Universal Journal of Educational Research 8(10): 4692-4699, 2020 http://www.hrpub.org
DOI: 10.13189/ujer.2020.081038

Examining Indonesian Secondary School Mathematics Teachers' Instructional Practice in the Integration of Technology

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Received June 24, 2020; Revised August 10, 2020; Accepted August 25, 2020

Cite This Paper in the following Citation Styles

(a): *[1] Mailizar Mailizar, Lianghuo Fan , "Examining Indonesian Secondary School Mathematics Teachers' Instructional Practice in the Integration of Technology," Universal Journal of Educational Research, Vol. 8, No. 10, pp. 4692-4699, 2020. DOI: 10.13189/ujer.2020.081038.*

(b): *Mailizar Mailizar, Lianghuo Fan (2020). Examining Indonesian Secondary School Mathematics Teachers' Instructional Practice in the Integration of Technology. Universal Journal of Educational Research, 8(10), 4692-4699. DOI: 10.13189/ujer.2020.081038.*

Abstract The Indonesian secondary school mathematics curriculum advocates the use of technology in teaching and learning of mathematics. The previous studies paid less attention to what type of digital tools that the teachers used and how they integrated them in the mathematics teaching. This study aimed at investigating Indonesian secondary school mathematics teachers' instructional practices in the integration of digital technology in classrooms and examined differences in teachers' instructional practice according to their background. It employed a quantitative approach whereby were collected through a questionnaire survey. The data were gathered from 341 mathematics teachers in 93 secondary schools. This study suggested that the integration of digital technology has emerged in Indonesian secondary school mathematics classrooms. However, it was also found that most of the teachers did not use the technology in constructive ways. The result also revealed that female teachers have better instructional practices in the use of digital technology than male teachers. In addition, teachers' levels of education play an important role on their instructional practices with digital technologies. This study suggests that it needs a radical improvement of the integration of technology in Indonesian secondary school mathematics classrooms in order to achieve the curriculum objective. Therefore, further research and development on this issue is needed in the country.

Keywords ICT in Teaching, Teacher Classroom Practice, Indonesian Mathematics Education, Technology in the Mathematics Classroom

1. Introduction

According to Mailizar, Manahel [1], in 1984, the Indonesian government introduced the first curriculum that stipulated the integration of modern technologies into teaching and learning of mathematics. Furthermore, the Indonesian current curriculum stipulates the integration of digital technology in the teaching and learning process. It is revealed in the curriculum document: "In order to improve the effectiveness of teaching and learning, schools should promote the integration of technology such as computer and other media (p. 397)".

Previous studies [2, 3] indicate technology integration in the classroom is a complex process and does not depend only on technology-related factors. Technological tools such as computer and tablets, do not direct teachers' pedagogical approach [4]. This is in line with Hardman [5] and Jackson [6], arguing that the impact of technology use in teaching depends on teachers' pedagogical practices.

Ottenbreit-Leftwich, Kopcha [7] conducted a literature review and revealed that teachers, integration of technology has been investigated in various ways such as the frequency use of technology and student-centred and teacher-centred teaching practices with technology. In mathematics education, a number of studies have also been carried out around the world aimed at investigating the use of technology in teaching of mathematics emphasizing at different aspects such as teaching approaches [e.g., 8, 9] and types of technologies [e.g.,10, 11-14]. Other researchers examined pedagogical approaches in the use of technology [e.g., 14, 15, 16-22]. Also, previous studies have also measured the frequency of technologies use in the mathematic classroom [e.g., 8].

A limited number of studies have investigated the integration of digital technologies in mathematics classrooms in Indonesia. Most of them are part of international studies [e.g., 23, 24]. Mullis, Martin [23], for instance, showed that 16% of students in Indonesian secondary school had access to digital tools in mathematics classrooms. In 2011, Mullis, Martin [24] revealed that the number had increased significantly that 87% of mathematics at least one computer for at least one student. They also revealed Indonesian mathematics teacher's frequency use of computers for exploring principles and concepts of mathematics and searching information and idea. However, the previous studies on Indonesian secondary school mathematics teachers' integration of digital technology paid less attention to what type of digital tools being used and how the teachers integrated them in mathematics classroom. For example, Mullis et al.'s [24] study did not reveal pedagogical activities regarding the integration of digital technology. In addition, there has been no study in Indonesian that uses Pierce and Stacey's (2010) Mathematics Analysis Software (MAS) pedagogical map to advance our understanding of the teachers' instructional practice in the integration of digital technology.

