Extent of Technology Integration in Mathematics Teacher Education Among State Institutions in Central Luzon

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Abstract

This paper reports the findings of a study which explored how ten state teacher education institutions in Central Luzon, Philippines implemented technology integration in mathematics classes in the Bachelor of Secondary Education – Mathematics (BSEd-Math) Curriculum for pre-service mathematics teachers. Descriptive survey data from teacher education supervisors, mathematics teacher educators (MTEs), and students were collected through questionnaires, interviews, classroom observations and related documentary sources. The MTEs reported high levels of technological pedagogical content knowledge (TPACK) as well as common reasons for integrating technology in their BSEd-Math classes. They typically indicated frequent use of scientific and graphing calculators, spreadsheets and graphics software, and the Internet but seldom use of computer algebra systems in their classes. The t-test indicated contrasting results for supervisors' and students' perceived mean ratings for MTEs' extent of technology integration. Nevertheless, the corresponding ratings validated the MTEs' extent of technology integration, which correlated positively and significantly with their level of technological pedagogical content knowledge (TPACK).

Keywords:

Technology integration, Mathematics, Teacher education, TPACK

Authors' Notes

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Introduction

We are living in a world of fast-changing environments, technologies, and social conditions. More than ever, schools and teachers have a critical role in preparing the future citizens of a global society in our rapidly-changing world. In the Philippines, the recent implementation of the K to 12 Basic Education Program as well as the fast-approaching regional integration under the ASEAN Economic Community (AEC) demands a great deal of curriculum innovations. High school mathematics teachers in particular need to adapt to the changes in the mathematics curriculum, including integration of technology. Teacher education institutions in the country, therefore, have to make their curricular program offerings responsive to these developments in basic education (TPTE, n.d.). In the process, they are also complying with the Memorandum Order issued by the Commission on Higher Education (CHED) under the Office of the President of the Republic of the Philippines on the Revised Policies and Standards for Undergraduate Teacher Education Curriculum (CMO 30, s. 2004).

This study explored how the ten state teacher education institutions in Central Luzon (Region III, Philippines) implemented technology integration in the Bachelor of Secondary Education – Mathematics (BSEd-Math) Curriculum for pre-service mathematics teachers. Integrating technology in mathematics classes is one of the innovations specified in the course description of each suggested mathematics subject in the CHED model curriculum. Technology integration in the context of mathematics education refers to the application of calculators, computer hardware and software, the Internet, and related information and communication technologies in teaching and learning mathematics.

The study aimed to determine the extent of technology integration in mathematics classes handled by the mathematics teacher educators (MTEs) in the BSEd-Math Curriculum offered by the state universities and colleges in Central Luzon. Specifically, it sought answers to the following questions:

1. What is the level of TPACK of the MTEs handling mathematics classes in the BSEd-Math curriculum?
2. For what reasons do the MTEs use technology in their mathematics classes?
3. What technologies do the MTEs use in their mathematics classes?
4. How frequently do the MTEs integrate technology in their mathematics classes?
5. Do the MTEs, supervisors and students differ in their perceived extent of technology integration by MTEs in BSEd-Math classes?
6. Is there a relation between MTEs' level of TPACK and use of technology integration in BSEd-Math classes?

Methodology

A combination of qualitative and quantitative approaches was used in this mixed-methods research study. Descriptive survey data were collected from 37 MTEs handling mathematics subjects in BSEd-Math. Data also came from the interview questionnaire for 32 students selected purposively from year levels with mathematics specialization subjects, and from classroom observations by 6 administrators who observed BSEd-Math classes of 21 mathematics educators, and related documentary sources. The content-validated research instruments, tried out in two satellite campuses of a multi-campus state university in Region III, consisted of survey questionnaires with 5-point rating scale items and open-ended questions, interview questionnaires, and a classroom observation checklist.

Permission from the heads of agencies, colleges and departments as well as consent of respondents was obtained before the actual data gathering -- survey, interview, classroom observation, and relevant documents. Rating scales, modified and adapted from existing instruments with established reliability, were also subjected to reliability analysis. Data from respective groups of respondents and from various sources were triangulated to establish the credibility of responses and authenticity of the information.

