Mathematics mobile learning with TPACK framework

by K Hernawati

Mathematics mobile learning with TPACK framework

View the article online for updates and enhancements.

Mathematics mobile learning with TPACK framework

K Hernawati* and Jailani

Department of Mathematics Education, Yogyakarta State University

* Corresponding author: kuswari@uny.ac.id

Abstract. The mission of twenty-first-century education is to construct a knowledge-based society through the integration of Information and Communication Technology in the learning process. Mathematics teachers are required to be able to integrate technology in learning. Appropriate model and instructional media can encourage students' critical thinking skills. Currently, the learning process not solely takes location in the classroom, however also makes use of digital media, online, teleconferencing, and cellular technology outside the classroom. Various learning applications in mobile devices can be utilized in mathematics learning. Mobile Learning is a learning model that is performed between places by means of the use of technology that is easy to raise when the learner is in a mobile situation. By using mobile learning, the availability of teaching materials can be accessed at any time and interesting material visualization. Mathematics Mobile learning is the use of mobile devices in mathematics learning. TPACK is a framework that describes the relationship and complexity between the three basic components of knowledge (technology, pedagogy, and content). The TPACK framework is a model used for technology integration in education. The suitability of material characteristics with appropriate instructional media, learning model, and technology selection in Mathematics Mobile Learning can improve learning achievement and motivation of learners.

1. Introduction

The usage of technology in coaching methods has extensively changed the getting to know the process. Technology has created much-gaining knowledge of opportunities for instructors and college students. Teachers learn how to combine generation in teaching, at the same time as students can interact extra in mastering. College students are also more inquisitive about classes that can be finished at any time through instructional gadgets.

The educational challenge of the 21st century is to build a knowledge-based society through the integration of Information and Communication Technology (ICT) in the learning process. In the context of education, ICTs are tools that enable effective and efficient learning processes to occur. ICT is a way to achieve goals and not as a goal to be achieved. In modern education, teachers are required to be able to integrate ICT in the learning process. Integration of ICTs in the learning process should enable teachers to (1) be facilitators, collaborators, mentors, trainers, directors, and partner of learning and (2) can provide students with choices and responsibilities to experience learning events [1].

In step with Keengwe et al ([2]) instructors in all disciplines must discover ways to design and broaden technologies that may foster student success in modern cutting-edge studying environment [2]. Idris in [3] additionally emphasizes that instructors ought to integrate information and communication technology (ICT) in studying techniques, approaches, procedures, and methods that are according with the content material of the material and characteristics of college students. Teachers

will succeed in teaching if they are able to: a) use various learning strategies to create different learning environments and experiences; b) providing access to various learning materials for students, as well as encouraging and guiding student activities. In addition, the teacher's skills in integrating information technology into mathematics learning are very necessary as a way to improve students' thinking and creativity [3].

Digital equipment and Internet-based work tools are increasingly available and potentially change the teaching and learning process fundamentally. The era of industrial revolution 4, which is dominated by fast-growing digital technology, requires a strategy to find an ideal approach that brings the appropriate innovation theory. Various innovations based on science and semiconductor technology can be enjoyed with the availability of computers that are getting smaller in size with higher capability and speed.

The development of the internet is inseparable from the development of web technology. Web 2.0 technology allows internet users to distribute content. The web is not only as information where the distribution of data occurs between few to many but as a platform where the distribution of information occurs from many to many. The point is that there is participation, collaboration, and many-to-many relationships. In fact, the development of the web and the internet has not been optimized for learning activities but more access to social media.

In 2017, there are 132.7 million Internet users in Indonesia consisting of 63.1 million (47.6 %) smartphone users and 67.2 million (50.7 %) people who use both the desktop computer and smartphone to access the Internet, and 2.2 million (1.7 %) user desktop computer. 97.4 % of all Internet users in Indonesia indicate that they use the Internet for social media such as Instagram, Twitter, Facebook and YouTube [4]. eMarketer estimates 3.47 billion human beings use the internet frequently in 2017, representing 46.8% of the worldwide population. Mobile phones may be the number one device for internet get entry to, utilized by 2.73 billion people, or 78.9% of internet customers [5]. From the survey facts, it is able to be visible that the majority of internet get right of entry to uses mobile gadgets and its largest use remains ruled by social media access.

Mobile technology has changed lifestyles and began to change the way of learning. Mobile learning is e-learning through mobile computing devices, such as smartphones, palmtops, and handheld computers, tablet PCs, laptop computers, and personal media players. Quinn in [6] defines mobile learning as any activity that allows individuals to become more productive when consuming, interacting or exchanging information, and mediated through portable digital devices that individuals do regularly, have reliable connectivity with pocket-sized or wallet-sized equipment [6].

