Implementation of Competency Enhancement Program for Science Teachers Assisted by Artificial Intelligence in Designing HOTS-based Integrated Science Learning

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Abstract

Education currently supported by technological developments such as artificial intelligence (AI) and robotics. Science learning based on higher-order thinking skills (HOTS) is needed as the main goal in learning. AI in teacher professional developments are the new way to be implemented. The purpose of this research was to describe the competency enhancement program for science teacher that assisted by AI in designing HOTS-based integrated science learning. 29 science teachers in West Java participated in this program. Descriptive analysis was used to analyze the data from all participants. The results revealed that the program held in blended learning with face-to-face sessions about higher order thinking skills in science learning, use of multiple representations in science learning, construct of science learnings' theme, integrated science learning, and continued by online learning by web based-AI. Science teachers perceived helpfulness to integrate various science content, followed courses, held discussion, answer the tests, and validating lesson plan products. Teachers has new experiences for the implementation program.

Keywords: Integrated Science Learning, Artificial Intelligence, HOTS.

INTRODUCTION

The future of education is very dependent on the existence of new technologies in providing and responding to various challenges for teaching and learning. Technology in general has a role, especially as a facilitator to achieve learning goals. The application of new technology is needed by presenting artificial intelligence (AI) which can be able to engage in experts-like abilities, so it can learn, adapt, synthesis, self-correction and use of data records for complicated processing (Huda et al., 2017; Popenici & Kerr, 2017; Roll & Wylie, 2016). AI to improve the quality of education is increasingly being accelerated and massive to use at various levels, not only for students, but also for teachers who are dealing with various administrations and teaching.

Teacher administration can take the form of lesson plans that are unique artifacts in lesson preparation and reflect teachers' goals for their lessons. The existence of these lesson plans is often used as evidence or teacher insights, especially knowledge, perceptions, and curricular choices in teaching (Sias, Nadelson, Juth, & Seifert, 2017; Wallace & Coffey, 2019). It's involves the integration of content knowledge and pedagogy that needs to be continuously trained in teacher professional development (Bidarra & Rusman, 2017; Cigdemoglu & Köseoğlu, 2019; Shulman, 1986). The development of teacher professionalism is important because it is seen as the key to gaining skills and knowledge in developing students' interest in science in scientific inquiry and higher order thinking skills (National Research Council, 2009, 2012; Sias et al., 2017).

The involvement of technology in the development of teacher professionalism is needed to increase participation and effectiveness of program implementation, especially by presenting AI (Castro-Schez, Glez-Morcillo, Albusac, & Vallejo, 2021; Gunawan et al., 2021; Gunawan, Liliasari, Kaniawati, & Setiawan, 2020; Holstein, McLaren, & Aleven, 2017; Xhakaj, Aleven, & McLaren, 2017). The condition of science teachers who have different scientific backgrounds causes various difficulties to arise in Integrated Science learning. The interdisciplinary linkage between various science content and directing it in learning is one of the difficulties and often presents various misconceptions (Gunawan, Liliasari, & Kaniawati, 2019; Rubini, Ardianto, & Pursitasari, 2019; Sun, Wang, Xie, & Boon, 2014; Winarno, Widodo, Rusdiana, Rochintaniawati, & Afifah, 2019). Whereas science learning requires interconnection in explaining natural phenomena in an integrated manner in

terms of physics, chemistry, biology, earth and space science, and various other branches of science.

Regarding the development and design of integrated science learning, the existence of Higher order thinking skills (HOTS) is one of the prerequisites for 21st century skills (Care, Griffin, & Wilson, 2014; Ma'ruf, Handayani, Marisda, & Riskawati, 2020; Onsee & Nuangchalerm, 2019). HOTS in integrated science learning can prepare students to be able to face and solve daily problems critically and creatively in accordance with developments in technology and science (Muskita, Subali, & Djukri, 2020; Siburian, Corebima, Ibrohim, & Saptasari, 2019). This situation is something that must continue to be developed for science teachers in designing HOTS-based Integrated Science learning with the help of the latest technology in the form of artificial intelligence (AI).

