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Exploring Science Teachers' Lesson Plans by the Implementation of Intelligent Tutoring Systems in Blended Learning Environments

K. D. H. Gunawan[1,2,*], S. Liliasari[1], Ida Kaniawati[1], Wawan Setiawan[3]

[1]Department of Science Education, School of Postgraduate Studies, Universitas Pendidikan Indonesia, Indonesia
[2]Department of Computerized Accounting, Politeknik Ganesha Guru, Indonesia
[3]Department of Computer Science, Universitas Pendidikan Indonesia, Indonesia

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Abstract Recent technological developments have increasingly supported the science learning that presents artificial intelligence as part of Internet of Things (IoT). Its implementation can be carried out through Intelligent Tutoring Systems (ITS) in blended learning environment. This technology was used to support 29 Indonesian junior secondary science teachers in creating innovative lesson plans, which are members of competencies improvement programs. The purpose of this study was to describe the lesson plans that contain an integrated science teaching, supported by ITS in blended learning. The lesson plan product was analyzed descriptively. This Qualitative method was used to determine its characteristics about curriculum integration, learning activity, technology integration, higher order thinking skills, and assessment process. The result revealed that most teachers have strongly represented aspects of these all required aspects. The lesson plan created reflects the ability of teachers who are creative and capable to integrate various contents in learning activities. Learning activities are student-centered oriented to higher-order thinking skills. Technological support applied in learning activities is also an aid for students to be more motivated, as well as the presentation of assessment aspects that are relevant to the learning objectives. There are still some inadequacies in these results to be discussed. Thus, the potential future researches for supporting the science teaching are highly welcomed.

Keywords Blended Learning, Intelligent Tutoring Systems, Integrated Science Learning, Lesson Plans

1. Introduction

The impact of technology in science teaching has become an interest to be widely studied in the last few decades for the sake of creating more innovative science teaching and learning. [1] [2] [3] [4] [5]. This aim results on the beneficial learning material and tools in order to achieve the expected competences and skills. Both can provide a variety of positive impacts for explaining various abstract phenomena, providing deeper explanations, fostering interest in learning, and providing feedback on problems [6]. The latest developments are artificial intelligences in education as part of the Internet of Things (IoT) [7].

Nonetheless, technological progress has not yet coincided with science education. PISA results show that students' performance in literacy, mathematics, and science are still below than OECD average, and the results of science performance have not increased significantly since 2006 [8]. These results can be caused by differences in the scientific qualifications of science teachers in Indonesia. Generally, science teachers in Indonesia have separated qualifications into physics, chemistry, and biology education [9]. The impact arises when the science teachers' abilities are insufficient, and then, there is still misconceptions both students and teachers appeared to integrate science contents [10] [11].

Technological support by applying IoT is used to improve the quality of science learning through teacher competencies development programs. The implementation is using the Intelligent Tutoring System (ITS) and blended/hybrid learning [3][12]. The systems have been designed to facilitate students and assist them to make decision recommendations in real-time. ITS in blended learning is focused on supporting users to work with adaptive learning technology based on their level of progress (one-on-one user supports) [13].

The current research on the development and use of ITS and blended learning is carried out in various scientific fields. The results showed that learning with Self-Regulated Learning (SRL) and involving ITS in human circulatory system material can help students in achieving high learning goals and achievement, as well as scaffolding abilities in the form of prompt and better feedback. In addition, learning that involves such adaptive technology can also increase motivation, so the students have high motivation to engage with their learning [14]. Blended learning can also increase motivation by combining context, technology, and pedagogy in science learning that is flexible, interactive, and uses the latest technology [15]. Both can improve student performance and integrated science process skills [16].

Because of its usefulness to improve the quality of learning at various levels of education with very little research has investigated the science teachers' lesson plans supported by ITS in the blended learning environment, the researcher feels motivated and eager to develop a study on how to generate and facilitate innovative science learning by applying blended learning and ITS. Hopefully, it can practically assist teachers in generating innovative science learning, and also enhance the teacher's quality.