This study aimed at investigating Indonesian mathematics teachers' instructional practices in the implementation of digital technology and examining their instructional practices based on to their background. Hence, we sought to respond to these research questions:

1) To what extent do Indonesian secondary school mathematics teachers integrate digital technology in their classrooms?
2) Is there any significant difference in Indonesian secondary school mathematics teachers' instructional practices in the integration use of digital technology according to their demographic background?

2. Conceptual Framework

The effectiveness of technology integration in the teaching and learning process depends on teachers' instructional practices [25]. Further, it also depends on how teachers select and manage resources of technology into their classroom activities as what instructional strategies they integrate in the classroom. Secondary school teachers' integration of technology has been investigated in many countries in which researchers looked at various aspects of the integration and employed different conceptual frameworks to understand it.

Previous studies have used various framework and approaches to understand teachers' use of digital technologies. The frameworks that have been used such as the *student-centred and teacher-centred* [e.g., 8, 14, 18, 19]; the *Learning with and Learning from* [e.g., 17]; *routine*, *extended* and *innovative* user [e.g., 15]. Regarding studies of mathematics teacher of the technology, Pierce and Stacey [26] proposed *the pedagogical map of MAS* framework explaining instructional opportunities offered by MAS. MAS is software that users can conduct many activities such as arithmetic calculations, statistics calculations, data visualization, algebra manipulations. Pierce and Stacey [26] structured three level of the pedagogical map of MAS, namely, the tasks level, classroom level and subject level.

In this study, we adapted Piece and Stacey's [26] pedagogical map to explain the mathematics teachers' instructional practices in the integration of digital technologies in the classroom. This framework provides relatively comprehensive aspects to examine technology integration in mathematics classrooms. Therefore, we investigated two aspects, namely, type of technologies and functional and pedagogical activities.

3. Methods

3.1. Design of the Study

We used a quantitative approach with the cross-sectional survey design. According to Creswell [27], the survey can be used to collect data concerning participants' opinions, perceptions, and practices. Hence, in this study, we collect data on instructional practices of Indonesian secondary school mathematics teachers in the integration of digital technology.

3.2. Participants and Settings

We employed a stratified random sampling technique to draw a representative sample as the technique increases data representative [28]. To acquire a large sample size, we distributed the questionnaire in 93 Schools from 16 regencies/cities. A total of 355 questionnaires were filled, and 14 of them were incomplete. Therefore, it left 341 questionnaires for the analysis. Participants' demographic backgrounds are provided in Table 1.

Table 1. Demographic profile of participants

Demographic Profile		Frequency (Percentage)
Gender	Male	213 (62.6%)
	Female	128 (37.4%)
Teaching Experience (Year)	Over 30	58 (16.9%)
	21-30	93 (27.2%)
	11-20	76 (21.9%)
	6-10	82 (24.6%)
	1-5	32 (9.5%)
Education	Master	29 (8.6%)
	Bachelor	310 (90.8%)
	Post-Secondary	2 (0.6%)

3.3. Research Instrument

In this study we developed a questionnaire for the conceptual framework and existing studies. As mentioned earlier, regarding teachers' instructional practices, we looked at types of technologies and teachers' classroom activities with technologies We developed a survey instrument to investigate the type of digital tools being used, and instructional activities with ICT. Some survey items were adopted from Law, Pelgrum [16]. All survey items were scored in a 5-point scales from 1 = never to 5 = always.

