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The STEAM Integrated Panca Pramana Model in Learning Elementary School Science in The Industrial Revolution Era 4.0

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Education in general, and science education in particular, have close links with culture. This can be seen from the function of education, which is empowering human potential to inherit and develop future cultures and civilisations. Until now, science education in Indonesia has tended to be adopted from the western model. The science curriculum that applies in formal schools, starting from Kindergarten, Elementary School to College, is adopted based on western culture. This shows the independence of the Indonesian people in science education. As a result of the practice of education that adopts western culture-style education that does not necessarily fit the style of the nation's own culture, it has been proven to succeed in forming a generation that is less confident, *inferior* and infatuated with western culture. Other impacts, can be seen from the still low quality of the Indonesian Human Resources. The innovative idea offered in this paper is the STEAM integrated panca pramana model.

Keywords: *science learning, learning cycle, panca pramana, STEAM*

INTRODUCTION

The world continues to move forward marked by various changes. At present, the world is engaged in the industrial revolution 4.0, which is characterised by *cyber* physical and manufacturing collaboration (Irianto, 2017; Sunarno, 2018). Industrial revolution 4.0 is characterised by the presence of new technologies that merge the physical world, digital and biological, which is manifested in the form of robots, computers, artificial intelligence, a vehicle without a driver, editing genetic material, digitisation in public services etc. (Firman, 2018). Furthermore, Lee, et. al. (2013) explained, industrial revolution 4.0 was marked by an increase in the digitalisation of manufacturing, which was driven by four factors: (1) increased data volume, computing power, and connectivity; (2) the emergence of analysis, capability and business intelligence; (3) the occurrence of new forms of interaction between humans and machines; and (4) the improvement of digital transfer instructions to the physical world, such as robotics and 3D *printing*. Lifter and Tschiener (2013) state that the basic principle of industrial revolution 4.0 is the incorporation of machines, workflows, and systems, by applying intelligent networks along the chain and production processes to control each other independently.

Taking into account the principles and characteristics of the industrial revolution 4.0, it appears that the industrial revolution era 4.0 is a period of competition. In this regard, the Minister of Manpower, Hanif Dhakiri, reminded people that competitiveness must be strengthened (Kompas, 2 July 2018). The challenge now is to improve the competence of labour in the fields of science, technology, engineering, and mathematics, while still paying attention to the arts, with increasing competence in the fields of Science, Technology, Engineering, Arts and Mathematics (STEAM); which can be done through education. Education should innovate in line with the demands of the times. The educational process paradigm will undoubtedly experience fundamental changes, adjusting to the demands of the industrial era 4.0. Consequently, the industrial revolution will induce a revolution in education to become education 4.0.

Education in the industrial revolution era 4.0 needs to be seen as the development of 21st century competence, which consists of three major components, namely the components of thinking, acting, and living in the world (Greenstein, 2012). Components of thinking include critical thinking, creative thinking, and problem solving. The acting component includes communication, collaboration, digital literacy, and technology literacy. The components of life in the world include initiative, *self-direction*, global understanding, and social responsibility. Firman (2018) conducted a study of views on the characteristics of education 4.0, which led to the following learning features:

1) Learning is student-centred. The strategy is to provide opportunities for students to learn according to their interests and the speed of their learning.

2) Learning develops students' abilities. The strategy is that that learners explore their own knowledge of the sources of information using the Internet, as a vehicle for them to life long-learning.
3) Utilisation of ICT infrastructure and virtual learning devices. The strategy is to provide flexibility for students to find quality learning resources, record data, analyse data, and compile reports and make presentations.
4) Emphasising *hands-on* learning through learning methods called the "*flipped classroom*". With this method learners learn aspects of theoretical knowledge at home and practise in the classroom. This method develops habits and abilities of *self-learning* while providing more loose learning time for learning in schools for developing competencies.
5) Develop the soft-skills of critical thinking, creativity, and problem solving, especially authentic and non-routine problem solving.
6) Collaboration and social interaction as the main approaches used in competency development, to introduce work culture in the world of industry and the world of work in the 21st century.
7) Provide flexibility for the learning process in the form of *blended learning*, which allows students to interact, collaborate and learn from each other in class settings and *distance* via the internet.

