Date: 31/08/2019

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Transformation of Research Education at Elementary School Mathematics in the Industry 4.0

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International Journal of Innovation, Creativity and Change. www.ijicc.net
Volume 5, Issue 5, Special Edition: ICET Malang City, 2019

Transformation of Research Education at Elementary School Mathematics in the Industry 4.0

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Industry 4.0 has brought change to all fields. This includes mathematics education, especially at the level of elementary education. The changes that took place in the era of the fourth industrial revolution demanded transformation in the field of research|education at elementary mathematics education. The "|" sign in the phrase signifies an interconnection between the transformations carried out in the world of mathematics education and those carried out in the world of mathematics education research. This paper was devised in order to see changes in the world in the era of Industry 4.0, as well as its impact on the direction of elementary mathematics education and the shifting paradigm of mathematics education research.

Keywords: *Industry 4.0; paradigm transformation; elementary mathematics education and research*

INTRODUCTION

The world in the industrial era 4.0 is seen to have applied cyber physical systems (CPSs) into the cyber physical production system in the industrial field. In America, this term is known as the internet industry (Gorecky, Schmitt, Loskyll, & Zühlke, 2014; Mrugalska & Wyrwicka, 2017; Rainer & Alexander, 2014; Thuemmler & Bai, 2017). This term first appeared in 2011 in Germany and sparked many ongoing debates. However, the influence of this term has entered the realm of politics and education in Germany. Examples of the impact of the industrial revolution in the transportation sector are the possibility of the emergence of high-tech cars, which can detect traffic lights, accidents and or congestion at a certain distance and can automatically adjust the speed to avoid traffic violations that result in accidents.

Given the expanding need for technological developments such as this, the world of education certainly has a role to play in preparing students for generation 4.0 in terms of the structure of the curriculum and material content. These dimensions need to adjust for rapid development and the changes that exist. Then what about in Indonesia itself? How has the Indonesian government welcomed and responded to the industrial revolution?

In Indonesia itself, the fourth industrial revolution began to appear when a large demonstration from taxi drivers and public transport demanded the Uber system and online transportation in 2016. The impact of this fourth industrial revolution was felt long before in 2011 when the Djarum Group collaborated with the online site Kaskus and bought the detik.com site by Chairul Tanjung's Group. Sitorus added that the action 212 was also an impact of the industrial revolution 4.0. because it maximized the role of social media in it (Praherdhiono et al., 2019; Sibarani, Lumbantoruan, Sitorus, Mindari, & ..., 2014; Sitorus, 2018).

The Indonesian government, in this case, the Ministry of Industry, has launched industrial template change programs that have had an impact on changes in education policy. This change in education policy adapts to HR preparation criteria to face work challenges in this new era.

Based on this background, three main things will be discussed in this paper: (1) What are the challenges and paradigms of change that occur in the era of Industry 4.0 that can influence the direction of our national education ? (2) What is the role and direction of education elementary school mathematics in sustaining the flow of this revolution ? and (3) What is the impact of these changes on the shifting direction of the research paradigm, especially in the field of Mathematics education?

To answer these questions, there is a need for a continuous transformation process in the world of Mathematics education and research. However, it is necessary to critically reflect and ask the question: should our direction of education be fully influenced by the swift changes in this flow or does our education need to be able to shape and determine the direction of large changes?

For this reason, in the first part, the author will describe the challenges and paradigms that occur in the era of Industry 4.0. Critically and reflectively, the writer will also invite readers to see the hegemony in this era so that we can build awareness of all the positive and negative effects of the hegemony.

SHIFTING PARADIGM IN THE INDUSTRIAL AGE 4.0

The industrial revolution happened in the 18th century. In 1784, the first Industrial Revolution began with the use of steam engines in the industry. According to Drath and Horch (Rainer & Alexander, 2014), home industries previously dominated the production and supply of goods. After the existence of a steam engine, productivity increased rapidly because the home industry switched to factories that could produce goods on a larger scale. The second industrial revolution took place about a century after it began in Ohio, with the use of electric power and fuel oil to drive conveyor belt machines in factories. Next, in 1969 the findings of an automatic control system by Modicon that used computer programming to drive factory machinery led to the emergence of the third industrial revolution. Industry 4.0 has been developing since 2011 with the first use of wireless and the internet to drive factory machinery in Germany, as mentioned in the background.

