

Trigonometry with ProjectMEC: A Courseware and Student Performance Evaluation

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Abstract: Spurred by the advent of integrating computer-aided instruction in the teaching-learning process of mathematics, the School of Information Technology Education of CKS College developed an online courseware named ProjectMEC that aimed to improve student performance. The study utilized the quasi-experimental posttest-only design: a purposively-selected college Trigonometry class of 26 students was chosen to be the respondents, with the mathematics instructor randomly assigning the participants of the experimental (courseware users) and control groups. As it was not the intention of the department to replace the instructor with the courseware, regular face-to-face classroom sessions were still held. The online courseware was used for the coverage of one long quiz consisting of three lessons. Results show that both instructors and students were generally satisfied with the features and qualities of the courseware; however, the posttest scores reveal that there is no significant difference between the performance of the two groups. Recommendations are provided for future studies relevant to computer-aided instruction.

Key words: College trigonometry, computer-aided Instruction, mathematics education, quasi-experimental design.

1. Introduction

A courseware is a software designed to serve educational purposes by providing a human-computer interaction platform to facilitate the teaching-learning process. Developing and implementing a courseware is anchored on utilizing e-learning as a means to education. According to Thorpe [1], the application of e-learning can be in conjunction with varying pedagogies. Moreover, Weller [2] supported this notion by associating constructivism as a pedagogical framework that can be combined with technology. As constructivism comes into action, it will not only build upon the knowledge acquired by students from their teachers as per Ausubel's Theory of Meaningful Learning [3], but also have the courseware serving as the *more knowledgeable other* in Vygotsky's terms. [4] Furthermore, Mayer's Multimedia Learning Theory [5] and Paivio's Dual-Coding Theory [6] very well support the use of courseware as a means of learning. Both theories suggest that when both visual and verbal materials are present and used, optimal learning can be achieved. Mayer's series of tests on exposing students to information delivered on more than one medium yielded favorable results for them; likewise, Paivio had shown that learners tend to better remember information that had been presented to them in a multimedia manner.

iMath [7], an arithmetic courseware developed for grade school pupils, not only provided students with supplemental arithmetic lessons, but also empowered teachers to design their own lessons and exercises online. Moreover, they were able to monitor student progress and deliver necessary intervention in class

when needed. In pursuant to the recommendations presented by Hao in his reflections on iMath, he suggested that the same tool be modified, to be applied on and tested by higher-level students. Furthermore, Shi and Shi [8] espoused that the increased presence of computer technology had promoted positive effects in higher mathematics classrooms. Echoed by Janier, Shafie and Ahmad [9], their study on utilizing technology in teaching the application of integration in calculus revealed that students who used their courseware did as well as those in the control group.

Heeding the aforementioned recommendation, the School of Information Technology Education of CKS College thus formed a working group composed of research faculty members and research assistants, aptly naming the courseware *ProjectMEC* (Mathematics Education Courseware). The group was generally tasked to develop an online courseware that would give the college mathematics instructor the freedom to design his lesson and quizzes, and be able to monitor student progress. Moreover, it would allow his students to access the lessons and answer the exercises available. Due to time constraints and possible ethical implications, the team decided to just evaluate ProjectMEC for the coverage of one long quiz in a Trigonometry class --- one of two mathematics classes offered with a higher number of enrolled students.

Specifically, the study aimed to apply technology side-by-side with the traditional method of teaching, as it is in consonance with the College's policy that face-to-face classroom sessions should be maintained at all times. In addition, the courseware was to be evaluated in terms of several technical aspects by both instructors and students. Lastly, as it is a quasi-experimental posttest-only study, the effectiveness of the courseware would be explored through the comparison of student performance in the long quiz administered by the Trigonometry instructor. It is reminiscent of the research design utilized by Bakar, Ayub and Mahmud in their Geometry study that used a dynamic mathematical software in a Malaysian school [10].

