Utilizing digital learning technology to enhance 21st century skills: Case study in mathematics

Dr. Erwinna Chendra[1], Agus Sukmana, MSc.[2]
[1,2]Department of Mathematics, Parahyangan Catholic University, Bandung, Indonesia
[2]Learning Innovation Center, Parahyangan Catholic University, Bandung, Indonesia
erwinna@unpar.ac.id, asukmana@unpar.ac.id

Abstract

The exponential rates of technology advancement, like it or not, happy or unhappy, demands changing in various fields that including education. Although it is relatively slow compared to the industrial revolution, the world of education currently invites every academic community to get out of the comfort zone and dare to try new things by utilizing technology, both in digitizing the administrative system or supporting the learning process. A lecturer is expected not only to share knowledge, which can be found on the internet, but to improve the skills needed by students in the 21st century. This 21st century skills include critical thinking / problem solving, collaboration, communication, and creativity. For basic sciences, such as mathematics, many lecturers are still teaching in the conventional way (there must need books, whiteboards, and markers). Admittedly this method may no longer be interesting for today's students. In this paper, we share our experiences using technology in supporting the learning process over the past two years. Despite of many obstacles and challenges, we are quite sure that the use of this technology can support a more systematic, interactive, and right on target learning process. One of the advantages using technology is that lecturers are no longer merely a source of knowledge but students can learn independently and have more in-depth experience during the learning process. Through this paper, we also hope that our activities can provide new ideas for other lecturers to make changes from conventional methods to more modern ways by utilizing technology.

Keywords: Digital learning technology, 21st Century skills, Mathematics

1. Introduction

Information and Communication Technology (ICT) has had a huge impact on our community life and changes the way that we communicate, learn, work, and socialize. Over the years, ICT application has been used extensively in education. In the early days of computers, lecturers realized the prospective of digital learning materials to make education better from a management point of view because digital content can be easily managed and distributed to large groups of learners. With the rapid development of technology, digital materials offered additional affordances over "traditional" print materials that can significantly enhance the quality of education such as multimedia, interactivity, and others. With the emersion of the internet, lecturers also realized the potential for supporting new forms of web-based learning.

Although still plays an important role in the learning process, the lecturer no longer gives the same influence as in the past. Students don't need lecturers to give them with lots of

knowledge anymore, because knowledge and content are all around them. What students really need is help exploring, making connection, and analyzing all of that information. Students need opportunities to feel as though they are in educational partnerships with lecturers—a zone of mutual respect, proficiency, and wisdom.

During the past years, the increased interest in utilizing technology to improve the quality of learning has led to significant growth in practice and research of ICT in education. Several national policies and practices worldwide are aiming at utilizing digital technologies to promote the integration of ICT into education and meeting the 21st century life-long learning skills. This yields in the development of e-Learning systems, which mainly support the sharing of digital learning materials and relate lecturers and students all around the world. At the same time, lifelong learning emerged as a vital necessity since all peoples need to be educated throughout their lives in order to remain competitive in the knowledge-based economy. Over the past decade, to meet these needs of supporting access to educate anyone, anytime, and anyplace, the e-Learning industries have experienced rapid growth. The remaining paper is organized as follows. ICT for supporting learning process is in Section 2. A brief description about the four C's of 21st century skills is in Section 3. Our experiences utilizing digital learning technology is shared in Section 4. Section 5 concludes the paper.

2. ICT for Supporting Learning Process

Learning is defined as a change in learner's behavior arising from experiences or tasks set by the lecturer. Learning occurs through the reinforcement of the desired behavior either through its reward (positive reinforcement) or through punishment (negative reinforcement) [4]. In the field of mathematics, student's active involvement in their learning processes has the main role to their engaging with mathematical ideas. It is very important for mathematics students to participate in forming and testing hypotheses, trying out models, and developing reasoned solutions to authentic problems. The use of software applications such as dynamic geometry, data-modeling packages, databases, interactive games, simulations, and programming tools enables students to reach accurate feedback and gain positive motivation [1]. The use of such applications also allows students to focus on strategies and interpretations and not on complex computational calculations. In this way the use of ICT in mathematics education supports constructivist pedagogy and supports students to explore mathematical concepts, relations and procedures, promoting higher order thinking and problem-solving strategies which are in line with the new trends in mathematics education [5].