A new innovation in learning is mobile learning. Mobile devices make learning portable, spontaneous, personal, and attractive. Mobile learning applications have been applied in mathematics learning called mathematics mobile learning. Various applications of mobile mathematics learning have been developed in the form of videos, educational games and learning applications that are intentionally designed specifically for mathematics learning, but most of these applications focus more on material content and technology utilization and are less touching on the pedagogical domain, so that new approaches are needed in using mathematics mobile learning, that is, with the TPACK framework.

In the study by Tay, Lim & Koh ([7]) resulted that the use of ICTs could increase the understanding of the content of instructor knowledge and pedagogical abilities in learning mathematics [7]. Schoen and Fusarelli in [8] state that the use of information and communication technology as an instructional tool and pedagogical abilities of teachers are factors that help teachers and schools meet the challenges of preparing students by improving skills needed in the 21st century [8]. Koehler and Mishra in [9] developed a Technology Pedagogical Content Knowledge (TPACK) model in the form of a combination of content, pedagogical abilities, and technological integration capabilities in the learning process in the classroom. TPACK adapted from Shulman's model (1986) the Pedagogical Content Knowledge (PCK). TPACK is the perfect combination of three domains of knowledge (content, pedagogy, and technology) which aims to develop basic knowledge when a teacher studies the subject matter and understands that technology can increase learning experiences

and opportunities for students, and to find out the appropriate pedagogy for improving the quality of learning. In learning mathematics, teachers with a TPACK perspective are instructors who understand pedagogy and understand the correct concept by using technology in teaching materials. By having TPACK capabilities, the instructor can involve and motivate students to explore the contents of mathematics learning to a more advanced level. The TPACK model shows that content knowledge that integrates technology and pedagogical skills is an important condition in creating innovative and effective classroom learning using technology [9].

2. Mobile Learning

At present, the World Wide Web (www) and the Internet have improved the learning process which provides a high level of connection between educators and students who are geographically isolated. The internet can create learning conditions that are in accordance with the current requirements, students who are diverse in which they involve students in many activities, such as collaboration, interaction, discussion and critical thinking, not just an approach to convey and circulate information and substance of learning. The internet empowers e-learning for distance learning around the world and mobile learning (m-learning) will be an age of upcoming distance learning [10]

M-Learning is a technique that uses cellular and wireless technology for learning and education that allows students to combine their learning experiences in a collaborative environment [11]. Mobile Learning, defined by Clark N Quinn, is an intersection of mobile computing and e-learning that provides resources that can be accessed from anywhere with powerful search system capabilities, full interaction, full support for effective learning and performance-based assessment [6]. Ally in [12] describes mobile learning as a process that results from the convergence of mobile technology, human, learning capacity, and social interaction. Referring to this definition, mobile learning is a learning model that utilizes information and communication technology. Mobile learning brings the benefits of the availability of teaching materials that can be accessed at all times and the visualization of interesting material.

M-Learning can reduce cultural barriers and communication between lecturers and students by using communication channels that are liked by students, support distance learning can improve student-centered learning. With M-learning, students can access content anytime and anywhere, support differences in student learning needs and support personalized learning, can also enhance interactions between and between students and instructors. [10].

In general, the main advantages of using cellular wireless technology are 1) people who live in remote locations can be reached, for example, locations where there are no or far from schools, teachers, or library technology, 2) can provide learning activities and provide information on remote areas without leaving their geographical area or place of residence, to go to different locations to access information, 3) Business owners and other work sectors can increase productivity and improve product quality Business owners by accessing information that supports, 4) Ease of accessing health information for people living in remote communities to improve health and improve quality of life, 5) Reduce carbon pollution on the earth and maintain a clean environment with reduced transportation needs. [13]

3. Mathematics mobile learning

Mathematics mobile learning is the use of mobile technology in mathematics learning. The National Council of Teachers of Mathematics (NCTM) claims that in the 21st century all schools must ensure that all their students have access to technology because technology is an important tool for learning Mathematics [13].

Recently, researchers have developed many online and mobile applications for learning such as Geometry, Algebra, Statistics, Mathematical Analysis, and other mathematical fields. Web technologies that support mathematics learning have also been developed over the past decade. Online and cellular education tools for mathematics can provide a dynamic representation of ideas and encourage general metacognitive abilities, support students' problem-solving abilities, and can

improve understanding of mathematical concepts. Students will be able to improve their skills using technology, besides that it will encourage increased cellular learning applications with the frequent use of cellular technology in mathematics learning [14].

