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Effects of the In-flipped Classroom on the Learning Environment of Database Engineering*

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The growth of information technology has led to the introduction of blended learning classrooms. A "flipped" classroom is a specific type of blended learning environment that allows students to learn outside the classroom through e-learning and then interact with the teacher inside the classroom. Although flipped classrooms have many advantages, some issues, such as low motivation prior to lectures, remain and should be improved. This paper proposes an in-flipped classroom to overcome the problems found in existing flipped classrooms and evaluates this type of classroom using a Database Engineering course in a master's program. This study uses the College and University Classroom Environment Inventory (CUCEI) to investigate the learning performance of the newly proposed in-flipped teaching environment. The results show that students in an in-flipped classroom exhibit better individualization than those in a traditional classroom and have increased interest in cooperative learning. The study also finds that students are more easily engaged in lectures and develop self-directed, self-regulating, and self-determined skills through the proposed method.

Keywords: in-flipped learning; collaborative learning; blended learning; problem-based learning; college and university classroom environment inventory

1. Introduction

The essence of database engineering involves designing, normalizing, merging, and optimizing data structures in the database system [1]. Database engineering combines specialized knowledge and skills in software engineering, computer science, electrical engineering, and other forms of related education with the principles and methods of engineering to specify, predict, improve, and evaluate the results obtained from database systems [2]. Therefore, database engineering is a subject-specific and cross-curricular field. Database systems are expected to integrate specific activities and to provide users with effective and efficient operations.

To provide students with a concrete background and knowledge in database engineering, this study developed a blended learning database engineering course. This course introduces students to necessary professional skills, conceptual frameworks, methods, and technologies and gives them hands-on experience with database systems to allow them to fulfill current needs in the marketplace.

This study discusses relative learning theories in Section 2 and designs a new learning method, the in-flipped classroom, and applies it to engineering education. The structure adopted is a blended learning method and resolves the disadvantages of flipped learning to satisfy the needs of various students. This study aims to determine how an in-flipped classroom influences: (1) the learning environment, and (2) learning efficiency in this type of engineering learning environment.

Focusing on these two main purposes, in-flipped learning is designed to be a learning environment that consists of real and virtual teachers in the same classroom. The proposed method asks students to learn essential database engineering material in class, along with asynchronous online learning (virtual teachers). Once students are presented with a problem, they can repeatedly check the online content or request face-to-face solutions and discussions from classmates and instructors (real teachers). This study proposes that the in-flipped classroom can offer students practical experience in database engineering and more personalized guidance and interaction than the traditional classroom. Finally, this study examines students' learning performance in the in-flipped classroom.

2. Theoretical framework

In this section, the basic concepts of traditional education and flipped learning are introduced. The related concepts of e-learning, collaborative learning and problem-based learning are also explained.

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2.1 Traditional education

Traditional database teaching is based on classroom discussion (also known as face-to-face teaching), and the teaching style relies on instructor-centered methods [3]. This teaching method emphasizes direct instruction, lecturing, and seatwork, in which students listen and observe to derive motivation and instruction [4].

Traditional teaching methods have many blind spots that must be improved. For example, classroom settings are often instructor-centered; the instructor talks to students instead of allowing students to communicate during the lecture [5]. Most classes involve rote learning, in which students depend on memorization without having a complete understanding of the subject. Passing tests that consist of descriptions, matching, and other types of indicators are all that matter to complete the curriculum. Long lectures and notations, rote memorization, and minimal interaction between students and instructors in the classroom often leave students inattentive and unengaged. Such students are prone to skipping classes and missing lessons. Moreover, students in a traditional class have little opportunity to interact with their classmates or their instructor [6]. To overcome these disadvantages in traditional education, a number of new learning concepts have been proposed, such as problem-based learning, collaborative learning, and e-learning [7].