Currently, machines that are still using Industrial 3.0 technology are shifting towards Industrial 4.0 technology. In other words, the development of Industry 4.0 is still running and undergoing gradual changes. As seen in Figure 2, Industry 4.0 not only penetrated the area of production of goods but also the production of services and the benefits could be felt more widely by many people. In its journey, Industry 4.0 has changed to what is called the Internet of Thing (Bücker, Hermann, Pentek, & Otto, 2016; Thuemmler & Bai, 2017). Furthermore, in his writing, Hermann et al. explained that the main idea of Industry 4.0 was to connect between Internet of Thing (IoT), Internet of People (IoP) and Internet of Everything (IoE). The point is that this idea allows communication between machines (technology, people, and resources needed). Thus, Industry 4.0 results in a paradigm shift from "centralized systems" to "decentralized control systems." Products produced must be products that can accommodate large data, save, control and process it.

From the explanation above, it appears that technological developments control all types of industrial revolutions that have ever occurred. From Industry 1.0 to Industry 4.0, the technology used is increasingly sophisticated and complex. Consequently, science needs to develop so that it can support the pace of change in the Industrial Revolution 4.0. This, of course, encompasses Mathematics. (Sitorus, 2018) in his writing reminds us of the paradox in the phenomenon of Industry 4.0 because the use of existing technology is like a knife that can be used for good or bad. As one example, he described how a kind of drone technology was used by the United States to carry out bombings in Afghanistan, Libya, Iraq, and Syria, which did not take a few casualties from civilians. In our own country, there are also many data thieves or hackers who use their expertise in developing technology to cheat and steal. Here it appears, that there is a need for a side other than technology that is to be developed in conjunction with the required knowledge.

If so, what kind of mathematics is needed to be packaged in our education world so that we can prepare generation 4.0?. If we look at the need for Industry 4.0 only from the pace of technological development, then the logical answer of these questions will certainly turn to the abstraction of Mathematical concepts needed to support technological developments. Here technology hegemony arises in dictating our mindset that indeed "only" mathematics is just what is needed in this fourth industrial era. Is it true that only Mathematics "like that" is needed for this era? What is the impact on changes in the Mathematics curriculum, especially at the elementary school level?

CHANGES IN THE DIRECTION OF PRIMARY SCHOOL MATHEMATICS EDUCATION

As we all know, during the last five years there has been a change in the Mathematics curriculum at the elementary school level. In the 2013 curriculum, Mathematics was initially integrated with other subjects through a thematic approach at all levels of elementary school. But in the results of the 2013 Curriculum revision conducted in 2016, Mathematics in grades 4 through 6 were separated from the integration model. Which of the two things is more suitable to prepare the generation that faces Industry 4.0? Mathematics integrated with other scientific disciplines or taught separately?

Referring to specific reference sources discussing Industry 4.0, researchers from Germany suggest an absolute requirement to sustain the success of Industry 4.0 is to build understanding across disciplines (Fujimura & Liu, 2007; Gorecky et al., 2014; Hoc, 2000; Schiele & Van Der Helm, 2006; Schuler & Welch, 1994). That means, Mathematics should be integrated with other fields of study in learning to support the objectives of the industrial revolution 4.0. If so, then what are the appropriate fields of study to be integrated with Mathematics at the level of primary education?

Several theories are developing to answer this question. One of them is the idea of STEM (Science, Technology, Engineering, Mathematics) which was originally coined in America. STEM integrates Mathematics with Science, Technology, and Engineering. Looking at the context of education in Indonesia, we certainly think that this idea is only suitable for middle school or college level. However, the results of the study show that STEM can be applied to children to adulthood (Barker, Nugent, Grandgenett, & Adamchuk, 2012; Nugent, Barker, & Grandgenett, 2008; Nugent, Barker, Grandgenett, & Adamchuk, 2010; Nugent et al., 2010, 2009). Nugent et al. Found that children like to be actively involved in robotic activities and the use of geospatial technology such as the use of GPS. This is in line with the arguments of several researchers who use the terms digital immigrant and digital natives. The children of the current generation are digital natives who have grown along with technological developments early on (Hainey, 2006; Prensky, 2006, 2007). Whereas the current generation of educators are digital immigrant who take longer to learn and adapt to new technologies. This causes STEM to be able to run even at the elementary level. However, is STEM sufficient to support the Industrial Revolution 4.0?

We would agree that learning pure science and technology alone is not enough to equip children to become a quality generation 4.0 (Sitorus, 2018). For this reason, an inventor of curriculum ideas, Georgette Yakman, sparked the addition of the integration of Art into STEM to provide the value of creativity and aesthetics in the development of science. STEAM offers more holistic education because it involves aesthetic values of humanity and creativity in STEM learning (Guyotte, Sochacka, Costantino, Walther, & Kellam, 2014; Quigley, Herro, & Jamil, 2017; Robelen, 2011; P. Taylor, 2016; P C Taylor & Taylor, 2019; Yakman, 2010). Global educators and researchers have developed STEAM in several countries, especially Australia, America, China, and South Korea. Is it enough until STEAM?