4. Technological Pedagogical Content Knowledge (TPACK)

Technological Pedagogical Content Knowledge (TPACK) endeavors to recognize the idea of learning required by instructors for innovation in their educating, while at the same time tending to the perplexing, multifaceted and arranged nature of educator information. The TPACK structure broadens Shulman's concept of Pedagogical Content Knowledge. At the core of the TPACK system, is a compound of three essential types of learning: Technology (TK), Pedagogy (PK), and Content (CK). The TPACK approach goes past observing these three learning bases in separation. The TPACK structure goes advance by underlining the sorts of learning that lie at the crossing points between three essential structures: Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), Pedagogical Content Knowledge (PCK), and Technological Pedagogical Content Knowledge (TPACK) [15] (See Figure 1).
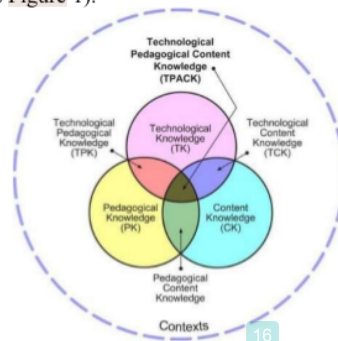

Figure 1. TPACK Framework © 2012 by tpack.org

Content Knowledge (CK) – Topics that will be studied and instructed must be mastered by educators. This is a combination of learning ideas, thoughts, hypotheses, confirmation information, hierarchical systems, evidence and also the completion of practices and methodologies to foster that knowledge.

Pedagogical Knowledge (PK) – Instructors must master the practices and procedures or strategies for teaching and learning, including determining learning goals, values, and targets. This is needed for planning and evaluating lessons, knowing how students learn and class administration skills in general.

Technology Knowledge (TK) – A teacher must have a mindset and knowledge about how to work with technology, tools, and resources and be able to consistently adapt to changes in information technology. This knowledge includes understanding about information technology comprehensively and applying it in daily life and at work and having the capacity to use information technology appropriately to help achieve goals.

Pedagogical Content Knowledge (PCK) – PCK conceptualized by Shulman in 1986 is the idea of changing topics for teaching. Changes that occur when the instructor interprets the topic, find many approaches to represent it and adapts teaching materials to alternative conceptions and student initial learning. PCK includes education, teaching, learning, assessment and evaluation programs related to curriculum and teaching methods.

Technological Content Knowledge (TCK) – Teachers must understand the ways in which content and technology limit and influence each other. The teacher needs to have extensive knowledge beyond the topic being taught; the teacher must also be able to modify the representation of subject

matter by applying technology specifically, as well as choosing the most appropriate technology to help students master the content.

    Technological Pedagogical Knowledge (TPK) – A concept about the use of specific technologies used in certain ways can make teaching and learning feel different. This includes knowing pedagogical abilities and applying pedagogical strategies that are compatible with technological developments.

    Technological Pedagogical Content Knowledge (TPACK) –TPACK is the basis of effective teaching with technology, which requires an understanding of the representation of ideas using technology; Pedagogical techniques use technology to show content; information about things that are difficult or easy to learn and how innovation can make it easier for students to solve problems; learn students' initial knowledge and epistemological speculation; and information about how technological progress can be used to expand existing information to develop new epistemologies or strengthen the old epistemology.

    Chai, Koh, & Tsai ([16]) reviewed 74 journal papers that examined ICT integration with the TPACK framework. TPACK's knowledge needs to be mastered by teachers to effectively implement ICT in the classroom. TPACK is a framework for teachers that discusses the problem of applying technology in learning which has been carried out separately from content learning and pedagogical training. [16].

5. Methodology

This research method used was a literature review that aims to give an overview about the use of mobile devices for mathematics learning dan TPACK ability of mathematics teacher and their impact on student achievement which will be known by reviewing some literature related to research.

6. Result and Discussion

Handheld device applications, such as iPad and smartphones are very widely available. Many of these applications focus on Mathematics. There are more than 4000 mobile applications for Mathematics education. However, not many studies in Mathematics education have examined the use of applications and their accompanying pedagogy. By increasing the use of mobile devices to classrooms and accompanying applications, teachers and educators need to consider their effectiveness in learning, especially mathematics [17]. Mathematics teachers require to have the ability of well-connected CK and PCK that they can access and modify before, during and after practice, to be effective learning. This is a continuing process that helps teachers to renew their knowledge.