Qualitative data were coded using appropriate rubrics for quantitative treatment. Descriptive statistics were used to summarize and analyze the quantitative and coded data. The t-test was used to test for significant differences between pairs of group mean ratings. Qualitative data from various sources

Table 1. Means and Standard Deviations of Mathematics Teacher Educators' Self-Ratings for Technological Pedagogical Content Knowledge

TPACK Indicator	*Mean*	*SD*
I choose technologies that enhance my teaching approaches.	3.78	0.85
I choose technologies that enhance my students' learning.	3.70	0.85
I think critically about how to use technology in my classroom.	3.76	0.83
I adapt the use of technologies to different teaching activities.	3.70	1.02
I use technology for understanding and doing math.	3.73	0.84
I am able to teach lessons that combine math, technologies and teaching approaches.	3.70	0.85
I am able to select technologies to enhance what I teach, how I teach and what students learn.	3.65	0.92
I use strategies that combine content, technologies and teaching approaches.	3.70	0.97
I am able to help others about effective integration of technology in teaching math.	3.65	0.92
I easily cope with changing technologies in teaching math.	3.54	0.96
Overall Rating for Technological Pedagogical Content Knowledge in Mathematics	3.69	0.79

Table 2. Mathematics Teacher Educators' Frequency of Use of Technology Integration

Technology in Mathematics	*Mean*	*SD*
Scientific and Graphing Calculators	2.69*	1.32
Computer Algebra Systems	1.91**	1.40
Spreadsheets and Graphics	2.71*	1.43
Internet & Web Technologies	2.86*	1.44
Overall	2.54*	1.11

*Note: * sometimes or often ** seldom*

were subjected to critical content analysis to explore the extent of technology integration from the three groups of stakeholders. Pearson correlation coefficient was computed to assess relationship between MTEs' level of TPACK and use of technology integration. The SPSS software was used to facilitate tabulation, analysis and interpretation of quantitative data.

Results and Discussions

Considered essential in technology integration in the classroom is the teacher's level of TPACK, a framework for understanding the kinds of knowledge (content, pedagogy, and technology) needed by a teacher for effective pedagogical practice in a technology enhanced learning environment. Table 1 shows a summary of the MTEs' responses to the 10 5-point self-rating scale items adapted from the TPACK Survey (Schmidt et al., 2009).

On a scale of 1 to 5, with 5 as the highest, the computed average ratings in the individual and combined items of the TPACK questionnaire are between 3.5 and 3.8 which indicate that the MTEs consider the descriptions of the TPACK items to be typically true of them. Hence, the MTEs consider themselves to be highly knowledgeable about content, pedagogy and technology considerations in integrating technology in teaching mathematics. The computed Cronbach alpha coefficient (α = 0.9645) indicates very high reliability of responses to the TPACK items.

Asked about their purpose for integrating technology in their BSEd-Math classes, a number of mathematics teacher educators indicated various reasons. A total of 31 (84%) indicated numerical computation, 26 (70%) graphical presentation, 25 (68%) interactive learning, 23 (62%) tabular presentation, and 22 (60%) symbolic manipulation.

Specifically, they indicated that they have used the following technologies in their mathematics classes at any part of a given term: graphing calculators (71%), computer algebra systems (37%), spreadsheets and graphics software (66%), and the Internet (66%). However, there were also those who had not integrated technology in any of their mathematics classes, especially computer algebra systems (63%).

The mathematics teacher educators were also asked to indicate how frequently they integrated technology in their mathematics classes in the BSEd-Math curriculum. Responses were coded (1 for "Never" to 5 for "Always") and descriptive statistics such as mean and standard deviation were computed from the coded responses. Table 2 shows the computed means and standard deviations for mathematics educators' frequency of use of technology integration. With computed means between 2.5 and 3.0, the teachers typically indicated that they sometimes or often use technology in their mathematics classes such as scientific and graphing calculators, spreadsheets and graphics, and the Internet. Exception, however, are computer algebra systems which teachers indicated they seldom use in their classes.

The teachers were also asked to indicate what best characterizes their participation and of their students in the use of technology in their BSEd-Math classes. A total of 25 (68%) allow students to use technology during their mathematics classes while 23 (62%) indicated that, together, the students and the teachers make use of technology during their mathematics classes. However, 15 (41%) demonstrate use of technology in class but let students practice outside the class while 12 (32%) encourage their students to use technology but not during their class. Only two (5%) indicated that they and their students do not use technology in their mathematics classes.

