL) activities outperformed their counterparts receiving traditional instruction, as noted by Barrows (2002) [8], Reeves and Laffey (1999) [9], and Rounds and Rappaport (2008) [10]. Similar, Dominguez and Jaime (2010) conducted a five-year study comparing teaching approaches for databases. In the initial three years, students received lecture-based instruction exclusively, while in the final two years, students had the option to engage in problem-based learning activities online. The online alternative provided access to discussions, email, and chats, with all students having access to online resources. The results revealed that students in PBL groups achieved significantly higher exam scores compared to those exclusively exposed to lecture-based lessons.

Conversely, students who utilized structured online tutorials as supplementary instruction performed better than those who did not access the tutorials, according to Silver and Nickel (2007) [12]. It is noteworthy, however, that there is a lack of studies directly comparing the effectiveness of PBL with structured online tutorials.

Therefore, the purpose of this study was to compare two instructional approaches, problem-based learning and structured online tutorials, for teaching the intricacies of relational database design within a web-based class at the Democritus University of Thrace. The outcomes of this

study aim to provide guidance for instructors delivering online courses, specifically targeting physical education undergraduate students. The intention is to shed light on the most effective modes of instruction, thereby assisting educators in enhancing the quality of teaching within web-based courses. The research question guiding this study was the following:

1. Can disparities in relational database proficiency be observed among physical education students who participated in web-based problem-based learning compared to those who followed structured online tutorials?

Methods

Participants

This study involved fifty-four (54) third-year students from the Department of Physical Education and Sport Science at Democritus University of Thrace. The participants, aged between 20 and 21 years ($M=20.5$, $SD=.504$), comprised 31 males (57.4%) and 23 females (42.6%). They were enrolled in the 334–New Technology in Health course during the spring semester of 2020. The students were randomly divided into two teaching method groups: a problem-based learning group consisting of 27 students (15 males and 12 females) and a structured online tutorial group with 27 students (16 males and 11 females). Before the assignments, participants received information about the study's purpose, their assigned experimental group, the teaching method, and their participation requirements. While all students in the two classes were invited to participate, the procedures varied for the two course delivery formats. Each student provided voluntary consent to participate, with assurance that their involvement would not impact their grades.

Instruments

A knowledge test was developed to assess students' learning in relational databases (LibreOffice Base, 6.4), considering two important conditions: a) they should be completable during a teaching hour, b) the process and content should not be of a higher level than the participants' knowledge. Based on these conditions, a questionnaire with 22 multiple-choice questions was constructed. Each question had five choices to reduce the likelihood of guessing. The construction of the questionnaire was based on the linear model that determined the test outcome by summing the number of correct answers. Each question had equal weight in the result. The questions were created based on the academic notes of the course "New Technologies in Health", and a textbook on LibreOffice Base database (Weber, 2020)^[13].

When the questions were constructed as mentioned above, a group of experts in teaching databases (LibreOffice Base, 6.4) evaluated the content validity of the questionnaire. This group reviewed the questions and checked if each question ensured the best measurement of learning in relational databases (LibreOffice Base, 6.4). Each time a set of changes was made, the questionnaire was reviewed again by the consultants until it was deemed sufficient.

The revised version of the knowledge test included 20 multiple-choice questions. The questions included in the questionnaire were categorized into one of the following 5 categories: a) familiarity with the working environment (2 questions), b) creating tables and entering data (4 questions), c) creating relationships between tables (4 questions), d) creating queries (4 questions), and e) creating

reports (4 questions). A pilot study was conducted to determine the difficulty level and discrimination index of the questions (Green & Salkind, 2017)^[14]. Each correct answer on the questionnaire received a score (1), while each incorrect answer received no score (0).

Procedure

A pilot study was conducted to determine the reliability and validity of the knowledge test. The participants were 50 third-year students from the Department of Physical Education & Sport Science at the Democritus University of Thrace (D.P.E.S.S., D.U.Th.) who belonged to the coaching specialization. This population was selected to make the pilot study similar to the main study in terms of the participants' age. The teaching method utilized was distance learning, incorporating both synchronous and asynchronous teaching methods such as lectures, activities, and discussions. Participants attended three 90-minute teaching sessions and a review of the relational databases.

The knowledge test took place on the fifth day using each student's personal computer through the eClass exercises service. Each computer had the capability to connect to an electronic multiple-choice answer system for completing and submitting the 22 multiple-choice questions. The completion time for the knowledge test was set at 30 minutes.

After the pilot study, a main study was conducted to compare the results from 54 third-year students in the knowledge test. The main study had a final measurement, regardless of group design. The teaching, practical exercises (activities), and tests spanned six consecutive weeks. Participants received five 90-minute instructional sessions for learning relational databases (LibreOffice Base 6.4).