2. Materials and Methods

Twenty-nine of science teachers joined the competency improvements program held by the Indonesia University of Education. This program is intended to master integrated science, improve higher-order thinking skills, and develop innovative lesson plans. These teachers have an age range of about 28 to 52 years old. Qualifications of these teachers are physics education (44.82%), biology education (31.03%), chemistry education (13.79%), and science education (10.35%). About 27.58% were teaching VII grade, 41.37% were teaching VIII grade, and 31.03% were teaching IX grade. In the opening program, participants were given information about the objectives and benefits and introduced to all the participating team members.

Participants use ITS in a blended learning environment to design lesson plans. The use of blended learning combines face-to-face session learning with the ITS online system to enable extensive discussion, interaction, and communication [15] [12]. Face-to-face learning sessions are divided into several sub-sessions, namely: 1) higher-order thinking skills in science teaching (6 hours), 2) multiple representations (4 hours), 3) themes in integrated science teaching (4 hours), 4) the ways to integrated science teaching (6 hours), 5) designing innovative integrated science lesson plan (10 hours).

The ITS system is designed in the form of online-based adaptive hypermedia, a system that has technology support with the adaptive ability and shows flexibility during learning [19]. The development of ITS consists of several main components (Figure 1), namely: 1) expert module, 2) domain module, 3) user model, 4) pedagogical module, and 5) user interface [18].

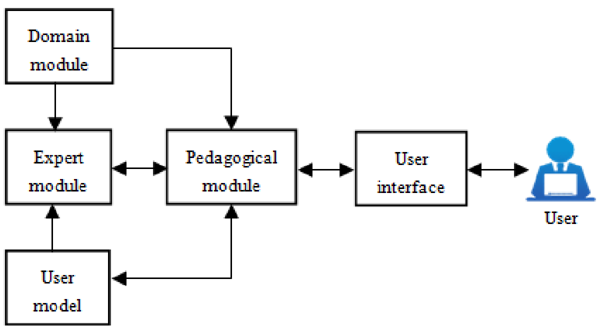

Figure 1. Design of Intelligent Tutoring Systems (ITSs) [18]

That system designed adaptively as expert systems so that it can give some suggestions like 1) diagnostic test, 2) choosing learning theme, 3) combining several basic competences become one theme, 4) joining some course, and 5) entering group discussion. The suggestion of part three using integrated, immersed, and networked types as formulated by Fogarty [17] for designing lesson plans as shown in Figure 2.

The user model will identify science teachers who are the new user or having account through the login features. If new, the user will be guided to create identity stored in the user model database. After successfully logging in, participants can begin learning and use all features. The expert module will direct to determine the learning theme first, and then provide a diagnostic test based on the chosen theme. The results can be immediately known after completion and saved into the user model. If it fails the test, the system will provide suggestions in the form of attending courses and group discussions. Here the expert module together with the pedagogical module selects the course stored in the domain module to the user based on its most appropriate characteristics. Then both of them will suggest integrating basic competencies based on integrated, immersed, and networked types.

User has the choice to determine the course topic on its own (independent learning mode) or lets the system help it (tutorial mode). Independent learning mode can be chosen if it meets the specified requirements. Lesson plans production is one of the outputs to be uploaded and validated by experts through this system. All of them were analyzed in a qualitative description which was adapted according to [20] as in Table 1. In this blended learning, it there has also carried out peer teaching based on participants' lesson plan for evaluation.