By integrating digital technologies into higher education, universities seek for innovative teaching and learning methodology, which has possibilities to maximize educational outcome. Students are equipped with e-learning or mobile learning devices that can support them to study whatever they want and whenever they want. Universities support their learning with ICT-based platform and well-designed learning contents, while lecturers support them by designing the flexible curriculum and managing learning community for the effective learning environment.

The most suitable teaching and learning model is necessary for a successful e-leaning, which can induce self-motivated and self-regulated learning, creative, and convergent problem-solving ability. Students will be put in the center of the learning process and should

be active in their own knowledge construction. They will be forced to collaborate with others through social network system. They want the very flexible and suitable instruction, which may be possible with ICT technology. E-learning or mobile learning system can track each individual student's learning history, analyze their weakness in the study and help them with an appropriate diagnosis and treatment. While ICT-based education handles mass students with learning contents, it also cares each student at the same time [3].

3. The Four C's of 21st Century Skills

With the rapid development of ICT technologies, students must not only possess strong skills in areas such as mathematics, sciences, or language arts, but they also must be adept at skills such as critical thinking, problem-solving, communication, collaboration and creativity. However, students in many countries are not attaining these skills, which are called the 21st century skills. Based on world economic forum analysis over nearly 100 countries, they reveal large gaps in selected indicators for many of these skills. To overcome this problem, numerous innovations in the education technology space are beginning to show potential in lowering the cost and improving the quality of education. In particular, they found that education technologies can complement existing and emerging pedagogical approaches such as project-based, experiential, inquiry-based and adaptive learning methods. At the classroom level, it should be integrated into a closed system that includes instructional delivery, ongoing assessments, appropriate interventions and tracking of outcomes and learning [7].

There is no consensus on the meaning of Critical Thinking and Problem Solving (CTPS), but there are four features of CTPS, i.e.: (a) Consider different perspectives, which is important to ensure that thinking is effective and avoids common pitfalls such as seeing only one side of an issue; (b) Evaluate evidence, which is important to ensure that thinking is effective and avoids common pitfalls such as failing to support statements with evidence; (c) Solve non-routine problems that allows students to practice self-directed and novel thinking; and (d) Look for deep structures that enables students to think effectively and understand issues more deeply. CTPS can help students to collaborate with others from different backgrounds and to become creative [2]. Creativity is essential human capacity that enables us to express thoughts, feelings, and aspirations. Creativity has a core of three elements, i.e. novelty, effectiveness, and ethicality. If students are thinking and behaving creatively, then there are five habits that we will see in our class, i.e. inquisitive, persistent, imaginative, collaborative, and disciplined [6].