2.2 Problem-based learning (PBL)

Problem-based learning (PBL) is defined as a process of teaching that uses concrete problems to motivate students and maintains a focus on student-centered activities. Instead of emphasizing the teaching process, greater significance is given to the learning process [8]. Several database researchers suggest that instructors act more as facilitators than as the primary source of knowledge [9, 10]. Students frequently collaborate in small groups or teams to clarify and define the nature of problems and attempt to establish procedures to solve them.

2.3 Collaborative learning (CL)

Collaborative learning (CL) directly addresses generic skills such as problem solving, critical thinking, and communication [11]. Although CL is not a new concept, it has recently gained a new dimension with computer-assisted methodologies such as Web 2.0 technology, learning management systems (LMS), and social media. In software engineering, studies have confirmed the effectiveness of collaborative learning to promote students' learning efficiency and outcome. Through the encouragement of teamwork in collaborative learning, students benefit from the active exchange of knowledge and ideas and are able to monitor each other's work [12].

2.4 E-learning

Many recent studies suggest that the use of computer-assisted methodologies can enhance classroom learning [13]. One representative computer-assisted methodology is e-learning, which can be defined as the use of computer network technology, primarily over an intranet or through the Internet, to deliver information and instruction to individuals [14]. E-learning has been examined as an important issue, particularly in higher education [15]. There are several proposed e-learning technologies that provide efficient learning in engineering education [16, 17]. E-learning can be applied to enhance traditional teaching methods and to develop students' technical skills [18].

Although e-learning has many apparent advantages, poor retention [19], low motivation for course completion, low student satisfaction, and the lack of interaction with teachers and peers are issues that need to be addressed [20]. Blended learning (BL) has been suggested to overcome these problems [21]. BL combines face-to-face classroom interaction with computer-mediated activities to benefit student learning [22].

2.5 Blended learning (BL)

Blended learning is a method based on various combinations of classic face-to-face lectures, Internet learning, and learning supported by other technologies [22]. It aims to select a combination that will motivate students and assist them in successfully mastering the course.

In recent years, flipped learning, a form of blended learning that uses technology to leverage classroom learning, has been discussed extensively [23]. Flipped learning includes both collaborative learning and problem-based learning [24]. In flipped learning, students preview learning materials (e.g., course notes and videos of lectures) for the classroom in advance and participate in discussions and practical activities during the lecture. Instead of traditional passive teaching, teachers can focus on specific questions and/or problems raised by tutors and students that promote or reinforce the targeted subject outcomes. The role of the classroom teacher is to guide students when they reach an impasse rather than to impart the initial lesson. Moreover, flipped learning allows students to review lessons and master topics, gives teachers more time to spend helping students one-on-one, builds stronger student/instructor relationships, creates a collaborative learning environment in the classroom, and offers a way for instructors to share information with other faculty, substitute instructors, students, and parents [24].

However, not all students can access the Internet whenever they want. In addition, time constraints for students at home may merely transfer poor classroom instructional practices from the classroom to the web if all of the subjects are flipped [24, 25]. Furthermore, there are doubts about students' ability to study lecture materials at home. Will students end up sitting in front of a screen for hours every night watching the required videos? Previous research has indicated that learning at home is not easy or automatic [26]. Lazy students are not likely to successfully complete their courses.

Based on these learning theories, this study finds that flipped learning can enhance teaching and learning effectiveness. However, technology cannot provide students with a transformative learning experience, nor can technology completely replace the human interactions of a face-to-face classroom. Therefore, this study proposes a new learning method called an in-flipped classroom, which integrates the concepts of flipped learning, collaborative learning, and problem-based learning to improve on traditional teaching and to design an environment in which the classroom becomes a dynamic learning community.

3. Design and evaluation of in-flipped learning

This method aims to support un-previewed students in learning material under supervision while the teacher primarily focuses on assisting previewed students in solving their problems during the lecture. This study employs quantitative data analysis in the form of multiple variance analyses and investigates the differences in learning performance between in-flipped and traditional classrooms.

The proposed method was applied to a graduate course. For PBL and group work, a low student–instructor ratio was a prerequisite for the strategy to be successful. This study adapted the argument found in previous research that the number of students enrolled in the course should be between 10 and 30 [27].

