Technological pedagogical content knowledge of junior high school mathematics teachers in teaching linear equation

S Wati¹, L Fitriana¹, and Mardiyana¹

¹Department of Mathematics Education, Universitas Sebelas Maret, Jl. Ir. Sutami No. 36 A, Kentingan, 57126, Jebres, Surakarta, Indonesia

Email: susilowati.maths@gmail.com

Abstract. Linear equation is one of the topics in mathematics that are considered difficult. Student difficulties of understanding linear equation can be caused by lack of understanding this concept and the way of teachers teach. TPACK is a way to understand the complex relationships between teaching and content taught through the use of specific teaching approaches and supported by the right technology tools. This study aims to identify TPACK of junior high school mathematics teachers in teaching linear equation. The method used in the study was descriptive. In the first phase, a survey using a questionnaire was carried out on 45 junior high school mathematics teachers in teaching linear equation. While in the second phase, the interview involved three teachers. The analysis of data used were quantitative and qualitative technique. The result PCK revealed teachers emphasized developing procedural and conceptual knowledge through reliance on traditional in teaching linear equation. The result of TPK revealed teachers’ lower capacity to deal with the general information and communications technologies goals across the curriculum in teaching linear equation. The result indicated that PowerPoint constitutes TCK modal technological capability in teaching linear equation. The result of TPACK seems to suggest a low standard in teachers’ technological skills across a variety of mathematics education goals in teaching linear equation. This means that the ability of teachers’ TPACK in teaching linear equation still needs to be improved.

1. Introduction

Algebra has been widely recognized as one of the most difficult topics within secondary school mathematics curricula [1]. One of algebra materials is the linear equation. A linear equation is an algebra material that has existed in junior high school to university. A linear equation is critical to the study of more advanced mathematical topics such as derivative in calculus [2], the line of best fit in statistics [3], and to describe nonlinear functions in advanced algebra [4]. Therefore, linear equation material is essential to be mastered. The linear equation is difficult for students to understand and becomes a problem in learning for teachers [5]. Studies have found students experienced various difficulties with a linear equation. Students got difficulties and misunderstood linear equations, graphs, slopes and could not comprehend the connection between slope and the $x$- and $y$-intercepts [6]. Research has documented procedural and conceptual students’ difficulties with slope [7]. Students also have difficulty in interpreting linear equations and their graphs [8]. The misconception and deficiencies of the students in the linear equation also may lead to severe learning difficulties in the subjects of functions, limit, derivation, and integral through high school and the university years.
Student difficulties of understanding the concept of the linear equation can be caused by lack of understanding of the concept and the way of teachers teach. Teachers' quality was identified one of the crucial factors attributed to the situation.

The Indonesia government launched a program called teacher certification. The program was designed as a tool to improve teacher quality through three strategies such as attraction channel (increasing the enrollments of preservice teachers), upgrading (improving teacher qualifications), and the behavioral (changing teachers' teaching practice). To obtain the certificate a teacher as to pass a certification qualification test conducted at the end of a training program especially designed for the purpose. However, a study suggest that teacher certification does not lead to improvement of teachers' teaching performance, teachers' behavior and teachers' participation in professional development [9]. The study also finds that there is no performance difference between certified and uncertified teachers.

Teachers’ perspective and competency with the regard to teachers’ attitudes, beliefs, subject matter knowledge, pedagogical knowledge, pedagogical content knowledge, and technological pedagogical content knowledge can influence what and how students learn mathematics [10]. Effective teachers not only know their subject matter but they also able to create a stimulating learning environment and apply pedagogical strategies, including technology-rich strategies that engage students while helping them improve their achievement [11]. Department of National Education of Indonesia also requires that every teacher in Indonesia must have standard competencies namely the mastery of knowledge (content), technology, pedagogy, culture, humanity, and civilization [12].

Technology is considered important to be integrated into learning to respond to the challenges of the 21st century. Information Communication Technology (ICT) has been developed rapidly and has been used in all areas of knowledge, including in the field of education. Realizing the importance of information technology in education, mathematics teachers should utilize the technology to assist the learners achieve their goals and to ease them in understanding and using the concepts of mathematics. Content-specific mathematics technologies support students in exploring and identifying mathematical concepts and relationships. Content-neutral technologies increase students’ access to information and ideas and enhance student-student and student-teacher interactions to support and enrich sense making. Strategic use of technological tools can support learning of mathematical procedures and skills as well as the development of advanced mathematical proficiencies, such as problem solving, reasoning, and justifying [13, 14, 15, 16].