2. Methods of Research

Fig. 1 below presents the operational framework of the study:

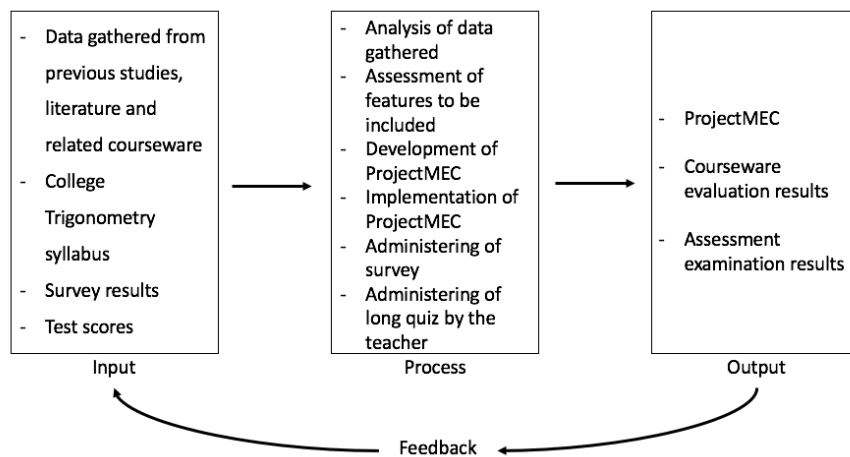


Fig. 1. ProjectMEC's framework of the study.

The study utilizes an Input-Process-Output model to present the flow of the study. In order to accomplish the research goals and objectives, the researchers first reviewed existing courseware and conducted a comparison of features. The information retrieved from previous studies on courseware and underpinning theories served as primary inputs, together with the College Trigonometry syllabus prepared by the instructor. With the inputs complete, the researchers analyzed the data gathered and assessed the features to be included in the development of ProjectMEC. It was then decided that all the features of iMath would

be maintained, with the welcome addition of the formula editor plugin that was developed using MathQuill which used LaTeX. This addressed the limitation experienced by both iMath and other existing mathematics courseware wherein users could not input mathematical expressions. Moreover, it was agreed that ProjectMEC would use the Drupal-based Opigno framework, an open-source learning management system; this significantly reduced the time required should the team have chosen to code the entire courseware from scratch. This is in consonance with the design utilized by Angeles, Fajardo and Tanguilig in building a math reviewer tool for engineering students. [11] Development phase then ensued, with the courseware being evaluated for continual feedback from both instructors and students alike to improve it before the final evaluation of features.

After the development of the courseware, implementation testing commenced. The courseware was accessible in the Internet at www.projectmec.com for a limited time of one month --- ample time to cover a long quiz coverage (i.e. consisting of trigonometric identities, inverse trigonometric functions, and exponents and logarithms). Moreover, employing the quasi-experimental research design, the students were randomly divided into two groups through random selection by the instructor: control and experimental, with both groups having 13 participants each. A test prepared by the instructor for one long quiz coverage was administered to both groups to check the effectiveness of the courseware. The results were gathered and statistically treated using Student's t-test via Microsoft Excel to determine if there is a significant difference between the performances of the experimental and control groups.

Moreover, the researchers surveyed the participants of the study and were asked to evaluate the courseware's features and qualities in terms of their level of satisfaction; it was associated with the Likert Scale that is employed in the survey, as adapted from Hao, et al. [12]. The Likert scale and corresponding interpretation are presented as follows:

Table 1. Likert Scale and Ranking (for Satisfaction on Features)

Scale	Range	Interpretation
4	3.51-4.00	Highly Satisfied
3	2.51-3.50	Satisfied
2	1.51-2.50	Somewhat Satisfied
1	1.00-1.50	Dissatisfied

Table 2. Likert Scale and Ranking (for Conformity to Standards)

Scale	Range	Interpretation
5	4.20-5.00	Excellent
4	3.40-4.19	Very Good
3	2.60-3.39	Good
2	1.80-2.59	Fair
1	1.00-1.79	Poor

3. The Project MEC System

This section presents the features of ProjectMEC for both teacher- and student-users, in terms of: Graphical User Interface, User Accounts Management, Personal Records Management, Course, Lesson and Quiz Management, and Online User's Manual.

3.1. System Features: Teacher Side

Instructors are given login credentials by the department, of which the Program Chair has administrator access to ProjectMEC. Upon successful login, several blocks are displayed. The following subsections

describe the features of the courseware from the perspective of a teacher-user.

3.1.1. Graphical user interface (GUI)

The courseware features a GUI that was customized to follow the color theme of the College.

3.1.2. User accounts management

The teacher is authorized to activate newly registered student accounts. He can add his students by enrolling them inside the course by going to the “Users” block in “MY COURSES”, then selecting the “Add members” block.

3.1.3. Personal records management

The teacher has access to the students’ progress (i.e. the lessons he has taken) and grades for monitoring purposes, whenever intervention is deemed necessary.