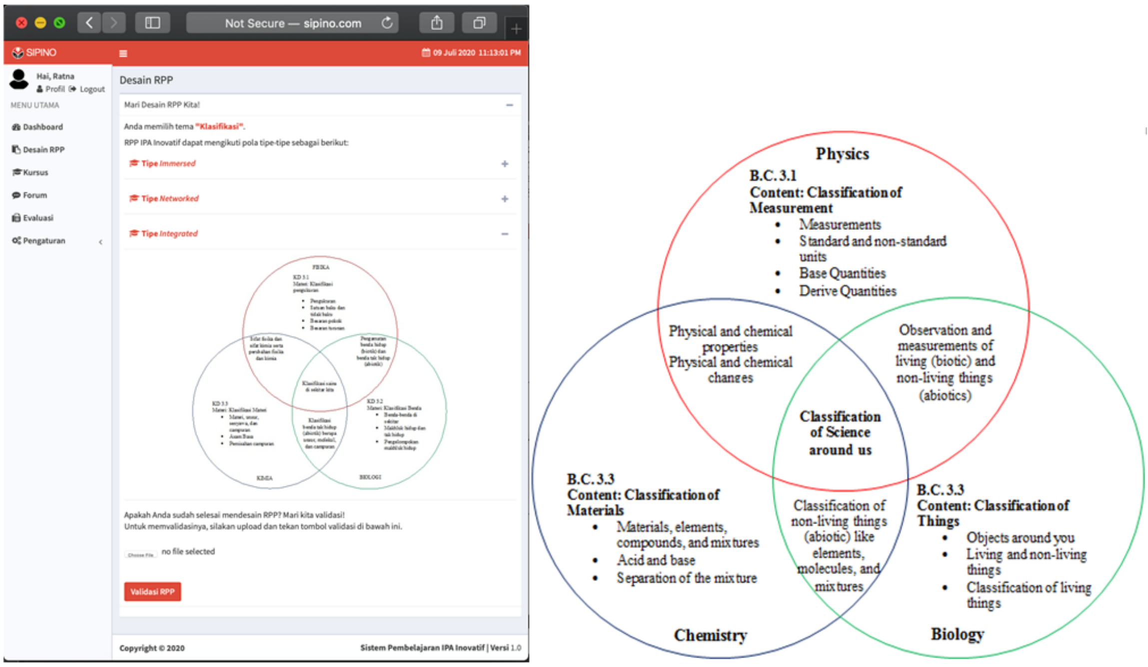

Figure 2. Example of integration using integrated type as suggests by ITS

Table 1. Criteria of integrated science lesson plans

Criteria and Items	Very inappropriate	Inappropriate	Appropriate enough	Appropriate	Very appropriate
Curriculum integration	No integration	Small integration	Partial integration	Large integration	Well-done integration
Learning activity	All by teacher	Mostly by teacher	Shared at same time portion	Mostly by student	All student
Technology integration	No technology integration	Small technology integration	Partial technology integration	Large technology integration	All technology integration
Higher order thinking skills	No skills developed	One skill developed	Two skills developed	Three skills developed	All 4 skills developed
Assessments procedure	No assessment	Irrelevant assessment technique	Relevant assessment technique	Relevant assessment technique and rubric	Complete assessment (form, technique, and rubric)

Table 2. Overview of the lesson plan results

Criteria and Items	**Descriptions**
Curriculum integration	Learning theme have presented in interesting way, made in accordance with the experience of students, capable of covering the basic competencies required and made using integrated, immersed, and networked types.
Learning activity	Learning activities facilitated the activeness of students in their learning as a mind-on and hands-on activity.
Technology integration	Technology integration used to present material and explain phenomena to students, as well as to support each part of the lesson plan.
Higher order thinking skills	Higher-order thinking skills are implemented along with 21st-century skills contained in student learning activities such as critical thinking skills, creative problem solving, decision making, collaboration, communication, characters, and literacies.
Assessments procedures	Assessment procedures have presented techniques and rubrics that are relevant to the learning objectives.

3. Results and Discussion

3.1. Results

There are 29 lesson plans done by participants during the program implementation. All of them use various types of the integrated curriculum which are divided into 12 lesson plans using integrated type, 9 lesson plans using immersed type, and 8 lesson plans using networked type. All lesson plans that are made are generally categorized as good. In accordance with the characteristics of integrated learning, the compiled lesson plans emphasize the learning process through direct experience. The teacher only acts as a facilitator while students as fact-finding and information actors to develop knowledge. Overview of the lesson plan results have shown in Table 2.