Many of researches result from mathematics education illustrate that the integrating of ICT may change the environment of teaching and learning mathematics [17, 18]. ICT seems to provide a focal point that encourage interaction between learners and the technology itself. This implies that ICT used in instruction will support constructivist pedagogy, where learners use technology to explore and reach an understanding of mathematical concepts [19]. Thus, ICT can make students more active and not solely dependent on their teacher so they can study independently. Furthermore, for ICT to be used effectively in everyday teaching, radical changes are advocated in approaches to the teaching of mathematics. For this reason, it is important to promote research and practice that are able to provide teachers the opportunities to adequately utilize and integrate the technology into mathematics classrooms.

Currently, one of the most important ways of providing technological support is to use a framework for integrating complex problems of knowledge from pedagogy, content, technology and different forms of interactions among these elements in classroom. Teachers are not only required have the ability of Pedagogical Content Knowledge (PCK) but also apply technology in learning, so technology, pedagogy, and content have become a part of teachers. The Technological Pedagogical Content Knowledge (TPACK) framework was developed by Mishra and Koehler based on Lee Shulman’s concept of PCK by adding technology. Ability to use appropriate strategies supported by the right technology tools on specific topics is a knowledge model called the Technological Pedagogical Content Knowledge (TPACK) [20].

TPACK in any discipline is the perfect union of three knowledge domains (content, pedagogy, and technology) to develop a knowledge base from which a teacher can view a lesson and understand how
technology can enhance the learning opportunities and experiences for students while also knowing the correct pedagogy to enhance the learning content. In mathematics education, a teacher with a TPACK perspective is a teacher that understand the correct pedagogy with this technology. By having a proper TPACK, he will be able to engage and motivate students as they explore the content of mathematics to a greater degree. The TPACK framework suggests that integrated knowledge of technology, pedagogy, and content is an essential condition to effective and innovative classroom teaching using technology.

TPACK comprises seven constructs which are Technological Knowledge (TK), Pedagogical Knowledge (PK), Content Knowledge (CK), Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK), and Technological Pedagogical Content Knowledge (TPACK). TK refers to knowledge about various technology that can be implemented in everyday life as well as in teaching and learning activities. PK is the knowledge about teaching and learning strategies. CK is knowledge about the actual subject matter to be learned. TPK, TCK, and PCK refer to knowledge about the interplay between the original constructs. Thus, TPK is knowledge relates to how technology can be used appropriately for particular teaching and learning strategy. TCK relates to how specific technology play importance role in delivering certain content so as to it is being conveyed successfully. Meanwhile, PCK relates to how certain teaching and learning strategy fits subject matter delivery [20]. This research was conducted in order to analyze TPACK of junior high school mathematics teachers in teaching linear equation.

2. Method
This study combines both quantitative and qualitative approaches in two phases. In the first phase, a survey method using a questionnaire was carried out on 45 teachers in Karanganyar. The instrument used was a questionnaire that measures the level of Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical Content Knowledge (TPACK) in teaching linear equation. Items were drawn from the current literature and from previous TPACK-related instruments and in some cases modified to reflect the mathematical focus of this study [21, 22]. The instrument constructed contained 19 items for measuring teachers’ self-assessments of the four TPACK domains: 6 PCK items, 4 TPK items, 4 TCK items, and 5 TPACK items. For these 19 items, participants answered each question using the five-level Likert scale: strongly disagree, disagree, neither agree nor disagree, agree, and strongly agree. The measure TPACK domains were used in this study to represent participants’ self-assessment of their knowledge. Internal reability of the four construct was established through Cronbach Alphas for all constructs: PCK(0.801), TPK (0.762), TCK (0.765), and TPACK (0.920). Data were analyzed using descriptive statistics, namely the mean. While in the second phase, the interview method involved three teachers were performed. They were selected using purposive sampling technique. The instrument used was the semi-structured interview protocol to asses the teachers’ TPACK integration in their teaching practice.