3.1 Academic context and the in-flipped setting of database engineering

A master programming course, Database Engineering, was used to evaluate the proposed method. This course consisted of designing, implementing, tuning, and maintaining database systems. The students were expected to learn and demonstrate the following skill set: 1) knowledge of the characteristics, objectives, and structure of relational databases; 2) the capacity to create a physical data model; 3) the capacity to evaluate and maintain database schema; 4) the capacity to generate DDL for the model; and 5) knowledge of reliability problems related to the use of a relational database and the mechanisms that exist to help avoid them. This course provided students with the necessary background and skills to help them develop their knowledge of database engineering.

The early stage of this course introduced the schema design by introducing a case study. The later stage introduced the maintenance of the database. The load for students included two mid-term exams, quizzes, and a final examination.

The study divided the students into two groups. The experimental group was structured according to the classroom in-flipped method and met in a computer laboratory. This study incorporated an actual teacher and a virtual teacher (videos of lectures) who simultaneously instructed the students. During the fall semester of 2012 at this university, the 32 students were divided by means of systematic random sampling of the enrollment sheet: 18 students were placed in the traditional class, and 14 were placed in the in-flipped classroom. The experimental group of students could review lessons and master topics in the classroom and could interact with students and the real teacher when they encountered problems. The control group was structured according to a traditional classroom. During the lectures, students had opportunities to ask or answer questions related to the discussed examples. The teacher made an effort to run the lectures as interactively as possible. After each session, the same set of problems from the book was assigned to both groups as homework. During the semesters, quizzes and term examinations were held for both classes at the same time and location.

3.2 Data collection and design

Data, including tests and questionnaires, were collected using quantitative methods after students spent several weeks in the in-flipped environment or the traditional environment. This study administered the College and University Classroom Environment Inventory (CUCEI) questionnaire to access preferences between the two sections. The CUCEI questionnaire provided insight into (1) the students' perceptions of their actual learning environment and (2) their opinions of how their preferred learning environment would look [28]. The CUCEI was developed to measure student and instructor perceptions of classroom psychosocial environments in college and university classrooms [28]. The CUCEI includes seven subscales: personalization (PE) (relationship and personal growth), innovation (INNO) (personal growth and system maintenance and change), student cohesion (SC) (relationship), task orientation (TO) (personal growth and system maintenance and change), cooperation (CO) (relationship and personal growth), individualization (INDI) (personal growth and system maintenance and change), and equity (EQ) (personal growth and system maintenance and change). The CUCEI's internal consistency reliability for the seven scales has been reported to be acceptable in multiple studies, with Cronbach's alpha coefficients ranging from 0.70 to 0.90 [28]. Structuring the survey into these two parts provided a full and meaningful measure of what students actually said about their personal preferences in the classroom.

3.3 Analysis results

This study relied on the methods of previous research using reliability, discriminant validity, multivariate analysis of variance (MANOVA), and t-tests to verify the questionnaire analysis [28].

The reliability and discriminant validity of the CUCEI were initially evaluated. The scales of the CUCEI are listed in Table 1, along with their Cronbach's alphas and discriminant validity. To examine the discriminant validity, the AVE value of each construct should be higher than the estimated square correlation. As Table 1 shows, the AVE value of each construct was higher than the square correlation values, and the Cronbach's alpha values all exceeded 0.70, meaning that this questionnaire exhibited good reliability and validity.

Because the CUCEI is multidimensional (seven subscales) and its versions (actual and preferred version) are paired, this study utilized repeated measures (MANOVA) to look for significant or interactional effects between the versions and instructional methods in the data. The results are shown in Table 2. The version of the CUCEI explained 72% of the overall variation in the data, and the instructional method explained 52% of the overall variation in the data. Both of these effects were statistically significant. Furthermore, the interaction effect between the version of the CUCEI and the instructional methods explained 35% of the overall variation in the data. This means that the difference between the version and the instructional methods was more significant than the interactional effects. Therefore, this study can verify the differences between the version and instruction methods.