    Furthermore, this device supports a high level of interactivity among the participants so that it can easily provide knowledge modification and restructuring. Teachers can increase knowledge by involving the use of cellular technology that is described as Pedagogical Technology Knowledge (PTK). PTK involves pedagogical content knowledge, teacher's understanding of mathematical content, and ways to represent the content through technology media that is appropriate to individual learning styles of individual students [18].

    Starting in 2007, to encourage the implementation of technology in the context of teaching and learning mathematics, the AMTE Technology Committee (Association for Mathematics Teacher Educators) proposes the TPACK Mathematics Teacher Standard, which provides a framework for guiding professional practices that support the improvement of mathematics teaching and learning. The four main themes are Teaching, Learning, Curriculum and Assessment, and Access. The following are the Standard Proposals for TPACK Mathematics Teachers [19]:

1. Arranging, designing and expanding digital-age learning experiences and environments.
   The teacher designs and develops environments and authentic learning experiences that combine the resources and tools of the digital age that are right for optimizing mathematics learning in context.
2. Teaching, learning and the mathematics curriculum

The teacher implements a curriculum plan that includes methods and strategies by applying the right technology to optimize the learning and creativity of students in mathematics.

3. Assessment and evaluation.

The teacher uses the right technology, to facilitate various effective assessments and appropriate evaluation strategies.

4. Productivity and professional practice

Teachers utilize technology to increase their productivity and professional practice.

Rapid technological developments are in line with new technologies introduced in mathematics classes, so the Mathematics Teacher TPACK Standards and the corresponding TPACK Development Model may change as new technologies. More research is carefully examined and describes the teaching and learning process. Regarding the use of cellular technology by teachers, it is important for teachers to develop a good understanding of the tools they will use during learning activities. Practitioners should allocate sufficient time for each teacher to become familiar with the many features of the smartphone [18].

Drigas and Pappas [15] have reviewed many mobile learning applications for mathematics. The review result shows that all the learning outcomes using technology and mobile applications have a positive impact on learning motivation and students' understanding of the material.

Some reasons why IT on mobile mathematical devices offer solutions to educational challenges such as a) Increasing student learning independence, ability, and motivation to experiment and exploring mathematical concepts, b) giving teachers the opportunity to set different levels of difficulty according to students' abilities, c) limited investment in graphics technology used in classrooms, d) making learning more enjoyable, e) providing real-time examples that are relevant to students, f) growing exploration skills in students, through personal devices, g) allows teachers to know students who have problems with the mathematical concept.

The use of mobile applications in mathematics learning has a positive impact on student achievement. According to the results of the post-test, pre-test and questionnaire data provided to students, the results of the test were improved and changes in students' attitudes towards mathematics learning. The increase in student test scores before and after the use of mobile applications is in the high category, while students' attitudes towards learning are still in the moderate category, which is because even though cellphone technology has become a necessity for students in daily life, but still not getting high attention to learning mathematics [20]. From the results of these studies, it is still necessary to cultivate the use of smartphones for learning.

Research on the ability of TPACK mathematics teachers in classrooms from various countries shows that mathematics learning becomes more effective. A study in South Africa showed that the increase in TPACK mathematics teachers, confidence in the ability to use ICTs and the level of knowledge of mathematical content contributed to mathematics teaching in 8th grade which became more effective in schools. The results show that mathematics teachers with adequate TPACK recognize that ICTs have a positive impact on them including (1) access to many resources for teaching and learning, (2) communication with colleagues and coworkers regarding the practice of teaching and learning, (3) conducting activities more innovative teaching and learning, (4) doing administrative work, (5) facilitating interactive lessons and (6) more confident using the most suitable teaching and learning strategies to achieve curriculum results. Therefore it is important for mathematics teachers to develop their TPACK abilities and self-confidence [21].

Other studies [22] show that TPACK competencies can be considered as core attributes for future mathematics teachers. The learning model using technological tools helps students develop the ability to understand mathematical practices and methods of teaching mathematics for teachers. Also, the competence of the mathematics teacher TPACK has a direct impact on student learning in mathematics.

Research on TPACK's abilities and their impact on student achievement [23] shows that rapid technological advances in the 21st century have changed the way teaching and learning. As a result, teachers must integrate technology into practice in the classroom, especially for certain subject

matter. Research conducted on 15 teachers to test the effect of Technological Pedagogical and Content Knowledge (TPACK) shows that pedagogical knowledge has a greater impact on TPACK. Teachers with low PK levels cannot make technological-psychology relationships even if they have high TK.