3. Results and Discussion

3.1. Pedagogical Content Knowledge (PCK)
Pedagogical Content Knowledge refers to the content knowledge that deals with the teaching process. Pedagogical Content Knowledge is different for various content areas, as it blends both content and pedagogy with the goal being to develop better teaching practices in the content areas. Based on the analysis, the profile of PCK junior high school of mathematics teachers is presented in table 1.

| No | Statement | M   | SD  | Criteria |
|----|-----------|-----|-----|----------|
| 1  | I can help students keep understanding the material of the linear equation using various strategies without using technology. | 3.29 | 0.61 | Good |
2. I can engage students actively in meaningful discussions on the material of linear equation even without the use of technology.  
   3. I can make students actively solve real problems on the topics of the linear equation without using technology.  
   4. I can help change the thinking process of students in order to master a difficult topic on the material of the linear equation without using technology.  
   5. I can evoke meaningful reflection on the students on the material of the linear equation without using technology.  

   Mean 3.57 Good

The average score PCK of junior high school mathematics teachers is 3.57, it is in the good criteria this indicates the ability of Pedagogical Content Knowledge teachers has been good average that the highest on the item statement “I can make students actively solve real problems on the topics of the linear equation without using technology”. However, the result of the interview show that teachers normally prefer teacher-centered approach namely the 'chalk-and-talk" in the explaining and elaboration of the principles, theories, definitions, and concepts. It also demonstrated that they adopt a passive lecture teaching style with textbooks as the primary source in their teaching practices. Students too still make the teacher as a dominant learning center.

3.2. Technological Pedagogical Knowledge (TPK)

Technological Pedagogical Knowledge refers to the knowledge of how various technologies can be used in teaching and to understanding that using technology may change the way teachers teach. Based on the analysis, the profile of TPK junior high school of mathematics teachers is presented in table 2.

   Table 2. Technological Pedagogical Knowledge Score Junior High School Mathematics Teachers

| No | Statement                                      | M    | SD  | Criteria |
|----|-----------------------------------------------|------|-----|----------|
| 1  | I use computer apps in the teaching linear equation. | 3.43 | 0.75 | Adequate |
| 2  | I choose technology that suits the approach and strategy of learning in the classroom. | 3.79 | 0.70 | Good     |
| 3  | I use internet facilities (like social networks, emails, and blogs) to communicate with students. | 3.83 | 0.64 | Good     |
| 4  | I use online quiz (such as Quipper School, Edmodo, Socrative) to do the tests. | 3.36 | 0.50 | Adequate |
|    | Mean                                          | 3.60 |      | Good     |

The average score TPK of junior high school mathematics teachers is 3.60, it is in the good criteria this indicates the ability of technological Pedagogical Knowledge Teachers has been good average that the highest on the item statement “I use internet facilities (like social networks, emails, and blogs) to communicate with students”. However, the result of interview show that teachers were quite familiar with the various types of techniques or methods of teaching, but the dominant methods among them were expository and discussion. With the disclosure of knowledge about the constructivist approached, teacher have the option to try the method of demonstration, cooperative, module-based activities and game-based learning. This technology integration should encourage teachers to conduct student-centered activities, where students actively involved in many instructional activities. Technology should be a tool that helps students to experiment and investigate and to help teachers create contests and accelerate the process of problem-solving. In this study, the use of technology synonymous with the method of lecture, in which teachers deliver the lessons and students just listen. Although there were bilateral discussions, teachers still clearly shown as a single authority 'knowledge' providers.
reflects that the teachers have yet to be able to select appropriate teaching approaches with appropriate technology how to teach a subject. If teachers could handle the demonstration method, cooperative, games and module-based methods, it means that the teacher can also customize any appropriate technology that can be used in conjunction with the teaching methods.

3.3. Technological Content Knowledge (TCK)
Technological Content Knowledge refers to the knowledge of how technology can create new representations for specific content. It suggests that teachers understand that by using a specific technology, they can change the way learners practice and understand concepts in a specific content area. Based on the analysis, the profile of TCK junior high school mathematics teachers is presented in Table 3.