3.1.4. Course, lesson and quiz management

One of the blocks is the “MY COURSES” block wherein the teacher can create courses; within a course, the teacher can create lessons, videos and quizzes. For the purpose of this study, Trigonometry was the only course created. For the lessons, the teacher can upload slides in PDF format through the “Manage questions” button on Theory and mixed type lessons. Lecture slides are treated similar to *questions* in the system. The instructor can also add photos by using the dedicated photo-uploader; for videos, a video-uploader button is available.

On the other hand, the teacher can add questions for the quiz through the “Manage questions” button in Quiz or Mixed Type lessons and choose which type of questions to create, since the courseware has various types of questions (e.g. identification, multiple choice, true or false, etc.). Furthermore, the formula editor plug-in enables the teacher to type mathematical expressions inside the quiz question. The teacher can customize responses for every item in the quiz; an explanation for the correct answer is provided to clarify possible computational errors or conceptual misunderstanding. Likewise, the teacher can simulate the quiz-taking experience by actually being able to take the quiz they designed; the “RESULTS” button will yield the correct answers, explanations and score. Additionally, the teacher does not only have the capability to create courses, lessons and quizzes, but is also authorized to modify and delete such.

3.1.5. Online user’s manual

A user’s manual is available online for reference. In the event that users have further inquiries not addressed by the user’s manual, they may contact the administrators at projectmec@gmail.com.

3.2. System Features: Student Side

The following subsections describe the features of the courseware from the perspective of a student-user.

3.2.1. Graphical user interface (GUI)

The courseware features a GUI that was customized to follow the color theme of the College.

3.2.2. User accounts management

For first-time users, they have to register initially before being able to log-in the courseware. After being activated by the teacher, the student may log-in and modify his password. After being enrolled in the course by the instructor-in-charge, the student may then go to “MY COURSES” block to take a course, begin to take lessons, and answer quizzes.

3.2.3. Personal records management

Students have access to the list of lessons they have taken and yet to take, and to scores of their quizzes to monitor their own progress and performance.

3.2.4. Course, lesson and quiz management

After the logging in, the student may go to “MY COURSES” to take a course (i.e. Trigonometry). If the user clicks the “start” button at the bottom, he may begin taking lessons and quizzes in order from first to last. On the upper right portion of the course page, there are blocks including the lesson and a video which the user can choose. The lesson block contains the lessons of the course and has three types, which are as follows: the “Theory” type that only has lesson content with no quiz included (i.e. exercise questions); the “Quiz” type that only contains questions to be answered by the user to test their understanding of the lesson; lastly, the “Mixed” type which is a combination of Theory and Quiz where there may be questions in between the lesson pages or vice versa. Users can only take quizzes, review lessons, and watch videos related to the lessons. When taking a quiz, students may skip a question and return to it afterwards.

3.2.5. Online user’s manual

A user’s manual is available online for reference. In the event that users have further inquiries not addressed by the user’s manual, they may contact the administrators at projectmec@gmail.com.

4. Results and Discussion

The researchers conducted a survey for mathematics teachers (i.e. Trigonometry instructor and other faculty members) and students (i.e. experimental group) to rate the courseware. The courseware evaluation was conducted to measure the satisfaction of the teachers and students with respect to the features and qualities of ProjectMEC. This is similar to the satisfaction survey employed by Angeles et al., Hao et al., and Chua. [11]-[13].

Table 3. Teacher Satisfaction on the Features of ProjectMEC (n=10)

ProjectMEC Features	Mean	Interpretation
Graphical User Interface	3.00	Satisfied
User Accounts Management	2.80	Satisfied
Personal Records Management	3.60	Highly Satisfied
Course, Lesson and Quiz Management	3.30	Satisfied
Online User’s Manual	3.60	Highly Satisfied
Overall mean	3.26	Satisfied

Generally, teachers (including the instructor for Trigonometry) were satisfied with the features of ProjectMEC. It is worth noting that User Accounts Management scored lower because of the enrolment procedure into courses. Some teachers suggested that the enrollment into courses should be based on codes (or keys) provided by the instructors, similar to the one employed by Edmodo [14]. Hence, this eliminates the need to manually enroll students who have applied to the online course. Having taken this suggestion into consideration early on, the researchers did not manage to find a workaround into the enrollment issue within the prescribed period of time.