Science education as part of education programs in schools, which are given from elementary and secondary education, hold a strategic position in preparing students to face the industrial era 4.0. Therefore, according to Firman (2019), this required reinforcement in the design and implementation of science education in the era industrial revolution 4.0, that includes: (1) Science content covered in the school's science curriculum needs to be more selective to the level of essential concepts to avoid the "material-laden" curriculum; (2) Enhancing the relevance of science education in the industrial revolution era 4.0 that can be done by including elements of industrial case studies related to selected science concepts that are taught, including a *flow chart* of industrial processes, production installations, machinery, process control, separation, yield, and handling of chemical industrial waste (Hofstein and Kesner, 2006); (3) Science education in the industrial revolution era 4.0 is functioned intensively to develop 21st century skills, consisting of 4C, namely *critical thinking and problem solving*, creativity and innovation, collaboration, and communication; and (4) Science education in the industrial revolution era 4.0 also needs to contribute to the development of Information and Communication Technology (ICT) skills, in the sense that it not only uses ICT as a learning media, but integrates these technologies for the entire laboratory work and science research, including *searching* for information from websites, recording data from observations and measurements, transforming data into visual form, making reports, and presenting research results.

Besides doing reinforcement-strengthening above, operationally the science needs to be packaged in learning in accordance with the demands of the times. One alternative learning approach that is deemed appropriate in the industrial era 4.0 is STEAM. STEAM is a further development of STEM by adding elements of Art. STEAM as the theme of the educational reform movement in the US to grow the workforce in the fields of STEAM, as well as develop citizens who are STEM literate, and increase US global competitiveness in science and technology innovation. STEAM's education does not only mean strengthening educational praxis in the fields of STEAM separately, but also developing educational approaches that integrate science, technology, engineering, art, and mathematics, by focusing the educational process on solving real problems in everyday life and professional life (Thai National STEM Education Centre, 2014).

The rapid change in the era of the industrial revolution 4.0 may not revoke the roots of education itself, namely culture. Education has a close relationship with culture. This can be seen from the function of education, which is empowering human potential to inherit, build and develop culture and future civilisations (Suastra & Tika, 2011). Until now, science education in Indonesia tends to still be adopted from western culture. The science curriculum that applies in formal schools, ranging from kindergarten, elementary school to college is adopted based on western culture. This shows, the independence of the Indonesian people in science education (Suja, 2011). As a result of the practice of education adopting the "ala" education of western culture, which is not necessarily compatible with the style of the nation's own culture, it has been proven to succeed in forming a generation of hedonists, consumptive, proud of external products, and feeling *inferior* to domestic products. Other implications, can be seen from the still low quality of education in Indonesia.

The UNDP report revealed that Indonesia's *Human Development Index* (HDI) in 2012 and 2013 was ranked 108 out of 187 countries (UNDP, 2014). *The program for International Student Assessment* (PISA) in 2009 ranked Indonesia as the top 10, the biggest of the 65 participating countries in PISA. The assessment criteria used included: cognitive abilities and skills of students in reading, mathematics and science. Almost all Indonesian students turned out to only master the lesson up to level 3. Meanwhile, many students from other developed and developing countries master lessons up to level 4, 5, and even 6 (Majelis, 2013). This level 3 in the revised Bloom taxonomy shows the ability of students at the level of remembering, understanding, and applying. While levels 4, 5 and 6 are related to high-level thinking skills. High-level thinking skills are needed in the 21st century in the face of the industrial revolution 4.0.

In anticipation of such problems, Stanley & Brickhouse (2001) suggested that science teaching in schools should balance western science (modern science) with a native science (traditional science) using a cross-cultural approach. A similar opinion was also conveyed by Ogawa, who stated that if the modern science subculture taught in schools is harmonious with the subculture of students' daily lives, then science teaching would tend to strengthen students' views about the universe. Conversely, if it is different, let alone contradictory, then science teaching will tend to destroy or separate students from their culture (Ogawa, 1995). This connotation is very negative because it involves cultural imperialism, which students usually resist by paying less attention to lessons (Jegede & Aikenhead, 2002).

