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Digital Pedagogy in Mathematics Mobile Learning

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Today's digital age trequires teachers to create a generation that is able to think ahead. Therefore, teachers need to be prepared by strengthening their digital pedagogical competencies so that they are able to design or implement information technology-based learning, while still exploring the values of local wisdom, implementing teaching strategies so that students master 21st century skills like critical, creative, and innovative thinking. Cellular devices are one of the tools that can be used for mathematics mobile learning. Mathematics mobile learning needs to be enacted in digital pedagogy, so that students become active partners in finding and developing their own mathematical knowledge. In doing so, mathematical topics are linked with the real world and integrated with mobile and non-mobile technology. Learning activities would also provide opportunities to connect with fellow students during the learning process through conversation and discussion, and encourage collaboration activities between students and teachers to create new knowledge.

Key words: *Digital Pedagogy, Mathematics Mobile Learning*

Introduction

The digital age has been able to connect the world. Connectivity requires a person to have a strong foundation in his/her core competencies, namely language, mathematics, and ability in information and communication technology (Karoly & Panis, 2004). The digital age requires someone to be able to adapt so that a teacher is required to create a generation that is able to think far beyond the sophistication of the existing technology. Technology is no longer a way to simplify teaching and learning, but rather to transform knowledge (Richardson, 2010).

Today's students are digital learners, who prefer learning that actively engages them, and prefer learning by processing images, sound, and video rather than by reading text (Hamid et al, 2019). The term students and learners in this digital age is no longer limited to narrow groups,

that is, to people who are formally studying at school. Instead, it is informed by a lifelong learning trend. Learners now learn at all times. Accordingly, the learning process is conducted according to needs and circumstances, and can be done informally by utilising students' experiences or assets (Willms, Friesen, & Milton, 2009), as well as by utilising available digital devices.

At the moment, cellular devices have been widely used as educational tools. These devices have the potential to change learning models (Dias & Victor, 2017). The use of cellular devices in learning is commonly referred to as mobile learning (M-learning). M-learning allows students to combine their learning experiences in a collaborative environment (Ketamo, 2002), combining mobile computing and e-learning that provides resources that can be accessed from anywhere with strong search system abilities, full interaction, full support for effective learning, and performance-based assessment (Quinn, 2011). Mobile learning beneficially increases the availability of teaching materials, which can be accessed at any time, and makes material visualisation interesting, including in learning mathematics. Mobile learning in mathematics learning is referred to as mathematics mobile learning.

Optimal results in implementing mobile learning for mathematics learning cannot be separated from the selection of appropriate learning strategies, models, and approaches. Pedagogical approaches in the learning process that utilise digital devices are referred to as digital pedagogies. Digital pedagogy is very important in the reflection of the Piagetian learning pathway, specifically in terms of learning that requires from children active involvement with the environment, physically and mentally (Riyati & Suparman, 2019). Children build their own knowledge structure and do not passively accept knowledge but organise and transform their knowledge structure. Intelligent computing tools are the best tools for creating new paradigms for learning environments that can help students learn and develop their own mathematical knowledge organically. Computational devices support personalised and unique learning (Tabesh, 2018). The ability of teachers to educate in this digital era must also be improved. Teachers need to be prepared by strengthening their digital pedagogical competencies to design or implement information technology-based learning, while still exploring the values of local wisdom, and implementing teaching strategies that can improve children's thinking abilities to become more critical, creative, and innovative.

Literature Review

21st Learning

21st century learning is defined as learning that gives students 21st century skills, which include creativity, critical thinking and problem solving, collaborative abilities, information technology abilities, and literacy abilities, and social, cultural, and metacognitive awareness (Griffin &

Care, 2012). According to the Organisation for Economic Co-operation and Development (OECD), in order to achieve 21st century learning a school learning environment should have the following characteristics, i.e.: a) **personalised learning**: learning will be more effective if each student receives a learning experience that is adaptable to the conditions of each student (Suparman & Wijayanti, 2019). Different students enter classes with different cognitive structures. Students can learn in the best environment with teaching strategies that suit the individual needs; b) **the importance of motivation and emotions in learning**: motivation for learning, beliefs about one's own abilities, and the existence of learning strategies are prerequisites for successful and lifelong learning. This is consistent with the theory in neuroscience that negative emotions (e.g.: emotions caused by learning material that cannot be understood) negatively affect cognitive function; c) **use various sources of knowledge**: students can gain knowledge whenever they need it from various sources such as books, technology, and experts around the world; and d) **assessment for learning**: evaluation must be done to find out students' deeper conceptual understanding, and the extent to which their knowledge is integrated, coherent, and contextual. Formative assessment is not only used to test students' abilities but to help students assess their own learning progress (OECD, 2008).