3.4. Reliability and Validity

To assess reliability of the questioner, we used the internal consistency reliability. The inter-item correlation was examined through coefficient of Cronbach's alpha [29]. The data showed a high alpha coefficient of .968. In terms of the validity of the questionnaire, we evaluated the construct validity. Furthermore, we employed the confirmatory factor analysis to assess whether the items measure the construct accordingly. According to Muijs [29], factor loadings can show a correction between items and the overall factor. Results of this analysis produced .924 of the scale values, which fell into the range of being superb. Eigenvalues of all the five factors are 18.6, 2.4, 2.2, 1.4, and 1.1. In addition, 69.6% of the total disparity was described by those factors. In addition, Factor loadings for this scale ranged from .490 to .786, .492 to .868, .660 to .778, .462 to .847, and .460 to .742, which indicate high factors loading.

3.5. Data Analysis

We employed analysis descriptive and inferential statistics to analyse the data. s. We calculated means and standard deviations of all the items. Furthermore, we conducted a repeated measure ANOVA as well as a paired t-test to examine differences across survey items. In addition, Kruskal Wallis and Mann Whitney tests were run to examine teachers' instructional practices according to teachers' demographic background.

4. Results

We present results of based on the research questions. First, we provide results of teacher classroom practice which is followed by results of differences in teachers' instructional practices in the integration of digital technology according to their background.

4.1. Description of Teachers' Classroom Practices

The results showed that 67.7% of the participants had at least once used digital technology in their mathematics classrooms. Unfortunately, 47.8% of the participants integrated the technology in 21% to 50% of their mathematics lessons. We present further detailed results on teachers' use of hardware and software, and teachers' functional and pedagogical activities when they used ICT in the classroom as follows.

4.1.1. Teachers' Use Digital Tools

Results of the frequency of secondary mathematic teachers' use of digital tools the classroom are shown in Table 2.

Table 2. Results of teachers' use of digital tools in the mathematics classroom

ICT Use		**Mean**	**Std. Dev.**
Hardware	Handheld Devices	2.5	.99
	Computers	3.4	.81
	Calculators	2.2	1.16
General Software	Word processor software	3.1	1.09
	Presentation software	3.3	.97
	Spreadsheet software	2.7	1.06
	Software of concept mapping	1.7	.89
	3D software	1.6	.80
Mathematical software	Software of Computer Algebra System	1.8	.98
	Software of dynamic mathematic and dynamic geometry	2.1	1.00
	Software of Statistic	1.8	.98
Online Resource	Online teaching resources	2.0	1.06
	LMS	1.8	1.02

We employed the repeated-measures ANOVA to examine differences in teacher's instructional practices. The results showed that teachers' use of hardware ($p = 0.00$) were significant differences across the hardware category. It also revealed their integration of general software ($p = 0.00$) and mathematical software ($p = 0.00$) were significant differences across the mathematical software categories. Furthermore, a paired t-test was carried out to assess differences in teacher's integration of online teaching and learning resources. The results revealed that teachers' use of online resources (p = 0.00) and LMS (p = 0.00) had significant differences.

4.1.2. Functional and Pedagogical Activities with technologies in the mathematics classroom

We also investigated teachers' functional and pedagogical activities when they used digital technology in the mathematic classroom. Survey results of teachers' functional and pedagogical activities with ICT in mathematics classroom are illustrated in Table 3.

We conducted the repeated-measures ANOVA to examine differences of teacher's functional and pedagogical activities with digital technologies. There were significant differences in teachers' functional activities (p = 0.00) with digital technologies. The results also showed significant difference in teachers' pedagogical activities (p = 0.00), mathematics topics being taught (p = 0.00), and tasks being set by the teachers (p = 0.01). Furthermore, in term of teachers' teaching approaches, results of a paired t-test revealed that teachers' use of digital technology to support teacher-centered approach and the student-centered approach was not significant difference with p=0.51.

4.1.3. Teachers' Instructional Practice According to Their Background

We used Mann-Whitney and Kruskal-Wallis tests to assess differences in teacher integration of digital technologies according to their backgrounds. Table 4 and Table 5 present the results of Mann-Whitney as well as Kruskal-Wallis tests respectively. In addition, Table 6 highlights the results from both tests.