3.1.1. Curriculum Integrations

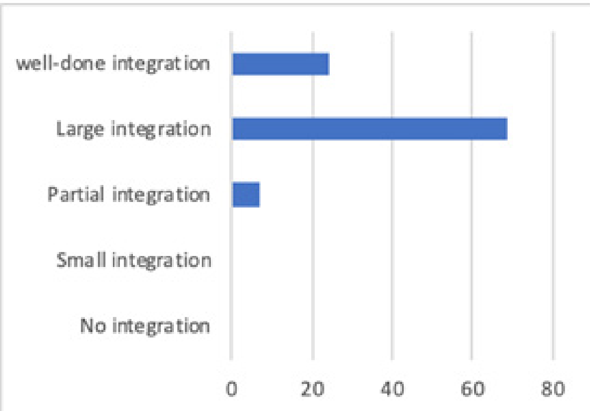

Figure 3. Percentages of curriculum integration

Integration of several basic competencies into one theme using integrated, immersed, and networked types. All of 29 lesson plans include the main integration of biology, chemical and physical content. Integration is also carried out by connecting to various other branches of science such as health, technology, environment, astronomy, and geology. Most of the relationship lies in the application of the integration contents, such as when discussing the classification of matter, in the geology fields that's the earth which is composed by various elements and mixtures, and also various forms of physical and chemical changes. The percentage of all curriculum integration is presented in Figure 3.

Lesson plans are generally in the category of large integration, which the design integrates two or more content areas of basic competences. In the partial integration section, there is still not appropriate or not related integration. For instance, only making activities measure length, mass, and time by considering accuracy without linking it to other concepts. In the large integration section, science teachers have been able to share between two or more content of basic competencies, but have only connected the content, the skills and attitudes developed for students are presented separately from the curriculum integration. In the well-done integration section, they have been able to integrate the curriculum well. Integrity is also seen when integrating students' skills and attitudes. While learning the theme of "the classification of science around us", the main content in basic physics competency explains the classification of measurements and scientific methods, biology about the classification of objects, and chemistry about the classification of matter. The intersection of biology and physics becomes the observation of an object that allows developing students' critical thinking skills. The intersection of physics and chemistry has changed the form of substances designed to develop creative thinking skills. The intersection of chemistry and biology becomes chemical changes in the process of photosynthesis designed to develop scientific process skills. All intersections are designed by developing attitudes such as curiosity, honesty, conscientiousness, diligence, discipline, objective, tolerance, cooperation, and responsibility.

3.1.2. Learning Activity

Learning activities developed in the lesson plan are appropriate, student-centered, and accommodates hands-on and minds-on activities. Learning activities are divided into three parts, namely introduction, main activities, and closing. The introduction activities begin with orientations and give apperception which generally takes assimilating student experiences about the learning. At the main activity, the students' involvement in learning appears generally by involving science process skills directly or simply implied. Their activities are generally described as 1) observing, 2) comparing, 3) classifying, 4) measuring, 5) communicating, 6) making inferences, 7) predicting, 8) composing hypotheses, 9) defining and controlling variables, and 10) interpreting data. In addition, learning activities also include scientific inquiry that accommodates learning activities in the form of asking questions, planning experiments, testing hypotheses (predicting), analyzing data, and drawing conclusions. There are no core learning activities that are entirely carried out by the teacher or students only in the whole lesson plan. There is equal distribution of time between the teacher and students and mostly done by students (Figure 4) in the closing section done by reflecting and feedback on the learning process to make conclusions in general. Besides that, some also gave assignments or small quiz, rewards, and information about planned learning activities for the next meeting.