METHOD

Descriptive method was used in this research to investigate case studies on the implementation of teacher competency enhancement programs. The participants consisted of 29 science teachers with various scientific backgrounds. eight teachers in biology education, twelve teachers in physics education, five teachers in chemistry education, and four teachers in science education. They were invited as representative of various junior secondary schools in West Java, Indonesia. Data collection was conduct by three instruments: test of integrated science, peer teaching observation sheets, and questionnaire of program evaluation.

RESULTS AND DISCUSSION

Program Implementation

The competency enhancement program for science teacher was implemented in blended learning. This strategy was chosen by integrating face-to-face and online-based learning through http://sipino.com. In the face-to-face sessions, some theme of learning: HOTS-based learning in science, multiple representation, learning themes in integrated science, and some type of curricula in integrated science must be followed by all participants. Online learning was carried out asynchronously. Various features were available in the system, involve: 1) diagnostic test, 2) integrated science themes, 3) integrated science courses, 4) online forums, and 5) types of curricula suggestions in integrated science learning.

Systems account was required by participant by filling their identity and various supporting data. Participants must answer some questions as diagnostic test, before the system gives some suggestion. This data uses for providing suggestions in the form of types of curricula, content integrations, learning themes, course suggestions, and

online forums. Each user got different suggestions based on their result in diagnostic test. The example of suggestion given by system is presented in Figure 1.

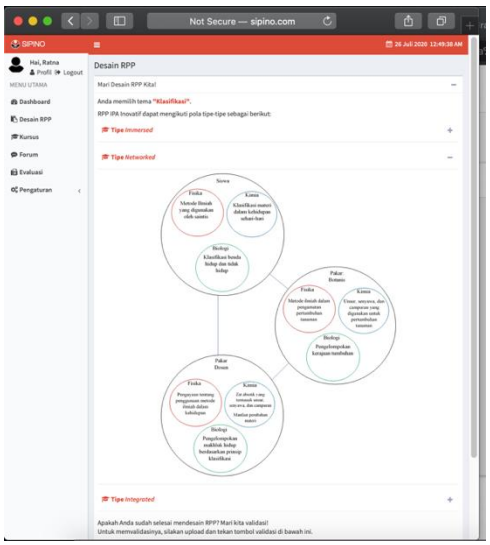

Figure 1. Suggestions given by the system for integrated science content

Figure 1 provided example suggestion in networked type of curricula integration that involved some experts to engage in their science learning. User can follow the system suggestion or ignored it and use their own knowledge into their lesson plan. Others example suggestions is discussion activities in online forums. User can also follow some topics that held by administrator to give the answers or help other users. The additional features were provided in the form of “like” to capture the participants' responses to the system suggestions. The example of the online forum is presented in Figure 2.

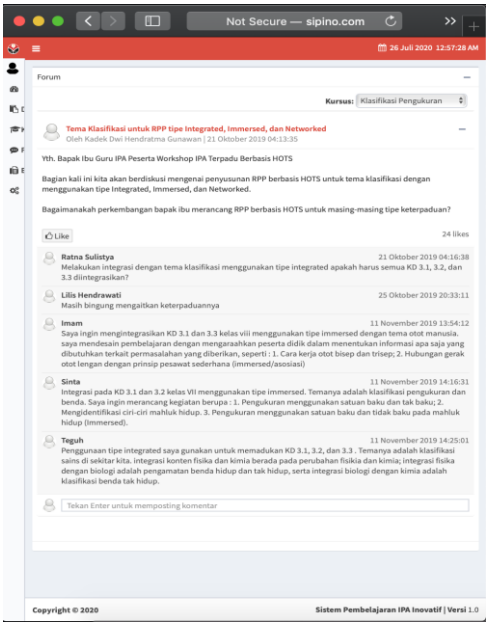

Figure 2. online forum suggestions

Based on all suggestions from the system, users are directed to create HOTS-based integrated science lesson plans. This task must be validated by administrators in order to be used in peer teaching sessions and their learning at school.