Mastery of 21st century skills requires education that is able to adapt learning methods in an effort to meet the demands of the 21st century. This requires teachers that are able to respond and adapt to the needs of students in the future. Teachers play a fundamental role. However, what is important is not the simply the depth the teacher's knowledge, but how well they can act as catalysts for students to foster curiosity and desire to discover something.

M-Learning

Advances in cellular technology allow various applications to be developed and used in mobile conditions. Small screen sizes, limited connectivity, high levels of power consumption, and limited input are just a few minor problems that arise when designing applications for small and portable devices. The biggest problem is the context in which they are used. The aforementioned devices are designed to allow users to use them while mobile, hence the impact of using these devices on user's mobility is an important factor for the success or failure of their application (Harrison, Flood, & Duce, 2013).

M-learning integrates e-learning and cellular communication technology. An important difference between M-learning and e-learning is mobility. M-learning is an e-learning system that is able to support cellular data services. From the perspective of information and communication technology (ICT), mobile learning mobility lies in the indicators of cellular device support and wireless communication technology support (Adi, Deng-yin, & Hai-bo, 2008). From the above definition it can be concluded that M-learning is an e-learning model that refers to the acquisition of knowledge, skills, and attitudes by utilising wireless

communication technology. With the increasingly broad reach of cellular networks, learning services can play an increasing and effective role in education anytime and anywhere.

Mobile Learning Design Principles

The principles in designing mobile learning are given as follows: 1) relevant to the real world, that is, using cellular learning in an authentic context, 2) cellular context, that is, using cellular learning in the context in which the student is located, 3) exploration, which gives students time to explore with cellular technology, 4) blended, that is mixing between mobile and non-mobile technologies, 5) anytime, that is using mobile learning spontaneously at anytime, 6) anywhere, that is, using mobile learning in non-traditional learning spaces (not in the classroom), 7) anyone, that is, using cellular learning is both individual and collaborative, 8) affordances, that is, optimising the benefits of the costs incurred for the cellular technology, 9) personalisation, that is, employing students' cellular devices, 10) mediation, that is, using mobile learning for knowledge construction mediation, and 11) produce, that is, using M-learning to produce and consume knowledge (Herrington, Mantei & Herrington, 2009).

Mathematics Mobile Learning

Mathematics mobile learning is mobile learning for learning mathematics. The National Council of Mathematics Teachers claims that technology is an important tool for learning mathematics in the 21st century, and ensure that all students have access to technology (Skillen, 2015).

Many researchers develop online and mobile applications to introduce teaching in mathematics, such as Geometry, Algebra, Statistics, Mathematical Analysis, and other fields of mathematics. Online and mobile educational tools for mathematics can develop students' problem solving, improve understanding of mathematical concepts, provide dynamic representations of ideas, and foster general metacognitive abilities. Frequent use of cellular technology in mathematics learning will help students to improve their skills on the one hand, and on the other hand will encourage the improvement of mobile learning applications. Drigas & Pappas (2004) have reviewed many mobile learning applications for mathematics. The results of the review indicate that all learning outcomes using mobile technology and applications have a positive impact on students' learning motivation and understanding of the material (Drigas & Pappas, 2004).

Some reasons why information technology on cellular mathematics devices offers solutions to educational challenges are as follows: a) increasing student learning independence, increasing the ability and motivation to conduct experiments, and explore mathematical concepts, b) giving teachers the opportunity to set the level of difficulty according to student ability, c)

limited investment in graphic technology used in classrooms, d) making learning more enjoyable, e) providing real time examples that are relevant to students, f) developing exploration skills in students through personal devices, and g) enabling teachers to get to know students who have problems with mathematical concepts (Riyati, & Suparman, 2019).

The results of a comprehensive analysis and synthesis of 48 studies of mobile learning trends in mathematics since 2000 found that most of the studies focused on the effective use of mobile technology and mathematics learning, as well as the learning design. Another finding is that mobile phones are the most widely used devices today (Crompton & Burke, 2014).

Pedagogical Competency

Pedagogical competence refers to educational and teaching qualifications. A teacher must master pedagogical competency. In pedagogical competency, the quality of teaching must be a primary consideration. This includes coverage, breadth and depth, as well as the ability to plan, initiate, lead, and develop education and teaching, as well as the ability to provide research-based teaching on relevant subjects (Ryegård, Apelgren, & Olsson, 2010). Components in pedagogical competencies include: (1) controlling students' characteristics based on the physical, moral, spiritual, social, cultural, emotional, and intellectual aspects; (2) control of learning theories and principles of learning; (3) developing a curriculum related to the subject matter; (4) conducting educational learning; (5) utilising information and communication technology for learning purposes; (6) facilitating the development of students to actualise their potential; (7) communicating effectively, empathically, and politely with students; (8) conducting assessment and evaluation process and learning outcomes; (9) utilising assessment and evaluation for learning purposes; (10) taking action to improve the quality of reflective learning. The contribution of all these pedagogical competencies can simultaneously or jointly have a significant influence in improving the quality of performance in the learning process (Hakim, 2015).

