I CAN READ MATHEMATICS BUT I CANNOT WRITE MATHEMATICS

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Abstract

Developing educational technology improves the student learning environment and pedagogical methods. Online homework systems such as WebAssign, Mymathlab, and WeBWork help undergraduate students improve their learning in math because of prompt feedback, accessibility, supplemental explanations, and visual materials. Instructors can focus on student progress because of learning management systems on the online homework systems instead of grading homework. Yet most math instructors have concerns that students' writing in math is getting worse and intermediate students still struggle with learning mathematics. Even though writing in math is an essential component to develop conceptual understanding of content in the learning process, students have limited opportunities to improve their writing in math through the online homework systems, visual materials, and lecture-centered learning. For example, students just learn the math techniques through online homework systems. As passive learners, they simply listen to lectures and copy instructors' solutions in class. To prepare for exams, students watch review videos or read instructors' notes without writing in mathematics. The purpose of this project is to promote student conceptual understanding of mathematics content, engagement, achievement, and critical thinking through the intensive development of writing in mathematics in blended learning. The use of the educational applications, Google Classroom, Mathist, Mathematics, and GeoGebra, encouraged students to develop writing in math and collaborative learning inside and outside class. Pre-and post-tests, questionnaires, and completion and retention rates were collected in up to four math courses in spring semesters 2019. In blended learning, the results of this project help researchers and instructors study to promote students to be active learners and to deeply understand the mathematical content through a wide range of writing activities utilizing the innovative applications. It provides a valuable solution for developing student writing in math. In addition, this project encourages math faculty to improve their pedagogical methods using innovative educational technology, and faculty in mathematics and English to conduct collaborative research regarding the relationships between writing in mathematics and writing in English.

Introduction

Colleges and universities have applied digital technologies to improve student teaching and learning environments according to the development of educational technology. Math instructors have adopted online homework systems because of instant feedback, effective interactions with students, and analysis of student learning in progress. In addition, students are able to watch videos for reviews at any time and anywhere through

their class learning platforms. Yet math instructors have concerns that students in math class still struggle with understanding concepts of content and improvement of critical thinking. Student mathematics writing is getting worse every year. To enhance student learning and engagement through a wide range of learning activities in class, researchers have suggested blended learning as an innovative approach. Blended learning refers to the combination of face-to-face and online instruction. For example, students in blended learning learn in a face-to-face classroom and through online delivery at the students' own pace. Gecer and Dag (2012) indicate that blended learning is a more effective pedagogy than purely face-to-face instruction or purely online instruction for students, who are accustomed to technology. Therefore, more and more instructors in colleges and universities have used blended learning utilizing educational technology.

Writing in math is a vital tool in the learning process as all other disciplines have been a key part of learning, however, writing in mathematics is different and isolated from the learning process of other disciplines, such as history or English. Streeks (2007) describes "expository writing" as writing to describe and explain mathematical ideas. The improvement of expository writing helps students develop their writing literacy skills in general. Through writing in math, students have more opportunities to find where theorems or formulas are coming from and how those are applied (Wilcox and Monroe, 2011). In addition, math writing promotes students to connect new concepts and learned materials (Wilcox and Monroe, 2011). Thus, writing in math is essential in the growth of students' mathematical abilities and of conceptual understanding of content in all subjects.

The purpose of this project is to promote student conceptual understanding of mathematics content, engagement, achievement, and critical thinking through the intensive development of writing in mathematics in blended learning. To promote students' writing in math, this project adopted the educational applications of Google Classroom, Mathist, Mathematics, and GeoGebra. The integrated use of the applications, Google Classroom, Mathist, Mathematica, and Geogebra, make students be interested in math writing and new content. **Google Classroom** is a blended learning platform that aims to simplify creating, distributing, and grading assignments in a paperless way. Students can submit their work to their class folders using mobile apps, available for IOS and Android devices. Google Classroom allows instructors to monitor the progress for each student and return work with comments after being graded. In addition, students and instructors can use all Google applications. **Mathist** is a touch-optimized application for writing math notes and expressions. It has strong social integration by connecting students' classmates through social networking systems. In addition, Mathist allows students to share their notes, ideas, and solutions, and comment on other people's work. **Mathematica** is a mathematical symbolic computation program. **GeoGebra** is an interactive mathematics software program for learning and teaching mathematics as an application for geometry, algebra, statistics, and calculus. Mathematica and Geogebra encourage students to correct their solutions by themselves because these interactive programs guide them to have the right equations or expressions and instantly show their results with dynamic graphs. The writing activities with the applications inside and

outside class enhanced their conceptual understanding of content and engagement. In class, they wrote their solutions on tablets with tablet pens using Mathist, checked and saw their solutions with dynamic graphs, and immediately share and discussed their results on the SmartBoard.