Introducing AI to participants in integrated science learning was a challenging part. The system design was made to be user friendly. This is because participants have never used AI in education. AI unconsciously has actually reached all sides of life. Technology products from the big apple.inc company use "Siri" as one of AI's products embedded in Apple devices, also "Cortana" on Windows devices and "Google Assistant" on Google / Android devices; Google also uses AI in search and map systems (Google Maps); braking systems in today's vehicles; and

can also be a self-driving system in modern cars (Popenici & Kerr, 2017). The use of AI in education can also be in the form of an expert systems whose scope are flexible and broad in the form of: self-assessment, communication and collaboration including group formation, and various other learning needs (Różewski et al., 2019). It can occur in blended learning environment (Elfeky, Masadeh, & Elbyaly, 2020; Hamed & Samy, 2017). AI in education also applied in the form of an gamification to mastery the concept (Saprudin, Liliasari, Setiawan, & Prihatmanto, 2020), or Intelligent Tutoring System (ITS) which can be applied in a flipped classroom to help users deal with problems in the course, and the result implies that users feel helped, improve self-efficacy, self-adjustment, and support social interaction (Castro-Schez et al., 2021; Jiménez, Juárez-Ramírez, Castillo, & Armenta, 2018; Mohamed & Lamia, 2018), collaborative learning, conceptual knowledge, and problem solving (Olsen, Belenky, Aleven, & Rummel, 2014).

Program Evaluations

The program evaluations consisted of two parts: evaluation of the process and evaluation of the product. Evaluation of the process includes participants' test of integrated science and responses to program implementation. The result of the test present in Figure 3.

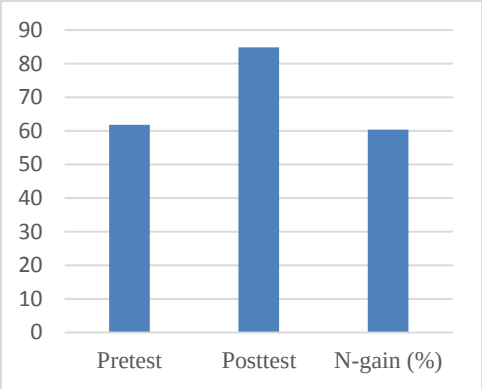

Figure 3. Result of the test of integrated science

The participants had good skills in integrating various integrated science content. Their competency enhances (N-gain = 60.45) after follow the courses and online forums that suggest by system. These results indicate that with AI-assisted training programs, they can attend courses and online forums according to their initial knowledge. The directions given by the systems can be used as a reference for participants to update their knowledge.

The Participants' interest can also be seen from the number of likes obtained by each course and online forums with high results (average = 84.32%). Topics of the courses and online forums are made more attractive in order to provide motivation and challenges for participants. This indicates that they like the topic suggested by the system.

Participants responses on the program implementation show good results. The implementation of

competency improvement programs in general can help participants in designing HOTS-based integrated science learning. Some participant response present: "My new experience was AI assistance in sipino.com. The suggestion provides information needed to designing HOTS-based integrated science learning. The curricula suggestion and the courses were my favorite features, update knowledge provided by the system based on my result" (Participant A from West Bandung). "I usually made the lesson plan in one basic competency, while in this implementation program, the curricula can integrate various science content in different basic competencies in same level. Integrated science learning made more practical and interesting" (Participant B in Bandung City).

The evaluation of the product consisted of the HOTS-based integrated science lesson plans. At least one lesson plan was made by each participant as a task (Figure 4) and must be presented in peer teaching. The lesson plan products generally made focus on critical and creative thinking with little proposed problem solving and decision making. This is also related to a topic that has developed in online discussion forums where teachers more interested in critical and creative thinking skills.