Of course, there is still a need to establish character and filters that are good for forming technology-literate people, while being responsible for their use and development. For this reason, values and morals are needed for STEAM learning. In the context of education in Indonesia, Pancasila, an integrative auto|ethnography study, concluded that Religion should be added to STEAM (Cetin-Dindar, 2016; Mariana, 2017; Murdiana & Lefrida, 2019; West & Staub, 2003). This is in line with the first principle of Pancasila which needs to be made more applicable in the learning of each field of study (not only Religious Education). The authors believe inserting the values of local wisdom and the goodness of religion will be able to reduce the negative impact of the current Industry 4.0, which is misused because of its immoral human resources and knows no goodness of religion.

Furthermore, the STEAM base is located in "T" which stands for Transformative (P. Taylor, 2016; P C Taylor & Taylor, 2019). Transformative education theory was initiated by Mezirow's adult learning theory. Humans are helped in learning by using the frame of reference that they have from the experience, culture, and identity attached to it (Mezirow, 1991, 1997, 2003). Transformative learners will be fully aware of the changing viewpoints that occur in the learning process because of the critical reflection that they make on the reference framework they have. This theory underlies the paradigm shift of research, including the research paradigm in Mathematics Education.

SHIFTING IN THE MATHEMATICAL EDUCATION RESEARCH PARADIGM

Mathematical research that involves only abstract concepts, logically, should not be equated with Mathematics education research involving humans. Philosophically there are two different views regarding Mathematics Education (Cornelius & Ernest, 1991; Ernest et al., 1991). The first view states that mathematics should be free of values and culture because of the exact, rigid, and objective nature of mathematics. This has an impact on their views on Mathematics education where Mathematics learning is dominated by abstractions and does not include culture and good values. While the second view states that Mathematics in the history of its development follows the development of human civilization, which is inseparable from social and cultural values. This second view raises the idea of ethnomathematics, which in its development not only inserts culture but also inserts moral messages and social justice (D’Ambrosio, 2007, 2017).

The differences and developments of the two views above influence the paradigm shift that has occurred in research in the field of Mathematics education from the positivist paradigm, which is characterized by quantitative research, towards a multi-paradigm that combines and integrates various qualitative research paradigms (See Figure 3). The positivity paradigm, which has dominated educational research with quantitative methods and its mix-method, has become a hegemony in the world of educational research because of the influence of rigid scientific methods and demands empirical evidence that ignores the subjectivity of researchers. This is not surprising because this paradigm was adapted from scientific research that was abstract and empirical so that objectivity was prioritized (S Grundy, 1987; Shirley Grundy, 1987). However, this becomes problematic if forced to always be applied to qualitative research that makes humans the object of their research. In translating qualitative data researchers cannot deny that they will certainly use their subjective interpretations, feelings, emotions, and criticisms. Therefore in this multi-paradigm study, researchers are required to honestly acknowledge their subjectivity and open themselves to the hegemony of their views, so that the critical interpretations and reflections that they carry out in translating qualitative data will be well understood by readers of his qualitative research.

The paradigm shift in research in the field of education does not need to be debated too greatly, because each study has a different purpose and the selection of research paradigms that are used can be adjusted to that goal so that there can be a transformation in educational research. An integral perspective in transformational research that combines the paradigm of positivity to postmodern can be done if the knowledge to be gained in the study requires a combination of all or part of existing paradigms (Luitel, 2019; Luitel & Taylor, 2019; Peter Charles Taylor, Taylor, & Luitel, 2012). Thus, what is the implementation in Mathematics education research for the Industrial 4.0 era?

From the description above, the author believes that all these paradigms are needed to develop research that requires empirical data but does not forget human values, emotions, feelings, culture, and religious values. Objective research is still very much needed to develop mathematical abstractions that are useful for the development of technology and other sciences. However, it would be wonderful if this was also juxtaposed with transformative research that considered the values of local wisdom, culture, and local culture, so that existing technological developments can be in harmony with the values of universal good that are adhered to and agreed upon by the world community.

CONCLUSION

Changes in the world in the era of Industry 4.0 have an impact on the need for a transformation process in education, especially Mathematics education in elementary schools. Mathematics education in elementary schools should be integrated with other fields of study to prepare generation 4.0, both in the form of STEM, STEAM, or STREAM. However, to reduce the negative impact of this fourth industry flow, the author suggests inserting local values and the goodness of religion in Mathematics education. This can also influence the type of research paradigm chosen.

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