Methods

This project were conducted in spring 2019. It employed three data: 1) pre- and post-tests to measure students' achievements, 2) questionnaires, and 3) completion and retention rates. The data were collected from two sections for College Algebra with support for College Algebra and Calculus I at the University of North. The participants completed questionnaires consisted of 7 questions for background and 7 questions for engagement and learning at the end of the semester. To analyze the quantitative date, two sample t-tests with significance level of 0.5 were conducted.

To enhance writing activities in class, students watched assigned approximately 10-minute preview lecture videos through Google Classroom outside of classrooms. After a 15-minute lecture in class, students had problems through Google Classroom as groupwork in class. They wrote their solutions using Mathist on tablets and immediately check their answers with dynamic graphs utilizing Mathematica or Geogebra. One or two selected groups presented their solutions on the SmartBoard since Google Classroom allows students to promptly share their solutions. Instructors assigned the remaining non-multiple choice problems on Google Classroom in order to keep students engaged in learned materials outside of classrooms. After the deadline of submissions, instructors posted correct solutions on the platform and wrote similar non-multiple choice problems on exams.

Results

Students received better grades in a post-test than their grades in a pre-test except students in calculus I. Even though the mean of the pre-test grade of students in calculus I was decreased from the post-test grade of them, the students' passing rate is extremely high because they maintained their grades of all exams. Most students were completed with their courses, 93% in college algebra, and 100% in calculus I (Table 1).

Table 1. Comparisons between previous courses and the projected courses				
	Regular College Algebra in fall 2015	Projected College Algebra in spring 2019	Regular Calculus 1 in fall 2015	Projected Calculus I in spring 2019
Number of students	22/24	26/28	26/27	22/22
Pre-test	73%	69%	81%	87%
Post-test	72%	78%	79%	78%
Retention rates	92%	93%	96%	98%

From the qualitative data, this project significantly improved student writing in math and conceptual understanding in mathematics (Table 2, #1, 2, and 3). Students had a number of opportunities to explore the other students' solutions and correct their work in math writing (Table 2, #4, 5, and 6.) About 84% of students were satisfied with the writing math activities using technology.

Table 2. Results-questionnaire for student engagement and learning in mathematics	
1) How writing activities encouraged you to participate in solving problems or activities?	A lot : 69% A moderate amount: 31%
2) How helpful is writing math activities to learn materials?	Extremely helpful: 38% Very helpful: 62%
3) How much did writing math activities help your understand class materials?	Extremely helpful: 23% Very helpful: 54%
4) Have you corrected your writing in math because of the writing math activities?	Extremely often: 23% Very often: 46%
5) How much did writing math activities help your writing skills in math?	Extremely helpful: 31% Very helpful: 46%
6) Overall, are you satisfied with the writing math activities in class?	Very Satisfied: 69% Somewhat satisfied: 15%

Conclusions

From the results of this study, this project was that the integrated use of innovative technologies for developing writing in mathematics and pre-existing educational technology enhanced student conceptual understanding of mathematical content, learning, achievement, and critical thinking. In addition, this project transformed lecture-centered learning to student-centered learning and increase student engagement and interest in the mathematics content. Students could write their solutions on tablets, check their results with dynamic graphs, and immediately share their solutions and ideas inside and outside class using the innovative applications for developing writing in math. Moreover, this project encouraged students to learn math and concepts that come up with techniques, not just to learn techniques.

Therefore, this project provided more opportunities for students to experience peer-tutoring and collaborative learning, and to improve their learning and achievement in innovative learning environments because of the integrated use between pre-existing educational technology and the applications for developing writing in math. Math faculty has chances to be introduced to the innovative applications for writing in math and to improve their pedagogical approaches regarding writing in math utilizing technology. In addition, the results of this project encouraged mathematics and English faculty to conduct collaborative research since developing writing in math is connected to developing writing in English.

Reference

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