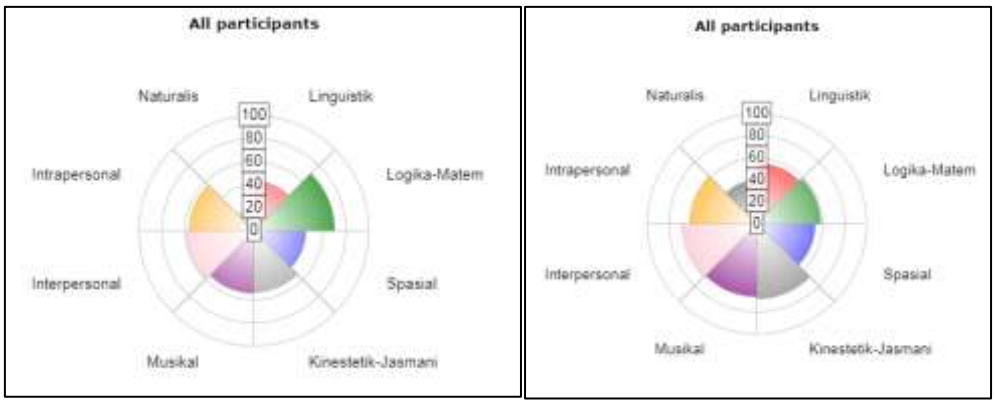
4. IDE for Monitoring Learning Process

In this paper we share our experiences using technology in supporting the learning process over the past two years. We use Interactive Digital Learning Environment (IDE) developed by Learning Innovation Center, Parahyangan Catholic University to support hybrid learning in our university. IDE uses open source software Moodle, Modular Object-Oriented Dynamic Learning Environment, as a platform. Some of the activities and sources that we usually use are assignment, attendance, choice, lesson, quiz, file, page, etc. Through these activities and resources we can observe and keep track of the student learning process especially outside the class. The subjects of our research are mathematics students who take

Elementary Linear Algebra course and Elementary Statistics course (more than 80 first grade students).

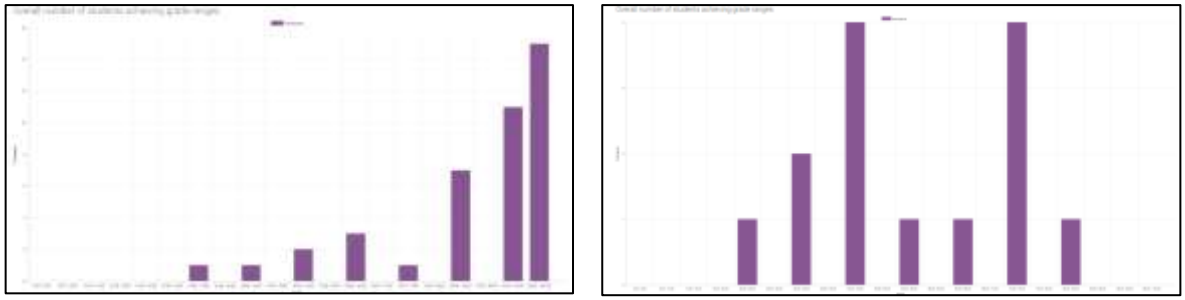
Picture 1. Interactive Digital Learning Environment (IDE) Display

Starting the lecture we conducted a survey to find out how the general pattern of students' multiple intelligence in our class. We develop this survey using questionnaire feature in the IDE. For example in Elementary Statistics course, in one class logical-mathematical aspect is the most prominent whereas in other class is the bodily-kinesthetic aspect. This information helps us to develop different learning strategies for the two classes even though the courses are the same.



Picture 2. Multiple intelligence results

We also design that our students must learn the material a few days before face-to-face sessions are held. The aim is that the lecture's material that is informative (remembering) and understanding can be studied first, so the face-to-face session becomes more effective. However, the lecturer needs to ensure that students have achieved our targets and these are done through assessments with the help of quiz activity via IDE. The quiz activity enables lecturers to create quizzes with various types, such as multiple choice, matching, short-answer and numerical. The quiz can be designed with repeated trials and questions shuffled or randomly selected from the question bank. The following is an example of the pre-test results before the face-to-face session begins.



Picture 3. The two class student's pre-test results

In the first class, students generally understand the material, while in the second class there are two major groups, namely students who do not understand and understand enough. This information helps to determine what actions the lecturer must take in face-to-face sessions. For example, reviewing material in the second class at the beginning of the lecture so that there will be no misconception in understanding.

Quizzes may be used as mini tests at the end of topics to check students' understanding and to deliver immediate feedback about performance. In a short time, we can analyze which parts of the topic are still not understood or misunderstood by students. Students also can use quiz activities for self-assessment (see Picture 4).