Table 3. Results of teachers' activities with digital technologies in the classroom

Activities in the integration of digital technology in the classroom		Mean	Std. Dev
Functional activities	Doing arithmetic activities	3.1	.91
	Drawing and plotting graphs of functions	3.0	1.03
	Solving problems	2.9	1.16
	Constructing diagrams	3.0	1.23
	Doing computation and calculations	2.8	1.16
	Creating 3Dobjects	2.7	1.22
Classroom activities	Giving mathematics classroom instructions	2.8	1.10
	Presenting content of mathematics in the classroom	2.8	1.11
	Conducting assessments	2.3	1.06
	Guiding student in mathematical exploratory and inquiry activities	2.4	1.07
	Providing feedback in learning mathematics	2.4	1.15
	Providing remedial in learning mathematics	2.3	1.13
Teaching approach	Teacher-centred methods	3.0	.90
	Students-centred methods	3.0	.98
Subject	The content of Geometry	2.8	.99
	The content of Calculus	2.5	1.07
	The content of Trigonometry	2.6	1.03
	The content of Algebra	2.6	1.01
	The content of Statistics and Probability	2.8	1.03
Task	Learning pen-and-paper skills	2.5	1.15
	Exploring regularity and variation	2.4	1.10
	Linking representation	2.4	1.08
	Simulating real situation	2.4	1.10
	Using real data	2.6	1.11

Table 4. Results of Mann-Whitney test

Variable	Median of Each Category		P
Gender	Male = 2.0	Female = 3.0	.006

The results show male and female teachers' use of digital technology were statistically significantly different, indicating female (3.0) was better than male (2.0) with p= .006.

Table 5. Results of Kruskal Wallis test

Variables	Values
Education Level	H-Value = 7.1; df = 2; Significant. = .029; Mean Rank = Post-Sec. (53.5); Undergrad. (165.9); and Post-Grad. (202.8)
Teaching Experience	H-Value = 3.0; df = 4; Significant. = .55; Median = 2.0 (1 Years-5 Years); 2.0 (6 Years-10 Years); 2.0 (11 Years-20 Years) (2.0); 2.0 (21-30 Years); 1.0 (Over 30 Years)

The results suggested there were statistically significant differences in mathematics teachers' instructional practices according to gender of the participants and their education level. The teachers with a post-graduate degree had better instructional practices with digital technologies than teachers with other lower level degrees. Moreover, female teachers had better instructional practices with the technologies than male teachers.

Table 6. Summary of the results

Demographic Background	Results
Gender	Significant
Level of Education	Significant
Teaching Experience	Not Significant

5. Discussion

This study investigated Indonesian secondary school mathematics teachers' instructional practices in the integration of digital technology in teaching and learning of mathematics and examined differences in their practices according to demographic background. It was conducted in Indonesian that involved 341 secondary mathematics teachers as participants of the study. The findings of this study show several important points of discussion.

First, this study showed that 68% of the mathematics teachers in Indonesian have at least once used digital technologies in their classrooms yet they use it for the teaching of a limited number of lessons. This indicates a large numbers of secondary school mathematics teachers in Indonesia did not implement the policy on the integration of digital technology and did not fully implement the current curriculum stipulating the integration of digital technologies in the teaching and learning.

Second, the Indonesian secondary school mathematics teachers dominantly used presentation-oriented tools such as PowerPoint. This finding is in agreement with previous studies in other countries [e.g., 10, 11, 14, 18]. It indicates that teachers did not take advantages of the digital tools that are specifically designed for teaching and learning of mathematics. In mathematics classroom, the use of presentation-oriented software such as PowerPoint does not provide many advantages in teaching of mathematics. Presentation-oriented software is not equipped with features that can facilitate students' knowledge construction and support them to work on rich mathematical tasks. Furthermore, this study showed the teachers mostly used GeoGebra software. GeoGebra was the most popular software over other mathematics software because it is free software that has been used widely around the world [see. 30] and accommodates the teaching and learning of a various mathematics topics such as Algebra, Geometry, and Statistics.