Table 3. Technological Content Knowledge Score Junior High School Mathematics Teachers

| No | Statement                                                                 | M    | SD  | Criteria |
|----|---------------------------------------------------------------------------|------|-----|----------|
| 1  | I use technology to help understand the concept of the linear equation.   | 3.29 | 0.61| Adequate |
| 2  | I can download the application of computer and animation related to a linear equation. | 3.79 | 0.70| Good     |
| 3  | I can develop student activities and tasks that involve the use of technology | 3.59 | 0.51| Good     |
| 4  | I can create self-learning activities for students using ICT devices (eg web quest or flip) | 3.43 | 0.65| Adequate |

The average score TCK of junior high school mathematics teachers is 3.52, it is in the good criteria this indicates the ability of Technological Content Knowledge Teachers has been good average that the highest on the item statement “I can download the application of computer and animation related to a linear equation”. However, the result of interview show that the mathematics contents were flatly referred without modification and only referring to the textbooks or workbooks provided. Not just confined to the requirements of the syllabus, the process of teaching also limited to the scope teaching the basic concepts, and the procedural aspects which emphasized only on writing the right steps in solving questions. The use of technology only in the introduction phase of the lesson to introduce the basic concepts and also for finding questions sources. PowerPoint constitutes TCK modal technological capability in teaching linear equation. The teachers were able to name same technology software such as the Geogebra instead of PowerPoint presentations which were considered suitable for teaching topic the linear equation. This means that teachers can choose the appropriate technology to teach a particular subject, but they have not been able to explore specifically how the software can be integrated into teaching and learning process which is very helpful in learning activities and accelerate the process of understanding the concepts. In the learning process carried out, almost all teachers use learning resources in the form of the same textbooks used by students, in addition to using the internet as other supporting material. Research conducted by the Son, Robb and Charismiaji regarding the Computer Literacy and Competency revealed that teachers in Indonesia generally have basic computing skills are quite high, but the frequency of utilization of these capabilities are limited only to a few applications only (one quite dominant is a word processing application) [23].

3.4. Technological Pedagogical Content Knowledge (TPACK)
Technological Pedagogical Content Knowledge refers to the knowledge required by teachers for integrating technology into their teaching in any content area. Teachers have an intuitive understanding of the complex interplay between the three basic components of knowledge (content, pedagogy, and technology) by teaching content using appropriate pedagogical methods and
technologies. Based on the analysis, the profile of TPACK junior high school of mathematics teachers is presented in table 4.

Table 4. Technological Pedagogical Content Knowledge Score Junior High School Mathematics Teachers

| No | Statement                                                                 | M   | SD  | Criteria |
|----|---------------------------------------------------------------------------|-----|-----|----------|
| 1  | I understand how to integrate mathematical knowledge (especially the linear equation), pedagogical knowledge and technological knowledge. | 3.71| 0.61| Good     |
| 2  | I can choose a learning strategy and technology that match the material of the linear equation that will be delivered in class. | 3.71| 0.73| Good     |
| 3  | I can integrate knowledge of the content, pedagogical knowledge and knowledge of technology to realize meaningful learning. | 3.50| 0.85| Adequate |
| 4  | I can apply different learning strategies and varying technologies in the implementation of mathematics learning | 3.50| 0.65| Adequate |
| 5  | I can enable students to construct deep and meaningful insights into the material of the linear equation using various technologies. | 3.50| 0.52| Adequate |

The average score of TPACK junior high school mathematics teachers is 3.58 are in good criteria this indicates TPACK junior high school mathematics teachers are good. Although the means to integrate the three content knowledge, pedagogy and technology are still sufficient criteria, the selection and application of technology in learning strategies is also sufficient, but teachers are good enough in constructing meaningful knowledge in learning the linear equation. The result of interview show that the teachers said that the limitations of the technology or media used in learning are the main problem in the learning process. Teachers also have difficulty in choosing learning strategy and model, allocation of a limited time, while very much a concept that should be taught. The procedure teaching is tailored to the teacher’s lesson plan, but the teaching procedures used to focus more on the order of the material in the textbook. The method of teaching often utilized by teachers is the conventional method. Sometimes adds the discussion method in learning. But overall learning implementation that teachers use still conventional methods. When asked in an interview, the reason teachers are still using conventional methods because of limited facilities in schools so that there is no other choice than conventional methods. The lack of supporting facilities such technology in learning make teachers tend to retain the conventional method. This indicates that the pedagogy of teachers is still less because it can not create meaningful learning on the grounds no technology can be utilized.