Based on the results of the research from the researchers above, TPACK's ability is very important to improve student achievement. Various positive effects on the use of mobile applications in learning mathematics. This is because smartphones have become an inseparable part of students 'lives, also mobile learning, especially in mathematics, can increase students' learning motivation. Ease of access wherever and whenever will enable students to learn according to their needs. Learning will be more effective if each student receives a learning experience that is in accordance with the conditions of each student. Students can learn in the best environment when in a flexible learning environment to adapt teaching strategies to individual needs. Therefore it is important to develop mathematics mobile learning with the TPACK framework.

7. Conclusion

ICTs can be used as epistemic tools, metacognitive tools and cognitive tools to support critical and creative thinking, and authentic and inventive problem solving, as usual elements learning in the twenty-first century. Teachers still need understanding to formulate lessons that are integrated with technology that supports 21st-century learning with seven TPACK constructions.

Mathematics mobile learning can improve learning achievement and student learning motivation. To get optimal results the teacher should apply the TPACK framework, starting from choosing the content of the mobile application that is in accordance with the mathematics material, choosing the appropriate learning model and method, managing the class and evaluating it according to the characteristics of students.

Mobile learning and technological innovation need to be introduced to schools and make changes in learning practices. Learning that enables student involvement by educators, develops learning and teaching opportunities that are in line with emerging trends, especially in the field of Mathematics studies

References

[1]   UNESCO 2002 *Information and Communication Technologies in Teacher Education: A Planning Guide, Division of Higher Education* (UNESCO) Retrieved from http://unesdoc. unesco.org /images/0012/001295/129533e.pdf, 2002.

[2]   Keengwe J, Onchwari G, and Onchwari J 2009 *AACE Journal* **17**(2)

[3]   Idris N 2006 *Teaching and Learning of Mathematics* (Kuala Lumpur: Utusan Publications & Distributors)

[4]   APJII 2017 *INFOGRAFIS: Penetrasi & Perilaku Pengguna Internet Indonesia 2017* (APJII) Retrieved from http://www.teknopreneur.com

[5]   eMarketers 2017 *Worldwide Internet and Mobile Users: eMarketer's Updated Estimates and Forecast for 2017–2021* Retrieved https://www.emarketer.com/Report/Worldwide-Internet-Mobile-Users-eMarketers-Updated-Estimates-Forecast-20172021/2002147, 2017.

[6]   Quinn C 2011 *Designing mlearning: tapping into the mobile revolution for organizational performance* (San Francisco: Wiley).

[7]   Tay L, Lim S K, Lim P C and Koh J 2012 *Australas. J. Educ. Technol.* **28**(4)

[8]   Schoen L and Fusarelli L 2008 *Educ. Policy* **22**(1)

[9]   Abbitt J 2011 *J. Digit. Learn. Teach. Educ.* **27**(4)

[10]   Sarrab M and Aldabbas H 2012 *Int. J. Distrib. Parallel Syst. (IJDPS)* **3**(4)

[11]   Ketamo H 2002 *Proc. IEEE Int. Workshop* p 167

[12] Ally M 2009 Mobile learning: *transforming the delivery of education and Training* (Edmonton: AU Press, Atabasca University)

[13] Skillen M A 2015 *Proceedings of the 20th Asian Technology Conference in Mathematics* Leshan China.

[14] Drigas A S and Pappas M A 2015 *IJIM* **9**(3)

[15] Koehler M J and Mishra P 2009 *Contemporary Issues in Technology and Teacher Education* **9**(1)

[16] Chai C S, Koh J H L and Tsai C C 2013 *Educational Technology & Society* **16**(2)

[17] Steinle V, Ball L and Bardini C 2013 *Proceedings of the 36th Annual Conference of the Mathematics Education Research Group of Australasia*, Mathematics Education Research Group of Australasia Inc. Melbourne VIC

[18] Chinnappan M 2009 *Role of mobile digital technology in fostering the construction of pedagogical and content knowledge of mathematics* in In J. Herrington, A. Herrington, J. Mantei, I. Olney, & B. Ferry (Eds.), *New technologies, new pedagogies: Mobile learning in higher education* (Wollongong: University of Wollongong).

[19] Niess M L, Ronau R N, Shafer K G, Driskell S O, Harper S R, Johnston C, Browning C, Özgün-Koca S A and Kersaint G 2009 *Contemporary issues in technology and teacher education* **9**(1).