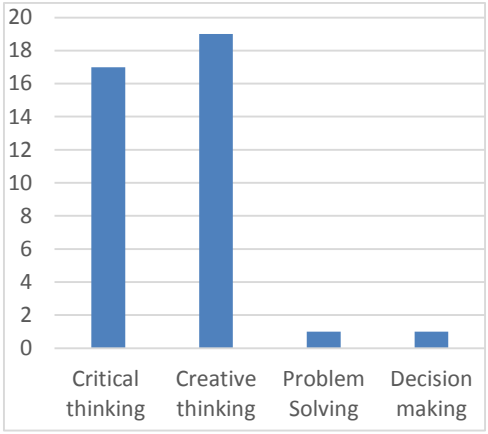

Figure 4. Result of HOTS-based integrated science lesson plan

Example of the lesson plan presented by A from Bandung City, used networked type of curricula integration. Basic competencies 3.4 and 3.5 on seven grade into one learning theme about. The learning theme about "heat and energy in our daily life". The learning objectives are made so that students able to analyze the various factors that affect the temperature of objects due to the provision of heat and use it as a source of heat energy. The involvement of experts was also carried out with the task of online consulting doctors as project about the process of metabolism and human body temperature. The teacher facilitates each group of students through the questions on the worksheet. Critical thinking skills are trained through learning activities. Students are asked to formulate hypotheses from the problems that exist in the worksheet. Then students conduct literary studies, conduct experiments, and discuss to identify

factors that affect the temperature rise of objects and use them as a source of heat energy. At the end of the activity the award was given to all groups and students were asked to conclude the learning activity and relate it to the next material. Critical thinking skills are measured by instrument tests.

Participants gave good responses to program implementation. The flexibility of AI when helping participants and asynchronous blended learning becomes a new experience in enhancing the competencies of science teachers. Participants can arrange an appropriate time and space to take part in online courses and discussions in blended learning (Fung Choy & Quek, 2016). By taking courses and having online discussions, participants can collaborate with each other and convey their arguments in building critical knowledge (Peterson & Roseth, 2015; Wang, Kollar, & Stegmann, 2017). Regarding the diverse scientific backgrounds of teachers, the collaboration in knowledge construction is well facilitated (Noroozi, Weinberger, Biemans, Mulder, & Chizari, 2013; So, 2013). Besides that, it can also overcome weaknesses in face-to-face learning to present various abstract objects, or even dangerous in terms of updating knowledge (Mamun, Lawrie, & Wright, 2020; Rubini, Permanasari, & Yuningsih, 2018). This benefit directly impacts higher-order thinking skills, literacy, and social involvement in learning activities. (deNoyelles & Reyes-Foster, 2015; Goodsett, 2020; Jenny & Sebastian, 2012; Lee, 2015; Wogu et al., 2019; Yang, Lee, Hong, & Lin, 2016). This is very beneficial for science teachers with different learning activities in their teaching and learning.

Participants' needs and appropriate recommendations are the keys to the successful application of AI in learning. (Desouza, Dawson, & Chenok, 2020; Nappi & Cuocolo, 2018; Roll & Wylie, 2016; Timms, 2016). This technology can be like a pedagogical agent in order to be able to provide predictions to assist decision making in self-regulated learning (Duffy & Azevedo, 2015).

The process of knowledge update through courses and forums is very helpful in designing lesson plans. Participants can combine their knowledge with various system suggestions. Participants can also share information with each other and adapt to their lesson plans.

CONCLUSION

The implementation of competency enhancement program that assisted by AI can be helpful for science teacher. The implementation carried out by blended learning generally has an impact, especially on the knowledge of

science teachers and lesson plans in the context of integrated science learning. The various suggestions recommended by AI become an interesting and new thing for all participants.

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