4. Conclusion

This study aims to identify TPCK of junior high school mathematics teachers in teaching linear equation. The result PCK revealed teachers emphasized developing procedural and conceptual knowledge through reliance on traditional in teaching linear equation. The result of TPK revealed teachers’ lower capacity to deal with the general information and communications technologies goals across the curriculum in teaching linear equation. The result indicated that PowerPoint constitutes TCK modal technological capability in teaching linear equation. The result of TPACK seems to suggest a low standard in teachers’ technological skills across a variety of mathematics education goals in teaching linear equation. This means that the ability of teachers’ TPACK in teaching linear equation still needs to be improved. Although TPACK may not directly relate to teaching practice, however, TPACK shapes teachers their practice. Deliberate and systematics efforts are needed to facilitate the improvement of teachers TPACK.

References

[1] Jupri A, Drijvers P and Van den Heuvel-Panhuizen M 2014 Mathematics Education Research
Journal 26(4) pp 683-710

[2] Stanton M and Moore-Russo D 2012 School Science and Mathematics 112(5) pp 270-277
[3] Casey S and Nagle C 2016 Educational Studies in Mathematics 92(2) pp 163-177
[4] Hattikudur S, Prather R, Asquith P, Knuth E, Nathan M and Alibali M 2011 School Science and Mathematics 112(4) pp 230-240
[5] Dhoruri A and Markaban 2011 Pembelajaran persamaan garis lurus (Yogyakarta: PPPPTK Matematika) pp: 2
[6] Birgin O 2012 Bolema, Rio Claro (SP) 26(42A) pp 139-162
[7] Cho P and Nagle C 2017 International Journal Research in Education and Science 3(1) pp 135-150
[8] Nathan M J and Kim S 2007 Mathematical Thinking and Learning 9(3) pp 193-219
[9] Chang M C, Shaeffer S, Al-Samarrai S, Ragatz A B, de Ree J and Stevenson R 2014 Teacher reform in Indonesia: The roles of politics and evidence in policy making (Washington DC: The World Bank)
[10] Bingolbali E, Akkoc H, Ozmantar M F, and Demir S 2011 International Electronic Journal of Mathematics Education 6(1) pp 40-59
[11] NCATE What make a teacher effective? National Council for the Accreditation of Teacher Education Retrieved 22.11.17 from http://www.ncate.org/LINKCLIK.aspx?fileticket=JFRrmWqa1jU%3d&tabid=361
[12] Kementrian Pendidikan dan Kebudayaan Indonesia 2013 Kurikulum 2013 Retrieved 22.11.17 from http://www.kemdiknas.go.id/
[13] Gadanidis G and Geiger V 2010 ZDM 42(1) pp 91-104
[14] Nelson J, Christopher A and Mims C 2009 Tech Trends 53(5) pp 80-85
[15] Pierce R and Stacy K 2010 International Journal of Computers for Mathematical Learning 15(1) pp 1-20
[16] Roschelle J, Shechtman N, Tatar D, Hedgesus S, Hopkins B, Empson S, Knudsen J and Gallagher L 2010 American Educational Research Journal 47(4) pp 833-878
[17] Chandra V and Briskey J 2012 International Journal of Pedagogies and Learning 7(1) pp 73-83
[18] Tay L Y, Lim S K, Lim C P and Koh L 2012 Australasian Journal of Educational Technology 28(4) pp 740-754
[19] Sang G, Valcke M, Braak J, Tondeur J and Zhu C 2011 Journal of Computer Assisted Learning 27(2) pp 160-172
[20] Mishra M L and Koehler M J 2006 Teachers College Record 108(6) pp 1017-54
[21] Widodo A 2017 TPACK Integration (TPACK) Survey
[22] Pamuk S, Ergun M, Cakir R, Yilmaz H B and Ayas 2013 Education and Information Technologies 20(2) pp 241-263
[23] Son J B, Robb T and Charismiadji I 2011 Computer-Assisted Language Learning - Electronic Journal 12 26-42