Based on the above conditions, the idea of an integrated STEAM panca pramana model is very appropriate to be developed in science learning in elementary schools. As is known in elementary schools, according to the 2013 Curriculum, learning uses thematic approaches by integrating a number of subjects into one theme. Panca pramana is ways of learning in accordance with the pedagogic of local wisdom which is presented in one branch of Hindu philosophy (nawa darsana), namely mimamsa darsana (Seregig, 2012).

METHOD

From the point of language, science comes from the Latin language that is from the word Scientia meaning knowledge. However, the statement is too broad in everyday use. For this reason, other etymological studies need to be raised. Experts view the proper etymological boundaries of science, namely from the German language, with reference to the word wissenschaft, which has the understanding of knowledge that is structured or organised systematically. Conceptually there are a number of understandings and limitations of science proposed by experts. Amien (1987), defines science as a field of natural science. Whereas Collette (1994) defines science as a series of concepts and conceptual schemes that relate to each other, which grow as a result of a series of experiments and observations and can be observed and tested further. The same thing was expressed by Abruscato (1995), who gives an understanding of science as a theoretical science based on observation, experiments on natural phenomena in the form of macrocosm (universe) and microcosm (the contents of a more limited universe, especially about humans and their properties).

Analytically, some experts try to give limitations to science by dividing science based on the dimensions of the study. Sumaji (1988) states that narrowly science is Natural Science, consisting of physical sciences and life sciences. Including physical sciences are the sciences of astronomy, chemistry, geology, minerology, meteorology, and physics, while life sciences include biology, zoology and physiology. Carin (1993) views science from three aspects, *first* from the aspect of goals, science is a tool to control nature and to contribute to human welfare. *Second*, science as a systematic and resilient knowledge in a sense is a result or conclusion obtained from various events. *Third*, science as a method, which is a set of rules to solve problems, to get or know the cause of an event, and to get the laws or theories of the object being observed.

From the description above, a substantial understanding of science can be drawn. Based on the definitions that have been presented, it can be concluded that science can be viewed as both a process, a way of thinking, and a product, as well as an attitude. In other words, science can be seen as a unity of processes, ways of thinking, attitudes and results. At the elementary school level, it is expected that there will be an emphasis on learning SETS (Science, Environment, Technology, and Society) directed at learning experiences to design and make a work through the application of science concepts and competency in scientific performance (Kemendikbud, 2013).

Science Subjects in Elementary Schools is in accordance with the 2013 Curriculum, that aims to have the following abilities (Kemendikbud, 2013): (1) Obtaining confidence in the greatness of God Almighty based on the existence, beauty and regularity of His creation; (2) Developing knowledge and understanding of science concepts that are useful and applicable in daily life; (3) Developing curiosity, positive attitudes and awareness of the existence of interrelating relationships between science, environment, technology and society; (4) Developing process skills to investigate the environment, solve problems and make decisions; (5) Increasing awareness to participate in maintaining, and preserving the natural environment; (6) Increasing awareness to respect nature and all its order as one of God's creations; and (7) Obtaining knowledge, concepts and skills in science as the basis for continuing education to junior high school/MTs.

1. Definition of Panca Pramana

Humans were created by God equipped with tri pramana. Tri pramana are three basic types of potential that humans have, namely: *sabda*, *bayu*, and *idep* (Sanjaya, 2011). *Sabda* mean that humans have the ability to speak. *Bayu* means that humans have the ability to move. *Idep* means that humans have the ability to think. With *Tri Pramana*, humans can carry out various life activities. In the context of education, the tri *pramana* can be used as a means of conducting learning and learning activities.

Learning is intended to gain knowledge/truth (*pramana*). Hinduism has several ways/methods in obtaining a truth. These methods are contained in the teachings of *nawa darsana* (9 Hindu philosophical systems) (Pendit, 2005; Gunawan, 2012). One of the studies in this study is the *mimamsa* philosophy. According to the philosophy of the *mimamsa* there are six sources of knowledge, namely *pratyaksa* (perception), *anumana* (inference), *upamana* (comparative), *sabda* (verbal testimony), *arthapatti* (postulation), and *anupalabdhi* (noncognition). Furthermore, Prabhakara stated that he did not accept non-cognition (absence) as a source of knowledge (Seregig, 2012). Thus, the source of knowledge consists of five types (*panca pramana*).