Because the MANOVA was significant, independent sample t-tests were used to further analyze the data. One question is what the students thought of their actual learning environment compared with their preferred learning environment. In Table 3, the means for the actual version of each item ranged from 2.41 to 3.90, and the preferred version of the CUCEI ranged from 3.47 to 4.06. This result indicates that each mean of the subscales for the actual version was statistically significantly lower than the preferred version. Thus, the students as a whole were not fond of their actual learning environment. They required a new learning place to resolve their dissatisfaction with the learning experience.

Another question is whether students' scores on the subscales differed in the traditional and the in-flipped classrooms. This question can determine students' differences when comparing the preferred version to the actual version in the instructional method. Table 4 shows the means and standard deviations for each subscale of the actual version of the CUCEI for the traditional and in-flipped classrooms. These measures were analyzed using an independent sample t-test, and the results show significant differences in the actual version of the

Table 1. CUCEI Alpha reliability and discriminant validity for the proposed method

Scale	Alpha	PE	INNO	SC	TO	CO	INDI	EQ
PE	0.86	067						
INNO	0.87	0.59	0.61					
SC	0.76	0.29	0.33	0.66				
TO	0.84	0.46	0.48	0.41	0.70			
CO	0.71	0.29	0.25	0.35	0.48	0.63		
INDI	0.84	0.23	0.21	0.27	0.32	0.24	0.71	
EQ	0.89	0.52	0.56	0.39	0.52	0.29	0.24	0.65

Table 2. Repeated measures MANOVA for version of CUCEI (actual vs. preferred) and Instructional method (in-flipped vs. traditional)

Effect	df	F	*p*-value	Effect size (Wilks')
Version of CUCEI	7,54	14.08	0.000***	0.28
Instructional method	7,54	5.45	0.001**	0.48
Version * method	7,54	1.26	0.02*	0.65

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table 3. Means, standard deviations, and difference scores for actual and preferred Versions of CUCEI

	Actual		**Preferred**		
Scale	**Mean**	**SD**	**Mean**	**SD**	***t*-stat**
Personalization	3.90	0.21	40.05	0.32	–0.16*
Innovation	2.78	0.23	30.47	0.43	–0.70***
Student cohesion	2.71	0.27	30.83	0.31	–10.12***
Task orientation	3.71	0.15	40.06	0.24	–0.35***
Cooperation	3.59	0.46	30.99	0.27	–0.40***
Individualization	2.41	0.32	30.52	0.38	–10.11***
Equity	3.84	0.21	40.04	0.35	–0.20**

* Paired *t*-test significant at the 0.01 level (2-tailed).
** Paired *t*-test significant at the 0.001 level (2-tailed).

Table 4. Means and standard deviations for the actual version of CUCEI

	Traditional		**In-flipped**		
Scale	**Mean**	**SD**	**Mean**	**SD**	***p*-value**
Personalization	3.78	0.16	40.10	0.15	0.00***
Innovation	2.73	0.24	20.92	0.17	0.03*
Student cohesion	2.61	0.25	20.87	0.21	0.01**
Task orientation	3.74	0.16	30.65	0.12	0.12
Cooperation	3.42	0.29	30.87	0.56	0.01**
Individualization	2.23	0.16	20.69	0.32	0.00***
Equity	3.81	0.22	30.89	0.20	0.34

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

survey for the personalization, innovation, student cohesion, cooperation, and individualization subscales.

This study performed the same subscale analysis between the two classes for their preferred version scores. Table 5 shows the means and standard deviations for each subscale of the preferred version of the CUCEI for the traditional and in-flipped classrooms. The result indicates that students in the in-flipped class preferred an environment with greater personalization, innovation, student cohesion, cooperation, and individualization compared with the traditional class. The results also show that student preferences for the above scales were consistent with the actual experience of the class.