Digital Pedagogy

In a technology-mediated learning environment, which involves the use of mobile devices, the interactive, open, and non-linear nature of learning requires students to actively analyse, evaluate, and make decisions while manipulating existing information in order to build new knowledge or solve problems. Students must continually compare their existing knowledge with that presented in the learning environment and look for ways to reconfirm their existing knowledge or build new concepts (Ng et al., 2010).

Digital pedagogy is a way to create an environment for cognitive learning that requires a toolkit that is rich in knowledge and not force-fed. To develop such a new paradigm of cognitive learning requires an interactive learning platform and digital resources.

The growth mindset is also another important aspect of digital pedagogy. Students' talents and abilities can be developed and expanded through effort, good learning, and perseverance. Students do not have to believe everyone has the same intelligence, but students can become smarter if they make an effort (Boaler, 2016). Digital pedagogy is a paradigm to attract students and support a growth mindset. Problem solving abilities or "intelligence" can grow with experience on digital pedagogic platforms.

Methodology

The research method used in this study is literature review, which aims to provide an overview of digital pedagogy and its supporting activities in mathematics mobile learning by reviewing certain studies related to the research.

Results and Discussion

Digital pedagogy in learning mathematics is a learning paradigm that enables students to become active partners in finding and developing their own mathematical knowledge (Tabesh, 2018). Boaler (2008) suggests that smart computing devices are able to arrange media for digital pedagogy and influence the way people think and learn. The main key in developing innovative learning models, which is related to the developmental psychology of Piaget (1966), into digital pedagogy in mathematics learning is to increase creativity. In a modern approach to teaching and learning mathematics, students must become partners and active agents in the learning process and problem solving (Tabesh, 2018). This modern approach to learning mathematics is more experimental and collaborative and is based on the principles of "learning by doing" (Dewey, 1897), and authentic learning outcomes, because students are partners in the learning process. Students learn and develop their own knowledge step by step through innovative and creative thinking, experience, and discovery, as well as through collaboration, and teamwork. Access to information and online resources has the potential to change learning, and enable a personalised and collaborative learning environment that is no longer limited to schools and classrooms. Knowledge and skills are gained from cognitive learning by empowering students for daily activities such as data analysis, reasoning, and problem solving (Boaler, 2016).

The success of mathematics mobile learning should be fully supported by the government, especially through professionalism development training for teachers by the related educational agencies to improve digital pedagogy competency. Universities as producers of pre-service