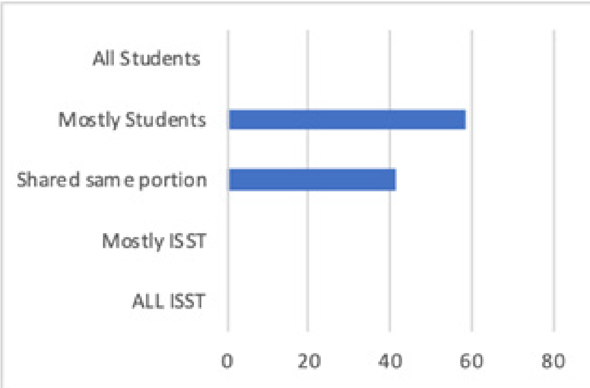

Figure 4. Percentages of learning activity

The core learning activities that divide the same time between teacher and student designed into some activities such as displaying a video about goods in the market and showing walking and playing demonstration, then displaying a robot toy. Students observe the video and demonstration as an introduction to classification of living things. Students ask "what is the relationship between walking teacher and a robot?", after that they are directed are directed to make predictions about the characteristics of living and non-living things. The teacher guides students to do a grouping about living and non-living things. Students search the data through student worksheets to fill in the grouping of plants, animals, and non-living things, classifying of plants by filling in the names of plants, benefits, and parts of plant groups (i.e. vegetables, fruits, etc.), classifying of animals by filling in animal names, body parts, wings and number of legs, classifying of non-living objects by filling in the name of the object, form of the object, and its benefits. Students review and discuss the benefits of classifying living and non-living things, and comparing the results of discussions with other groups. The group representative then explained the results of the discussion in front of the class and expressed their opinions based on observations and discussions. Students conclude and note the results and also receive further exposure by the teacher. The teacher invites students to give thanks for God's gift of order and the complexity creation regarding to the classification as religious attitudes.

The dominant main learning activities carried out by students designed to simplify the way of introducing diverse living creatures based on their characteristics. The teacher guides students to dichotomize the classification of living things. Students are expected to be able to ask about the meaning of dichotomous classification. The teacher divides students into heterogeneous groups. The teacher assigns students to bring 10 types of whole plants with roots, stems, leaves, and flowers (if any). Students are given the flexibility to determine their classification patterns depending on the accuracy of students to observe the similarities and differences which are delivered using student worksheets. Students formulate hypotheses and questions about the classification. Students are invited to explore and make dichotomous classification of plants by paying attention to plant characteristics. This result is predicted to invite very varied classification patterns, even in the same plant species. Students make observational comparisons with their hypotheses and provide an interpretation of the data obtained. Student work is presented in groups in front of the class to be responded together with the teacher and other groups. From the results of the discussion, students can appreciate the work of their friends despite the different classifications.

Another instance is in the form of students observing the picture presented by the teacher about the comparison of measurements using the meter and hand span. Students are expected to give questions about "will the results of the measurements same?" Students are directed to develop learning objectives independently in their groups about the standard and non-standard measurements, identify the characteristics of living things, and measurements using standard and non-standard units of living things. Students experiment in groups to collect data using student worksheets, then process it, discuss it, and analyze it. Students are invited to answer questions in student worksheets. Students verify observations, answers with data or theories on relevant books and internet sources. The students then present their work in front of the class and their discussion results are concluded together by the teacher and other groups.

3.1.3. Technology Integrations

Technology use in learning processes that are designed commonly supports every step of the lesson. There are only few lesson plans without using any technologies. However, there are no lesson plans in complete technology integration. All lesson plans spread in small, partial, and large integration technologies. This is seen in Figure 5 which shows the percentage of technology integration in the lesson plan.