Classes were conducted through the eClass Learning Management System, where students accessed their courses by logging into the system. Various tools, including email, discussion boards, assignments, tests, web links, and groups, were utilized in this course to align with instructors' strategies and course objectives. The facilitator, a full-time instructor in computer technology for physical education, had access to each class section and established a standardized set of assignments, tests, groups, and links within eClass Learning Management System. A dedicated folder on each class section's home page contained links to these resources.

An introductory email was sent to all students, outlining the study's purpose and tasks to be completed, with the facilitator addressing any queries. Students were organized into groups based on course sections, with one group assigned a Problem-Based Learning activity and the other a structured online tutorial. The PBL activity, guided by research (Hmelo-Silver, 2004)^[15], involved an ill-structured problem, requiring collaborative problem-solving within small groups facilitated through discussion boards, chat rooms, file exchange, and email.

On the other hand, the structured online tutorial, informed by best practices (Silver & Nickel, 2007)^[12]; Mayer & Moreno, 2002)^[16], presented information over several pages that students could learn at their own pace. It incorporated audio and video elements, maintained a consistent layout, included interactive quizzes with immediate feedback, and allowed students to visit any desired page(s). Both groups received instructional feedback up to three times during the study.

At the end of the experimental process, students were given a knowledge test as a final measurement. The procedure of the knowledge test was similar to that of the pilot study. There were only two fewer questions, reducing the total number of questions to twenty.

Statistical analysis

The experiment was a factorial design with teaching method group (problem-based learning, structured online tutorial) as independent variable, and knowledge acquisition as dependent variable. Independent samples t-test analysis was conducted to investigate the differences of knowledge acquisition among the teaching method groups (problem-based learning, structured online tutorial) of the participants. The hypothesis of this study was:

H01. Students who receive web-based problem-based learning will have higher knowledge achievement than students in the structured online tutorials group.

Results

Item analysis

The pilot study for the knowledge test had an average difficulty level of approximately 34.1%. When all data were analyzed, all questions had an acceptable difficulty rate, and thus, none were removed. The acceptance criterion for the difficulty rate ranges between 10% and 90% (Green, & Salkind, 2017) [14].

The pilot study for the knowledge test had an average discrimination index of 0.52. When all data were analyzed, two questions, or 10% of the items, had an unacceptable discrimination index and were consequently removed. The accepted value for the discrimination index is above 0.20 (Green, & Salkind, 2017) [14]. Finally, no questions were removed due to low difficulty and discrimination indices. In

total, 2 questions, or 10% of the items, were removed from the knowledge test.

Reliability analysis

The knowledge test questionnaire had a Cronbach's alpha reliability coefficient of 0.77 when evaluating the internal consistency of its twenty items. According to Green & Salkind (2017) [14], a Cronbach's alpha value equal to or greater than 0.70 is considered satisfactory. Therefore, the knowledge test questionnaire was a reliable measurement tool for assessing learning in the LibreOffice Base 6.4 database program.

Independent samples t-test analysis

An independent samples t-test was applied to examine the H01 hypothesis that students who receive web-based problem-based learning will have higher knowledge achievement than students in the structured online tutorials group. The homogeneity of variance was checked using the Levene's test, and the normality of the sample was assessed with the Shapiro-Wilk test. The level of significance for measurements was set at ($p < 0.05$). The analysis revealed that the use of web-based problem-based learning during distance courses has a significant impact on the knowledge acquisition of undergraduate students, $t_{(52)} = 2.39, p < 0.05, d = 0.651$. Online students implementing the teaching method of web-based problem-based learning ($M = 13.6, SD = 2.61$) showed higher knowledge achievement compared to online students who receive structured online tutorials ($M = 11.7, SD = 3.27$). Therefore, the use of web-based problem-based learning during distance courses did affect the knowledge acquisition of online students. In Table 1, the mean value (M), standard deviation (SD), and the t-value with the corresponding level of significance are presented in detail.

Table 1: Mean scores and standard deviations of knowledge acquisition for the PBL and structured online tutorial.

Variable	Problem-based learning (n=27)		Structured online tutorial (n=27)		t	p
	M	S.D.	M	S.D.		
Knowledge acquisition	13.6	2.61	11.7	3.27	2.39	.02

According to the results, the H01 hypothesis, which suggested that students who receive web-based problem-based learning will have higher knowledge achievement than students in the structured online tutorials group, is supported. Therefore, undergraduate students who received

web-based problem-based learning during the intervention did gain more knowledge acquisition from their participation in the distance learning course compared to undergraduate students who receive structured online tutorials (Figure 1).