Third, doing arithmetic activities and drawing as well as plotting graphs of functions were the two most dominant activities exhibited in the mathematics classroom. The existing literature revealed mathematical graphing software was the earliest computer technologies developed for educational purpose [see 31]. It relates to the finding showing that software that allow users to easily plot graphs was the most frequently used mathematical software. Furthermore, presenting contents of mathematics was another common teachers' classroom activity when they integrate technology. This finding indicates that teachers did not commonly use technologies for conducting constructive activities such as inquiry activities.

Fourth, at classroom level, the teacher-centred approach was more dominant compared to the student-centred approach. This is in agreement with existing studies [e.g., 8, 9, 19, 20, 32], showing that the integration of technology did not support student-centred instruction. Even in developed countries such as England where most of teachers still adopted teacher-centred practices when they used technology [see 14]. At the task level, most of the teachers used digital technologies as a tool for drill and practices. Cavanagh and Mitchelmore [33] argue that drill and practice tasks do not significantly affect students' learning outcomes since they are similar to rote learning exercises. In addition, at the subject level, this study showed that teachers commonly used technologies when they taught and they still approached mathematics topics in traditional ways such as starting a lesson by introducing a concept of mathematics which if followed by showing examples of mathematical problems and assigning students to complete them. This indicates that the mathematics teachers did not take advantages of building metacognition and overview of mathematics topics when they taught them. The literature [e.g., 34] highlights that higher-level thinking may be enhanced through the integration of technology if the teacher takes the opportunity to encourage metacognition and overview in learning of mathematics. Furthermore, the teachers did not change the balance between skills, concepts, and applicationsof mathematics. On the other hand,existing literature has showed that digital technology can help teachers to shift balance from learning facts to support students' argumentation [35].

Fifth, regarding differences in teacher use ICT according to their background, the study revealed that female teachers more frequently used technologies than male teachers. This finding contradict with the common view that technology-related activities have been seen as a 'male domain'[43, 44, 46, 47]. However, regarding the integration of technology in the classroom, the domination of male teachers over female teachers is no longer exist. For instance, King, Bond and Blandford [48] and North and Noyes [49] claimed that technological competencies is no longer seen as a male dominance. The present study agrees with those studies as it suggested that female mathematics teachers' instructional practices with digital technology were better male teachers. Furthermore, this study also showed teachers' level of education plays an important role in teachers' instructional practices. This finding is well suited to the view that teachers' education level as a crucial factor to improve teacher quality [see 50]..

Finally, to some extent, lack of Indonesian secondary school mathematics teachers who used digital technologies to facilitate students' knowledge construction. This finding is in agreement with existing studies in other countries, revealing that teachers have not reached a constructive way of technology use [e.g., 36, 37-40]. This might happen due to the fact that Indonesian teachers did not have sufficient technological knowledge as well as knowledge of technology integration in teaching and learning process [See., 41]. Therefore,, the development of teachers knowledge is necessary step that need to take into account in order to improve teachers instructional practices in the use of technologies [42]

6. Conclusions

This study showed that the integration of digital technologies in Indonesian secondary school mathematics classrooms has emerged. However, the current practice still leaves a large room for improvement as this study suggests that most of the teachers used digital technology for a very limited number of mathematics lessons. Furthermore, most of the teachers use used presentation-oriented software. As a result, it raised a concern about the impact of the digital technology integration since such digital tools do not offer many advantages for enhancing the teaching and learning of mathematics. To a large extent, the teachers did not integrate the technology in constructive ways to facilitate students' knowledge construction. In addition, this study reveals that female teachers have better instructional practices than male teachers. In addition, teachers' level of education plays an important role in the integration of technologies in mathematics classrooms. Finally, as the integration of technology in the classroom has emerged, we suggest a study to explore the impact of this integration on students' learning outcomes and their experience in learning mathematics with digital technologies.

Acknowledgments

We would like to thank Asian Centre for Mathematics Education, East China Normal University for financially support the completion of this paper by a research grant from (Project No. 92900-120215-10514). The second author's participation was also in part supported by a research grant from East China Normal University's "Happy Flowers" Strategic Research Fund (Award No: 2019ECNU-XF2H004)..

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