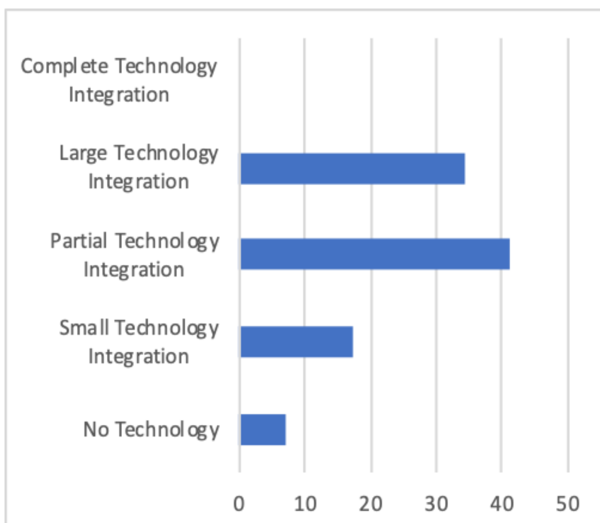

Figure 5. Percentages of technology integration

Technology integration in the lesson plan in the small category in question is that learning activities only use a little technology and tend not to be interactive. The use of this technology is only used to convey learning objectives in the beginning and present pictures and video phenomena such as the use of standard and non-standard measuring instruments, before students begin to work on the worksheets provided in the category of partial technology integration, where technology has a greater role to support learning activities but not in the main activities. Teachers in this category use a lot in the concluding form of using applications to give quiz and tests to students such as using the Quizizz and Plickers applications; or use the Google Classroom platform to deliver material and collect assignments. The use of technology included in large integration is technology presented interactively and plays an important role in the core learning activities. Technology is presented not only to present material and phenomena, but hands-on and minds-on activities can also be facilitated, such as using Quizizz also to present material, various standard measurement classification activities based on Macromedia Flash Player and Android, students can also present the results observations using Microsoft PowerPoint.

3.1.4. Development of Higher Order Thinking Skills

The lesson plan has been designed to develop students' high-order thinking skills in the form of critical thinking skills, creative thinking skills, problem-solving, and decision making. This is evident from a variety of student learning activities that are described directly or indirectly. The percentage is addressed in Figure 6.

Any comments and suggestions are welcomed so that we can constantly improve this template to satisfy all authors' research needs.

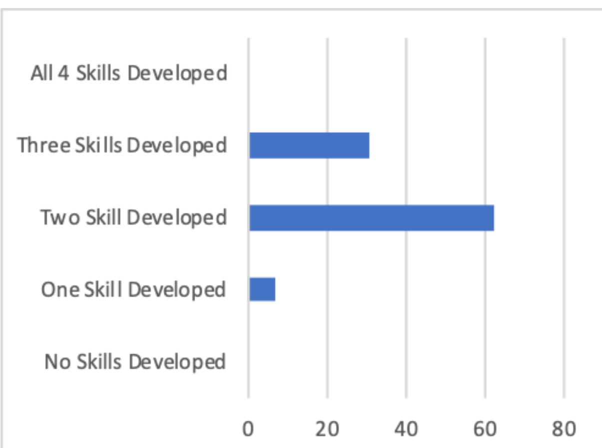

Figure 6. Percentages of Higher Order Thinking Skills

These percentages in general two higher-order thinking skills were developed. For instance, the development of critical thinking is shown by asking questions and answering questions such as "Are the same results shown between measurements using a ruler and fingers?", Formulating hypotheses, determining interaction actions in student groups, and constructing arguments in interpreting data obtained based on the classification process, living and non-living things, then concluding. Development of creative thinking skills can be in the form of reasoning activities and also includes testing the formulation of problems and hypotheses that have been made previously, grouping various types of plants freely in dichotomous patterns to arouse students' curiosity by looking at patterns and information from various points of view and concluding learning activities mentioned in groups and between groups. Development of problem-solving skills appears when the teacher presents problems about the characteristics of living and non-living things through demonstrations by the teacher that walking and presents robot toys. Students are asked to classify problems regarding what components are included in the characteristics of living and non-living things, and how to distinguish them in groups. Students predict these characteristics and then describe it and conclude it. Likewise, with decision-making skills students can evaluate the characteristics of living and non-living things and decide on the parts that are relevant to them, including concluding.

3.1.5. Assessments Procedures

The assessment process in the lesson plan has generally been listed to assess students' attitudes, knowledge and skills. The criteria for a good assessment process can be covering learning objectives through the form, technique, and rubric. The percentage of assessment procedures in the lesson plan is presented through Figure 7.

In the lesson plan, there is not found any kind of assessment procedures. Few science teachers only develop assessment techniques without the rubric and present a complete assessment to evaluate learning objectives. One example of the technique used is a written test in the form of multiple choice, scientific project assessment sheet and its rubric, attitude and rubric assessment sheets, or skills and rubric assessment sheets.