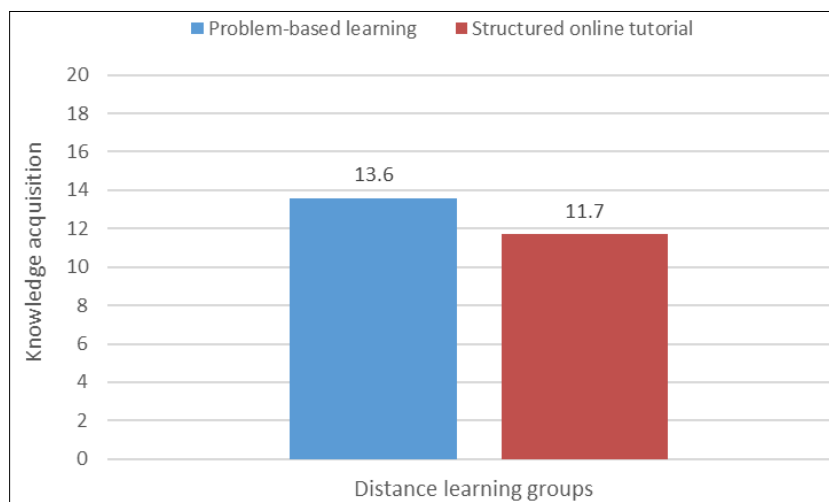


Fig 1: Mean scores of the distance learning groups (PBL, structured online learning) in knowledge acquisition.

Discussion

With the rising prevalence of web-based courses, there is a growing necessity to scrutinize the methods through which concepts are taught and absorbed in distance learning settings. In particular, instructing abstract notions like relational database design can pose significant challenges. Effective approaches may involve furnishing examples and hands-on activities, encouraging collaborative group work on real-world problems, leveraging social media tools such as discussion boards, and delivering instructional content through video lectures. These diverse methods contribute to enhancing the presentation of complex concepts in the online learning environment. Therefore, the goal of this study was to contribute to the distance learning literature by comparing two instructional approaches, problem-based learning and structured online tutorials, for teaching the intricacies of relational database design within a web-based class at the Democritus University of Thrace. To address this objective, a specific question was formulated and investigated, and the study's findings regarding this question are discussed below.

The research question focused on whether there could be differences in the proficiency of relational database among physical education students who participated in problem-based online learning compared to those who attended structured online tutorials. The data from this study appeared to support the hypothesis that participants exposed to problem-based learning would have higher knowledge performance than students in structured online tutorials.

The research indicated that both methods, problem-based learning and structured online tutorials, could be effective for teaching relational database design, as observed in prior studies (Dominquez & Jaime, 2010; Murray & Guimaraes, 2009) [17], and in line with the current study. Notably, students in these studies, including the present one, were permitted to use additional resources, though the extent of resource utilization and its potential impact on the results remains unknown.

While the results demonstrated that students engaged in PBL activities outperformed those receiving structured online tutorials in the posttest, it was interesting to note that the frequencies of tutorial use and participation in PBL activities did not correlate with posttest scores. In other words, the time spent on tasks did not appear to influence outcomes. One plausible interpretation is that students who performed well might have already possessed a solid understanding of the process, rendering additional instruction unnecessary.

In the PBL group, the facilitator played a role in guiding discussions by identifying redundancies in database designs. On the other hand, the only feedback received in the structured online tutorial was programmed into the quizzes. Importantly, no data were collected on how students engaged with the activities and lessons provided in the structured online tutorial. In summary, the superior performance of students in the PBL treatment might be attributed to more effective just-in-time instruction. The structured online tutorial relied on programmed feedback, while the PBL activity facilitated dynamic instructor feedback, better addressing relevant issues and concerns. Thus, it is possible that the structured online tutorial teaching method caused a sense of uncertainty among students about what the professor expected from them during the weekly classes.

Evaluating the results of the current research, greater attention should be given to those factors that strongly influence students' learning ability. Specifically, the participants in the study were third-year students from a university institution in Komotini. A different and larger sample would ensure a more rigorous research design for evaluating the learning of theoretical subjects through an asynchronous learning management system. Additionally, the results reported in this study are based on the e-Class platform. It is possible that a different asynchronous e-learning system, with different content, would yield different results.

Conclusions

In response to the COVID-19 pandemic, innovative educational adaptations have proven essential. However, it is crucial to subject these changes to further evaluation before considering permanent adoption. This study offers valuable insights to the distance learning literature and provides practical information for practitioners involved in the ongoing discourse on these matters. The findings demonstrated that students engaging in distance learning through problem-based learning activities displayed heightened proficiency in relational database design compared to those using the structured online tutorial approach. To fully understand the underlying reasons behind this discrepancy, additional studies are warranted.

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