2. Cycle Learning Panca Pramana

The rationale for the *panca pramana* based learning cycle is that this knowledge can be proven. Proof of knowledge can be done in various systematic ways. *Mimamsa* is one branch of Hindu philosophy that emphasises inquiry in acquiring knowledge/truth. The meaning of *mimamsa* itself is an investigation (Pendit, 2005). According to Prabhakara (Seregig, 2012), mimamsa has five ways in conducting investigations to obtain knowledge/truth (panca pramana). *Panca pramana* consists of *pratyaksa pramana*, *anumana pramana*, *upamana pramana*, *sabda pramana*, and *arthapatti pramana*.

Praktyaksa pramana is knowledge gained by observing directly. That is, learning can be done by directly dealing with learning material objects. *Anumana pramana* is knowledge obtained by logical reasoning. That is, learning can be done by drawing conclusions based on existing facts and initial knowledge already possessed. *Upamana pramana* is knowledge gained by using comparisons/parables. That is, learning can be done by comparing an object with other objects that have been previously known. *Sabda pramana* is knowledge gained by listening/reading from trusted sources. That is, learning can be done by listening to information from the teacher or reading a book. *Arthapatti pramana* is knowledge gained through an act that becomes a principle in order to explain two conflicting experiences, with the intention of eliminating the conflict of experience so that later it becomes clear knowledge. That is, learning can be done by making estimates (hypotheses) based on facts and knowledge that have been previously owned.

The *panca pramana* concept above can be used as a systematic learning cycle in obtaining scientific knowledge/truth. The learning cycle can be started from one of the *pramana* and then followed by the other *pramana*. The choice of a cycle can be adjusted to the characteristics of the material being taught.

RESULTS AND DISCUSSION

a. STEM and STEAM in Science Learning

Mastery of Science and Technology is the key to facing challenges in the era of industrial revolution 4.0. One characteristic of life in the era of industrial revolution 4.0 is the occurrence of very rapid changes. Education should be able to prepare students who have comprehensive knowledge and skills so that they can survive in the midst of very rapid changes. Comprehensive knowledge and skills are related to the fields of Science, Technology, Engineering, and Mathematics (STEM).

STEM has been applied in a number of developed countries such as the United States, Japan, Finland, Australia and Singapore. STEM is an initiative from the National Science Foundation. The aim of implementing STEM in the United States is to make these four fields (Science, Technology, Engineering, and Mathematics) the main career choices for students (PPPTKIPA, 2019). This situation occurs because the country is experiencing a scientific crisis in the STEM field. The seriousness of the United States government to overcome this problem, among others, is by establishing STEM Education and providing tuition assistance to prospective students who choose one of the STEM fields. But in recent years, STEM has been applied to various fields of study or departments at various levels of education.

STEM has been widely applied in learning. This situation is shown from the results of research that reveal that the application of STEM can improve academic and non-academic achievement of students (PPPTKIPA, 2019). Therefore, the application of STEM which initially only aimed to increase students' interest in the STEM field became wider. This situation arises because after being applied in learning, it turns out that STEM is able to increase mastery of knowledge, apply knowledge to solve problems, and encourage students to create something new.

The main characteristic of STEM education is integrating science, non-engineering, engineering, and mathematics in carrying out real problem solving (Firman, 2019). STEM education is an interdisciplinary approach to learning, in which students use science, technology, engineering, and mathematics in real contexts that connect between schools, the world of work, and the global world, so as to develop STEM literacy that enables students to compete in the new economic, knowledge-based era.

In further developments, STEM is deemed inadequate to answer challenges of the times because of lack of attention to the aspect *of art*. Therefore, STEM needs to be developed by integrating art, so that it becomes STEAM. The integration of art in STEM so that it becomes STEAM is expected to be able to make learning more meaningful, because students are involved in realising learning competencies that must be achieved in real form in the form of work (Hadinugrahaningsih, 2017).