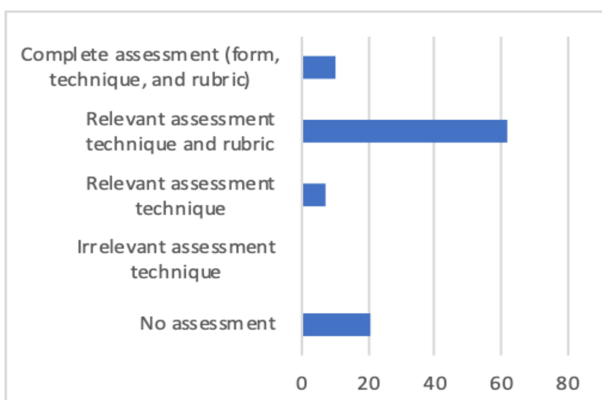

Figure 7. Percentages of Assessment Process

3.2. Discussion

This study has a purpose to describe the science teachers lesson plan that developed through ITS in blended learning environments. We discuss the results and implications that show that through ITS in blended learning, teachers are able to create lesson plans that can contain science content in an integrated way, integrate basic competences into one curriculum theme, create learning that is able to activate students, engage technology in it, develop thinking skills high level, and presents an assessment pattern that is relevant for use in learning. However, the results also show that there are some lesson plans that do not involve technology in their learning and do not provide access to assessments. To understand it, it can be predicted from the low ICT literacy of some science teachers, so they cannot follow the activities suggested by the system properly.

This system is designed to assist teachers in preparing lesson plans with the support of suggestions by ITS and ICT in which literacy plays an important role. The other part of this research shows that some teachers have minimal ICT literacy and are also constrained by internet signals in their area which is a challenge in implementing science teacher competency improvement programs through ITS and blended learning. Another reason that may occur is the limitations of ICT, and it requires much costs, risks, and some planning at school. However, the overall lesson plan product designed has been able to create the desired integrated science learning.

Science teachers initially had difficulty in developing lesson plans integrated with science learning. It is because they need scientific background and can be helped by this system. This is due to the ability of the system to advance a one-to-one approach. Adaptation system is very useful to improve the quality of teacher's lesson plan, because teachers want to update their knowledge, so that it can create lesson plans and improve student performance in the classroom [21]. Likewise, with the feedback provided by the system to help users to access any assistance provided, the performance improvement can be achieved significantly [22] [23] [24], and also it can be implemented as MOOC to enhance teacher abilities [25].

One basic part is curriculum integration. The advice given by the system is very useful for developing learning activities based on the integration of basic competencies. This is very useful to facilitate the problem of scientific background to create integrated science learning [26]. Although integrating the curriculum requires effort, coordination, collaboration, and communication between science teachers in creating the latest innovative learning, it can also help teachers to share knowledge and create good interactions. As science learning is required by NGSS that science learning includes 3 dimensions in the form of practices, crosscutting concepts, and core ideas [27], through this way the teacher can make it happen to create innovative learning.

The results also indicate a link between student learning activities and developed higher-order thinking skills. Both make learning activities more meaningful because student activities are directed at critical thinking skills, creative thinking skills, problem-solving skills, and good decision-making abilities. This result is supported by the results of research showing that both have a relationship between science process skills and inquiry learning with critical thinking skills [28] [29], creative thinking skills [30] [20] [31], problem solving abilities [32] and decision making [33].

The implications of the development of this system to support science teachers in developing lesson plans must continue to be developed. The findings of this study is also expected to be further developed, especially to improve the quality of learning, as applied to students, and facilitate interaction between teachers and students in virtual classrooms. This research can stimulate a better collaboration going forward between researchers in the fields of science and education, science teachers, researchers in the field of computers, and AI developers.

4. Conclusions

ITS in blended learning has been able to support science teachers to create lesson plans that contain science content with integrated ways. It can synchronize basic competencies into one learning theme, create learning that is able to activate students, involve technology in it, develop higher-order thinking skills, and present assessment patterns which are relevant to be used use in learning. This research also provides suggestions for the development of teacher competencies that have been carried out to be more effective, due to the limited time and place owned by teachers. The adoption of the latest technology can help them in creating innovative learning in various fields of education.

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