Furthermore, this study collected the ordinary paper-based test scores of the two classes to compare the efficiency of the learning environment. Students were tested with two examinations using identical tests for both classes administered at the same time and location. Table 6 shows the means and standard deviations for each exam for the traditional and in-flipped classrooms.

The scores of the item means and standard deviations for the traditional classroom were 81.67 and 88.89 for the two exams, whereas the in-flipped classroom values were 95 and 96.54. These results indicate that students in the in-flipped classroom exhibited better learning efficiency.

3.4 Scope and limitations

This study has several limitations. First, the sample size of the study is small. Future studies should include more individuals. Second, all participants were from the same institution in Tainan. Third, the quasi-experimental procedures were conducted

Table 5. Means and standard deviations for the preferred version of CUCEI

	Traditional		**In-flipped**		
Scale	**Mean**	**SD**	**Mean**	**SD**	***p*-value**
Personalization	3.92	0.25	40.27	0.31	0.00***
Innovation	3.33	0.36	30.71	0.47	0.02*
Student cohesion	3.69	0.21	40.06	0.32	0.00***
Task orientation	4.04	0.26	40.10	0.19	0.51
Cooperation	3.86	0.23	40.21	0.20	0.00***
Individualization	3.35	0.24	30.81	0.42	0.00***
Equity	4.03	0.42	40.07	0.19	0.75

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table 6. Examination results

	Traditional		In-flipped		
Scores	**Mean**	**SD**	**Mean**	**SD**	***p*-value**
Examination 1	81.67	11.36	95	5.19	0.00***
Examination 2	88.89	11.42	96.54	5.33	0.04*

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

over one semester. Fourth, the study did not use qualitative analysis to verify the quantitative survey methods. Therefore, the scope, sample size, geographic boundary, survey methods, and time constraints of the study hindered the ability to generalize the results to a larger population.

4. Discussion

This study aimed to determine how an in-flipped classroom influenced: (1) the learning environment and (2) the learning efficiency in this type of classroom. The main purpose of the new learning environment was to challenge the traditional concept of learning. In this pedagogical setting, teachers acted as facilitators. The teacher did not automatically provide predefined solutions but required students to take responsibility for their actions and to critically reflect on the decisions that they made.

In this course, the analytical results indicate that in-flipped classroom students were more satisfied with the personalization, student cohesion, cooperation, innovation, and individualization. The students in the in-flipped classroom contributed to a more cooperative environment than those in the traditional classroom. This environment increased peer cohesion and provided students with a more comfortable feeling in the class. With regard to individualization, students in the in-flipped classroom could interact with the virtual teacher (videos of lectures), select subjects, and review lecture material by themselves. The quantitative analysis shows that these students exhibited higher individualization than traditional students.

This study provided students with multimedia materials and with the practical experience of an in-flipped classroom in which students could operate computers and learn from a virtual teacher. The quantitative analysis shows that students in the in-flipped classroom showed higher motivation levels than traditional students.

This study addressed the deficiencies of the original concept of the flipped classroom by investigating an in-flipped database engineering classroom that not only supervised un-previewed students in completing their learning material but also used actual/virtual teachers to instruct students. The virtual teacher provides the ability for students to review lecture materials, helps students learn complex subjects, and promotes higher individualization. However, the actual teacher is able to address students' problems, spend more time assisting students, build stronger student/instructor relationships, offer a means for sharing information with other students, and create a collaborative learning environment in the classroom.

5. Conclusion

This study designed a new flipped classroom—an in-flipped classroom—that paralleled face-to-face and blended learning and evaluated the proposed method in a course on database engineering. In this context, this study discussed the importance of database engineering for engineering education as a whole. This course aimed to cultivate students' professional knowledge of database engineering and ensured that students would be able to use their knowledge to identify, analyze, and resolve engineering problems.

For engineering education, this study confirms that an in-flipped learning environment creates a new learning experience and promotes more efficient learning methods than the traditional classroom. This new learning environment of the in-flipped classroom is easily reproducible, scalable, and customizable for students and teachers. Thus, the in-flipped classroom can likely become a successful learning environment in database engineering education.

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