Science education has a strategic position in taking part in preparing a generation that has STEAM literacy. STEAM literacy can be grown in students through science learning using the STEAM approach. Science learning based on STEAM in class, is designed to provide opportunities for students to apply academic knowledge in the real world and produce real work. Learning science with the STEAM approach trains students to think critically, creatively, collaborate and communicate. Therefore, learning with the STEAM approach supports the achievement of 21st century skills (Permanasari, 2016; Hadinugrahaningsih, 2017).

Learning with the STEAM approach must fulfill several aspects in scientific and engineering practice, also illustrating the existence of the crosscutting concept or slices of concepts between science, technology, engineering, art and mathematics. In addition, *Higher Order Thinking Skills* (HOTS) are a necessity in their learning and assessment. In the context of learning and integration that might be carried out, without having to restructure the curriculum, is to incorporate engineering content, technology, art, and mathematics into STEAM education-based science learning, as illustrated in Figure 1.

In general, the application of STEAM in learning can encourage students to design, develop and use technology, sharpen cognitive, manipulative and affective skills, and apply knowledge (Permanasari, 2016). In other words, STEAM-based learning can train students to apply their knowledge to create designs as a form of solving problems related to the environment by utilising technology.

b. STEAM Integrated Panca Pramana Model

This model is a design that describes a system in the form of stages. Yang, *et al.* (2005: 167-168) state that the model is a narrative description to describe the procedure in achieving a specific goal. In the field of education, the model is often associated with learning, so it is known as the learning model. Joyce and Weil (2016) explain the learning model is a plan or pattern that can be used to build a curriculum, design learning materials needed and to guide learning in the classroom or in other learning situations. Furthermore, it is said that the function of the learning model is as a guide for learning designers and instructors in designing and implementing learning. Meanwhile, Arends (1997) defines the learning model as a specific approach to learning which includes goals, syntax, environment, and management of the class.

Suyono & Hariyanto (2015) explain that each learning model consists of: (1) rationale, (2) steps, (3) description of the relevant support system, and (4) a method for assessing students' abilities. Meanwhile, according to Arends (1997) the learning model must describe four main things, namely: (1) a coherent rational theory, (2) the output of learning achieved, (3) certain teacher behavior, and (4) a certain class structure.
Joyce and Weil (2016) state that the learning model has five (5) main elements, namely syntax, reaction principles, social systems, support systems, and instructional impacts and accompaniment impacts.

1) Syntax

Syntax is a sequence of learning steps that points to the phases that must be done by educators when using a particular learning model. Syntax is a description of the process and structure of learning activities by educators and learning activities of students to achieve learning goals. The STEAM integrated *five-pram* model syntax in science learning can be formulated as shown in Figure 2.
The description of the STEAM integrated *panca pramana* model syntax formula can be described as follows (example of the *panca pramana* model syntax starting from the *sabda* stage).

Stage 1. *Sabda*

At this stage, students are welcome to seek knowledge from various sources, both through print sources such as books or online sources. This stage also means that the teacher can emphasise the essential concepts that will be studied along with the delivery of contextual issues related to Science, Technology, Engineering, Art, Mathematics (STEAM) to attract students' learning interests.

Stage 2. *Pratyaksa*

At this stage, students carry out exploration activities through direct observation of the object being studied. In science learning, this stage can be done by conducting experiments.

Stage 3. *Arthapati*

At this stage, students formulate hypotheses on existing problems. At this stage, students are intended to think critically by analysing alternative answers (temporary guesses).

Stage 4. *Anumana*

At this stage, students make conclusions based on an analysis of data, facts, and information collected through exploration activities. This stage is intended to train students carefully and thoroughly to compile and connect various data, facts, and information.

Stage 5. *Upamana*

At this stage, students associate the knowledge gained with knowledge before what they already have. At this stage, it is also intended to link Science knowledge with Technology, Engineering, Art, and Mathematics (STEAM).