[20] Supandi, Ariyanto L, Kusumaningsih W and Aini A N 2018 *J. Phys.: Conf. Ser.* **983** 012106

[21] Muhtadi D, Wahyudin, Kartasasmita B G and Prahmana R C I 2017 *J. Phys.: Conf. Ser.* **943** 012020

[22] Leendertz V, Blignaut A S, Nieuwoudt H D, Els C J and Ellis SM 2013 *Pythagoras* **34**(2).

[23] Tanak A *2018 Kasetsart Journal of Social Sciences* 1-7

Mathematics mobile learning with TPACK framework

PRIMARY SOURCES

1	ro.investopedia.com Internet Source	1%
2	trace.tennessee.edu Internet Source	1%
3	Submitted to Postgraduate Schools - Limkokwing University of Creative Technology Student Paper	1%
4	Submitted to Universitas Terbuka Student Paper	1%
5	Submitted to University of Sunderland Student Paper	1%
6	www.scribd.com Internet Source	1%
7	Submitted to Walden University Student Paper	1%
8	www.e-jmii.org Internet Source	1%
9	jtsiskom.undip.ac.id	

Internet Source

1%

10 Maureen N. Short, Charity Uzochukwu. "chapter 10 Mobile Technology Integration and Student Learning Outcomes", IGI Global, 2018
Publication

1%

11 Submitted to Binus University International
Student Paper

1%

12 ml.goingeast.ca
Internet Source

1%

13 pt.scribd.com
Internet Source

1%

14 "Handbook of Mobile Teaching and Learning", Springer Science and Business Media LLC, 2015
Publication

1%

15 www.mohe.gov.my
Internet Source

<1%

16 Submitted to Laureate Higher Education Group
Student Paper

<1%

17 www.citejournal.org
Internet Source

<1%

18 Hatice Sancar Tokmak, Lutfi Incikabi, Sinan Ozgelen. "An Investigation of Change in Mathematics, Science, and Literacy Education

<1%

Pre-service Teachers' TPACK", The Asia-Pacific Education Researcher, 2012
Publication

19   "Mobile and Ubiquitous Learning", Springer Science and Business Media LLC, 2018
Publication   <1%

20   Adi Nur Cahyono. "Learning Mathematics in a Mobile App-Supported Math Trail Environment", Springer Science and Business Media LLC, 2018
Publication   <1%

21   Submitted to University of Cambridge
Student Paper   <1%

22   citeseerx.ist.psu.edu
Internet Source   <1%

23   Submitted to University of Reading
Student Paper   <1%

24   Teresa Assude, Chantal Buteau, Helen Forgasz. "Chapter 19 Factors Influencing Implementation of Technology-Rich Mathematics Curriculum and Practices", Springer Science and Business Media LLC, 2009
Publication   <1%

25   Submitted to University of Newcastle upon Tyne
Student Paper   <1%

Submitted to University of Southern Mississippi

26   Student Paper   <1%

27   www.readbag.com
Internet Source   <1%

28   www.science.gov
Internet Source   <1%

29   Submitted to University College London
Student Paper   <1%

30   tojet.net
Internet Source   <1%

31   www.crtvup.com.cn
Internet Source   <1%

32   Submitted to Swinburne University of Technology
Student Paper   <1%

33   www.ukessays.com
Internet Source   <1%

34   www.2015conference.ascilite.org
Internet Source   <1%

35   es.scribd.com
Internet Source   <1%

36   newmanpublication.com
Internet Source   <1%

Odette Umugiraneza, Sarah Bansilal, Delia

37   North. "Exploring teachers' use of technology in teaching and learning mathematics in KwaZulu-Natal schools", Pythagoras, 2018
Publication   <1%

38   Submitted to University of KwaZulu-Natal
Student Paper   <1%

39   A.T. Jesso, M.F. Kondratieva. "Instructors' use of technology in post-secondary undergraduate mathematics teaching: a local study", International Journal of Mathematical Education in Science and Technology, 2015
Publication   <1%

40   "Teaching Statistics in School Mathematics-Challenges for Teaching and Teacher Education", Springer Science and Business Media LLC, 2011
Publication   <1%

41   Submitted to University of Newcastle
Student Paper   <1%

42   Submitted to Regis University
Student Paper   <1%

43   Submitted to Vaal University of Technology
Student Paper   <1%

| Exclude quotes | Off | Exclude matches | Off |
| Exclude bibliography | On | | |

Mathematics mobile learning with TPACK framework