Students' Perception about Technology Integration in Their Mathematics Classes

Responses of the students generally indicated that mathematics teacher educators frequently use scientific calculators in their mathematics classes. However, corresponding average ratings by students indicate that mathematics teachers very seldom use graphing calculators (M = 1.47, SD = 0.98) and computer algebra systems (M = 1.28, SD = 0.58). They, however, indicated that teachers seldom use spreadsheets and graphics software (M = 2.31, SD = 1.26) and the Internet (M = 2.44, SD = 1.44), in their mathematics classes. Overall, the students indicated that mathematics teacher educators seldom use technology integration (M = 2.08, SD = 0.84) in their mathematics classes.

The t-test for independent-group means indicated no significant difference between the mean ratings of students and their mathematics teacher educators on the use of technology integration in their mathematics classes (t = 1.91, df = 67, p = 0.061). Nevertheless, students' responses validated that their teachers do not always use technology integration in the classroom. When students were asked to describe how much they have learned from mathematics instructors/professors who integrated technology in their mathematics classes, they came up with a variety of answers. A total of 23 (72%) indicated that they had learned much while three (9%) have not learned much. Six (19%) have not learned at all because their teacher did not integrate technology in their mathematics classes.

The following responses by students indicate that they have learned much from their mathematics teachers who integrated technology in their mathematics classes from motivation to various phases of the teaching-learning process. According to one student, integration of technology in their mathematics class helps them to be motivated because "mode of instruction is more simplified and clear. It arouses our interest to learn more."

Some students said they learned a lot from the use of scientific calculator, spreadsheets and other mathematical software to websites and other ICT-based resources and applications in the Internet. As one student said, "I've learned quite well. The use of scientific calculator simplifies the work so we learn easier." Another student related, "When we are using technology we see the application of what we have learned." One student shared: "I learned techniques, concepts and other methods in solving mathematical problems with the integration of technology and I found out that it is easier when technology is integrated." One student found "gold" in exploring: "I learned a lot about math software and websites because they make me and other students explore our topic."

Some students were fascinated with the use of technology in actual teaching. According to one student, "I've learned a lot most especially in using ICT-based presentation in teaching." Another student said, "It can help me as a future teacher. That's why I have learned a lot." And another concluded: "Through integration of technology learning math became more interesting and lively." One student simply said, "So far, with a math instructor who integrated technology in my math class, I'm learning the lessons very well."

For other students, use of some technologies in their mathematics classes limits their capacity to learn that they prefer traditional teaching with occasional use of technology. One student asserted: "Actually I prefer the discussion without integrating technology . . . somehow using [slide] presentation, for example, makes the students passive." But for another student, "Sometimes it depends upon the topic that they are discussing. Although they don't use technology more often except the calculator, we still learn from them." One student even said, "It is better to use the traditional method especially in step-by-step solution, the chalkboard is more effective for us than PowerPoint presentation."

Others, however, lack the opportunity for technology integration in their mathematics classes. Two students shared that their instructors are not using technology integration during math classes. Another asserted: "Our teachers only use the traditional way of teaching." One reasoned that "Instructors did not integrate technology during math classes because of lack of facilities and support from the administration." But one student claimed: "Honestly we lack integrated technologies but the ability and knowledge of our instructors is enough for us to learn and to understand every lesson." Another also remarked, "Even though the instructors did not integrate technology in math classes, I learned more from them compared to our high school teachers."

Problems met by students related to technology integration in mathematics subjects in the BSEd-Math curriculum include inadequate resources such as graphing calculators and limited access to Internet and web technologies. For effective teaching and learning of mathematics subjects in the BSEd-Math curriculum, students gave the following suggestions:

- "Technologies must be used in actual teaching. These may help the teachers to do their work more easily and the students to learn easily and quickly."
- "Math instructors must often integrate technology in their discussions. It will be more effective than traditional methods of teaching math."
- "Teachers should use technology in delivering the lessons so that students can adapt and know how to present the lesson using technology."
- "Use more advanced technology that will help to mold us to be globally competitive math teachers in the future."
- "Instructors will be more effective if the administration will provide and support the facilities and equipment needed in any subject especially integration of technology."

Classroom Observations

Mathematics teacher educators have demonstrated the use of technologies in their mathematics classes as reported by administrators who observed classes in the BSEd-Math curriculum. A total of 21 MTEs were observed by administrators in their respective mathematics classes in the BSEd-Math curriculum. Using a Classroom Observation Checklist, the MTEs were rated from 1 (not observed) to 5 (very much observed) based on their observed use of technology in their mathematics classes. The last part sought over-all impressions and observations about the teachers, the students, and the lessons.