2) Reaction Principle

The principle of reaction shows educators how to respect or assess students and respond to students' responses. The principle of reaction is related to the pattern of activities that describe the way educators see and treat their students. This reaction principle provides an overview of how educators use game rules that apply to each learning model. The principle of reaction of the STEAM integrated *panca pramana* model is: (1) educators provide assistance to students, both when exploring and analysing the problems faced, (2) educators provide reinforcement for every effort made by students, (3) educators respond to each student experiencing problems in learning, and (4) educators give equal attention to each student.

3) Social System

The social system indicates the role of educators and students, their relationship in learning and the norms of interpersonal behavior. The social system is the pattern of educator relationships with students at the time of the learning process. The STEAM integrated five-pram model social system is (1) learning is centred on students and teachers as facilitators, (2) teachers help students, when students experience problems, and (3) learning is carried out in groups and conducting conservation / investigative activities.

4) Supporting Systems

Support systems that are related to all facilities and infrastructure, tools, and materials needed to support the implementation of the learning process optimally. This STEAM integrated *panca pramana* model support system is a learning tool such as the Learning Implementation Plan (RPP), Student Participant Worksheet (LKPD), various tools and materials needed in LKPD, and reference books. In addition, other support is needed in the form of *wifi* (internet network).

5) Instructional impacts and accompaniment impacts

Instructional impact is the direct impact of the learning process carried out using certain learning models on certain materials as well. The direct impact is in the form of learning outcomes achieved by students according to the learning objectives. While the impact of accompaniment is the side learning results achieved as a result of the use of certain learning models. The instructional model integrated with STEAM's five pram models in science learning can achieve understanding of concepts, scientific and technological literacy, and science skills. While the expected impact of the accompaniment is the formation of scientific attitudes, mathematical literacy and engineering, increased collocation skills and student communication.

CONCLUSION

The rapid development of the world, and now entering the era of industrial revolution 4.0, must be balanced with fundamental changes in the world of education in general, and science education in primary schools in particular. Science education in elementary schools that has been implemented so far has not been integrated with other disciplines and must be abandoned and directed towards integrated science education. Likewise, science education, which has neglected local wisdom so far as the peculiarities of a nation and region, must begin to shift by utilising its own local cultural potential.

Integration of various scientific disciplines and local wisdom requires an approach or model that it is more operational. The approach that can be used to facilitate learners to learn comprehensively is the STEAM approach. STEAM is an acronym for Science, Technology, Engineering, Art and Mathematics. The STEAM approach can be implemented through various existing learning models or the design of new learning models. In order to accommodate the STEAM approach while adhering to the wisdom of local culture, an idea of the integrated STEAM *panca pramana* model was formulated in science learning in elementary schools.

The importance of learning science in elementary school (SD) is because students at elementary school are the foundation for students to understand science from an early age, so that they grow in love with nature and admire the greatness of God as the creator of the universe and its contents. In addition, science in elementary schools is the basis for children to learn more about science at a higher level of education. Science in elementary schools can educate students to become a "young scientist" while remaining based on local cultural wisdom.

Panca pramana is ways of learning in accordance with the pedagogy of local wisdom which is described in one branch of Hindu philosophy (*nawa darsana*), namely mimamsa darsana. STEAM integrated *panca pramana* model in science learning in elementary schools can be formulated syntactically with five learning steps, namely: *pratyaksa pramana*, *anumana pramana*, *upamana* pramana, *pramana pramana*, and *arthapatti pramana*.

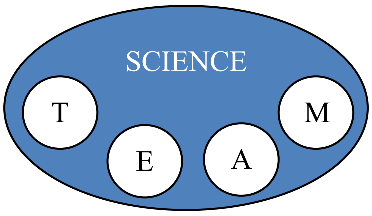

Figure 2.1 STEAM-Based Science Education

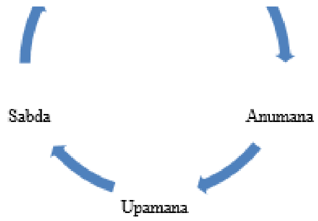

Figure 2.2 Formulation of the STEAM Integrated Panca Pramana Model Syntax

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