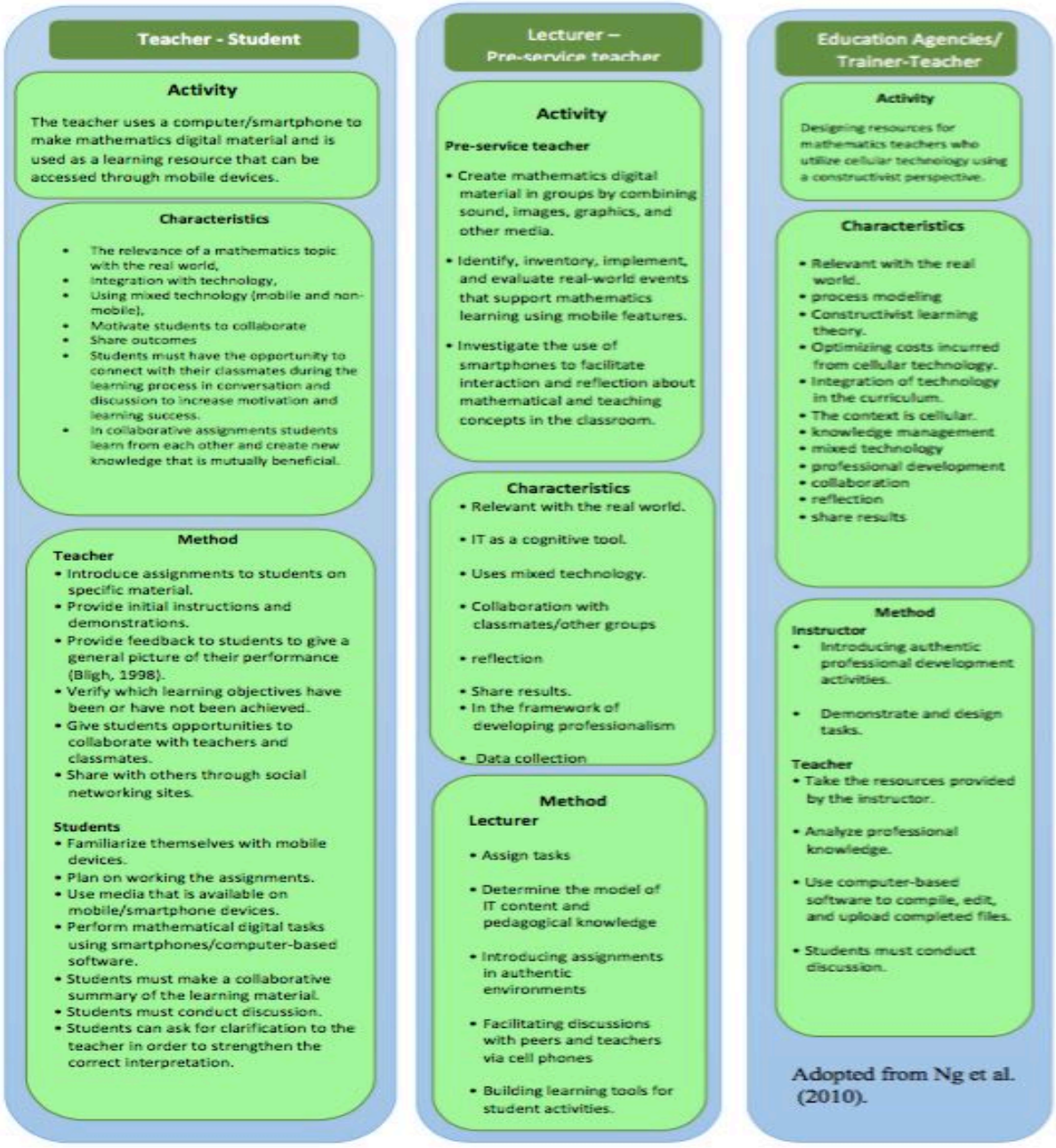
teachers must also prepare their programs to suit the needs of teachers in the 21st century. Based on the theoretical study mentioned earlier, Figure 1 is a design of activities that can be carried out by the government, in-service teachers, pre-service teachers, and students as a series of activities to ensure the success of digital pedagogy by the implementation of mathematics mobile learning.

Teachers plan designs or make task frameworks based on their relevance to the real world. They also provide information and resources needed by students when completing assignments, which can help their workmanship and support student success. Students try to think based on the experience they have, map of topics, and develop ideas. Students work individually or in groups and determine the activities and steps to be taken in accordance with the subtopics, plan the timetable of all sub topics, and save them in a mobile device. Students can ask the teacher or deliberate with friends synchronously or asynchronously via email, chat, and so on. The teacher monitors the activities and achievements obtained by students. Students make reports, presentations, videos, web pages, images or others as a result of the activities carried out. The teacher evaluates all the tasks done by students based on their participation and productivity of the task given.

Competency is based on science, technology, and also learning activities. When the teacher instructs students to conduct peer review with their classmates, the teacher is essentially encouraging his/her students to deeply understand the teaching material they are learning, accept it as new truths, and internalise it in their professional and social lives. At the same time, the teacher also trains students' interpersonal behaviour, communication skills, attitude, and to accept others.

Pre-service mathematics teachers need to be prepared to take advantage of advances in information technology, including mobile technology, to improve the quality of teaching and learning. This in order to prepare superior human resources, who have critical thinking skills, and are creative, innovative, communicative, and able to collaborate and solve problems. The government must develop teachers with a deep understanding of how learning takes place, the ability to work collaboratively, strong skills in technology, and the ability to use technology as a learning tool.

Figure 1. A design of digital pedagogy activities in mathematics mobile learning.



Conclusions

Mastery of 21st century skills requires education that is able to adapt learning methods in an effort to meet the demands of the 21st century. To achieve optimal mathematics mobile learning outcomes digital pedagogy needs to be implemented where students become active partners in finding and developing their own mathematical knowledge. Some learning characteristics that support the success of students are linking mathematical topics to the real world, integrating

mobile and non-mobile technology, offering learning activities that connect classmates during the learning process in conversation and discussion, and also encourage collaboration between students and teachers to create new knowledge (Felicia et al, 2017). In addition, government support is needed to improve the professionalism of teachers with mobile learning competencies as one of the 21st century learning models.

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