Table 4. Student Satisfaction on the Features of ProjectMEC (n=13)

ProjectMEC Features	Mean	Interpretation
Graphical User Interface	3.00	Satisfied
User Accounts Management	3.46	Highly Satisfied
Personal Records Management	3.53	Highly Satisfied
Course, Lesson and Quiz Management	3.27	Satisfied
Online User’s Manual	3.07	Satisfied
Overall mean	3.27	Satisfied

Participants of the experimental group are generally satisfied with the courseware features, especially with that of having their own student accounts and performance records.

Table 5. Conformity to Standard of the Qualities of ProjectMEC as Rated by Teachers (n=10)

Qualities	Mean	Interpretation
Accuracy	3.50	Very Good
Aesthetics	3.40	Very Good
Efficiency	3.20	Good
Functionality	4.20	Excellent
Learnability	4.20	Excellent
Operability	4.30	Excellent
Readability	4.70	Excellent
Reliability	4.40	Excellent
Robustness	4.20	Excellent
Overall mean	3.99	Very Good

The teacher-respondents generally found the qualities of ProjectMEC very much conforming to standards set by the School of Information Technology Education. Of the nine qualities listed, Efficiency scored lowest. This was echoed in the comments provided by the teachers: that despite the straightforward and easy-to-use nature of the lesson upload and deletion processes, the limitation that ProjectMEC only accepts PDF's for lessons reduces time-efficiency. Nevertheless, they praised the functionality of ProjectMEC as being faithful to the purposes it was tasked to do, and that the inclusion of a formula editor plugin truly saved a lot of time and effort.

Table 6. Conformity to Standard of the Qualities of ProjectMEC as Rated by Students (n=13)

Qualities	Mean	Interpretation
Accuracy	4.23	Excellent
Aesthetics	4.30	Excellent
Efficiency	4.15	Very Good
Functionality	4.22	Excellent
Learnability	3.92	Very Good
Operability	4.00	Very Good
Readability	4.00	Very Good
Reliability	4.00	Very Good
Robustness	3.69	Very Good
Overall mean	4.06	Very Good

The student-respondents generally perceived the qualities of ProjectMEC as conforming to standard, with Learnability and Robustness garnering lower scores than the others. From the feedback the students provided, the researchers gathered that they felt the learning curve was quite on the difficult side, thus some recommended removing icons or features provided by Opigno but not implemented in ProjectMEC. On the other hand, some commented on the quality of Internet connection (an external factor to the study), thus leading to a lowered score for the Robustness.

Table 7. Comparison of Test Scores of Courseware and Non-Courseware Users

	Experimental Group	Control Group
Number of samples	13	13
Mean	30.61538	33
Variance	250.7564	205
Standard Deviation	15.83529	14.31782
t-score	0.386939	
p-value	0.702211 > 0.05	

The Trigonometry instructor administered a 50-point long quiz covering the following topics: Trigonometric Identities, Inverse Trigonometric Functions, and Exponents and Logarithms. The

experimental group (i.e. courseware users) had a month to access the online courseware to prepare for the long test. The scores of courseware and non-courseware users, 13 each, were statistically treated using Student's t-test (difference of two means) at 0.05 level of significance via Microsoft Excel. The null hypothesis is set as the means of the test scores of both groups having no difference.

Since the p-value 0.702211 is greater than 0.05 (the level of significance), there is insufficient evidence to show that the means are different for the two groups. Hence, the null hypothesis is not rejected; the performance of both groups do not differ from each other. The same result was obtained from iMath [7]-[12], wherein students who were exposed to both courseware and traditional method of teaching did not exhibit any performance difference with those who were only exposed in the latter. Moreover, Janier, Shafie and Ahmad [9] also had similar results wherein both experimental and control groups did similarly well in the posttest administered. A possible reason is that the exercise content of ProjectMEC was also administered to the non-courseware users in printed form. This was allowed by the research group so as not to be detrimental to the learning opportunities of the control group.

5. Conclusion and Future Works

ProjectMEC generally received favorable feedback both from teachers and students for its features and qualities. Despite both experimental and control groups having no difference in their test performance, the result not only shows the courseware as an alternative medium of learning, but also emphasizes the role of the teacher (at least in teaching mathematics). It is suggested that future studies applying a similar approach with ProjectMEC expose the experimental group to the courseware only, without the possibility of external factors influencing the results of the study. Moreover, it is recommended that ProjectMEC fully make use of the features Opigno offer, such as forums, thereby extending its capabilities towards a learning management system for mathematics. Furthermore, student modelling may be applied to gauge the knowledge and skills of the student-participants prior to development of the courseware.

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