Based on the administrators' observations of mathematics classes of the 21 mathematics teacher educators, equivalent scores were determined from the corresponding ratings on the observed indicators. Generally, mean ratings for the use of technology ranged from 2.95 to 4.0. According to the administrators, mathematics teachers demonstrated much use of slide presentations (M = 4.0, SD = 0.55) but moderate use of Internet and web technologies (M = 3.44, SD = 0.62), scientific and graphing calculators (M = 3.29, SD = 1.10), electronic spreadsheets (M = 3.19, SD = 1.03), and computer algebra systems and mathematical software (M = 2.95, SD = 1.20). Overall, use of technology integration by mathematics teacher educators was moderately observed (M = 3.44, SD = 0.58).

Results of the t-test led to the rejection of the null hypothesis of no significant difference between the mean ratings by administrators and by mathematics teacher educators for use of technology in the mathematics classroom (t = 3.95, df = 53.286, $p < 0.01$). Hence, the administrators' mean ratings significantly surpassed the mathematics teachers' self-reported mean ratings.

Moreover, the administrators had very good remarks about their overall impressions and observations about teachers, students and lessons in BSED mathematics classes that they had observed:

- "There is evidence of planning. Activities are organized."
- "The teacher utilized inquiry-based approach in teaching, used variety of activities related to the lesson."
- "The teacher is very knowledgeable about the use of computer software related to what she is teaching."
- "The teacher has mastery of the lesson and made use of technology in teaching."
- "Students show willingness to learn. They are participative."
- "They listen attentively and participate in classroom activities."

These observations and impressions about the teachers, the students and the lessons complemented the corresponding ratings of administrators for the observed use of technology integration by mathematics teacher educators in their mathematics classes in the BSEd-Math curriculum. Somewhat expected, the MTEs seem to perform better in the presence of their supervisors thinking that the observations would be used in evaluating their teaching performance.

Relation between MTEs' Level of TPACK and Use of Technology Integration

Using Pearson correlation coefficient, the MTEs' level of TPACK had a moderate positive but significant linear correlation with extent of technology integration in mathematics classes (r = 0.50, df = 35, $p < 0.01$). This implies that the higher the MTEs' level of TPACK, the more frequently they use technology integration in the mathematics classroom. Somehow, correlation analysis validated the MTEs' typically high levels of technological pedagogical content knowledge, but occasional use of technology integration in their mathematics classes.

Conclusions

The following conclusions were drawn based on the results and findings of this quantitative-qualitative study:

1. The MTEs handling mathematics classes in the BSEd-Math curriculum have high levels of TPACK.

2. The MTEs make use of technology in their mathematics classes for numerical computation, graphical presentation, interactive learning, tabular presentation, and symbolic manipulation.

3. Graphing calculators, computer algebra systems, spreadsheets and graphics software, and the Internet are the technologies used by the MTEs in their mathematics classes.

4. Typically, the MTEs sometimes or often use technology in their mathematics classes. They seldom use graphing calculators and computer algebra systems but sometimes or often use spreadsheets, graphics software and the Internet.

5. The MTEs' self-reported use of technology integration differed significantly with the supervisors' but not with the students' perception. Categorically, however, the

ratings provided some support for the MTEs' extent of technology integration in their mathematics classes.

6. There is a significant positive relation between MTEs' level of TPACK and use of technology integration in BSEd-Math classes.

Recommendations

This qualitative-quantitative study was able to describe the extent of technology integration in mathematics classes by mathematics teacher educators. However, further analyses in a more in-depth study could be done to explore other underlying factors that influence the teachers' use of technology integration in the classroom.

The study should be validated in more teacher education institutions and other higher education institutions in the different regions in the Philippines. Other studies on technology integration, with a more comprehensive scope and not only in mathematics but also in other courses and disciplines, could be conducted in order to come up with a general statement about the status of implementation of technology integration in teacher education institutions and other higher education institutions in the country.

Follow-up studies on technology integration could look further into the policies and interventions such as professional development opportunities for faculty and staff, involvement and participation of stakeholders, provision and upgrading of facilities and resources, as well as strengthening linkages and collaboration with government agencies, other institutions and partners in the industry.

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