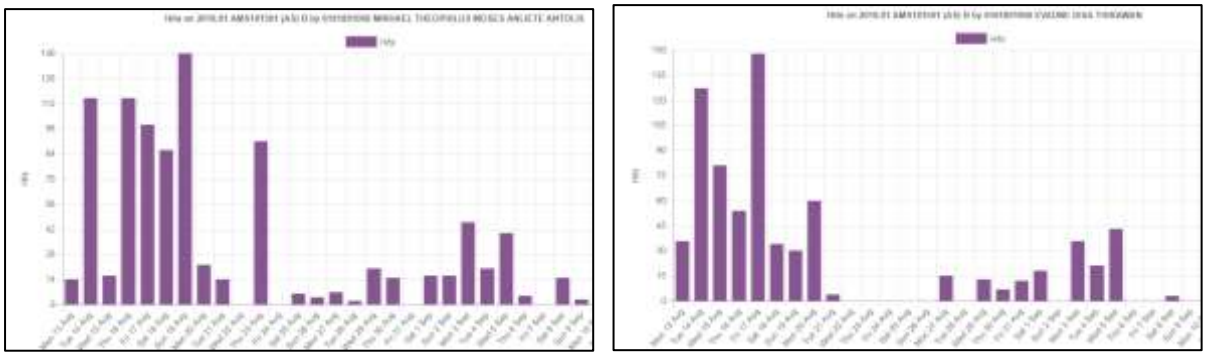
First name / Surname	Email address	Department	State	Started on	Completed	Time taken	Grade/100.00	Q. 1 /10.00	Q. 2 /10.00	Q. 3 /10.00	Q. 4 /10.00	Q. 5 /10.00	Q. 6 /10.00
2017710013 GLADYS AQUILA Review attempt	2017710013@student.unpar.ac.id		Finished	5 February 2018 8:31 AM	5 February 2018 8:48 AM	16 mins 34 secs	60.00	✓ 10.00	✗ 0.00	✓ 10.00	✗ 0.00	✓ 10.00	✗ 0.00
2017710042 NATHANIA ADELIA Review attempt	2017710042@student.unpar.ac.id		Finished	5 February 2018 8:31 AM	5 February 2018 8:48 AM	16 mins 39 secs	50.00	✗ 0.00	✗ 0.00	✓ 10.00	✗ 0.00	✓ 10.00	✗ 0.00
2017710004 FELISHA Review attempt	2017710004@student.unpar.ac.id		Finished	5 February 2018 8:31 AM	5 February 2018 8:46 AM	15 mins 16 secs	90.00	✓ 10.00	✓ 10.00	✓ 10.00	✗ 0.00	✓ 10.00	✓ 10.00
2017710014 MONICA Review attempt	2017710014@student.unpar.ac.id		Finished	5 February 2018 8:31 AM	5 February 2018 8:45 AM	13 mins 35 secs	70.00	✓ 10.00	✓ 10.00	✗ 0.00	✓ 10.00	✓ 10.00	✓ 10.00
2017710003 MARIA REGINA KUSNADI Review attempt	2017710003@student.unpar.ac.id		Finished	5 February 2018 8:31 AM	5 February 2018 8:43 AM	12 mins 3 secs	80.00	✓ 10.00	✓ 10.00	✓ 10.00	✗ 0.00	✓ 10.00	✓ 10.00

Picture 4. The quiz results for each student

Through IDE, we also want to monitor student activities for various types of learning designs, through 3 scenarios, namely:

a. **Independent learning**, by designing a learning process that the flow of learning determined by the lecturer but students can take the path that suits their learning styles. We use the Lesson feature in the IDE, which contains materials that must be learned, and some math problem solving activities related to the material. Through this scenario we can monitor student learning processes.
b. **Conventional learning**, by providing files that can be downloaded by students and assignments in the form of problem solving activities that must be completed by students until a predetermined time limit.
c. **Collaborative learning**, by designing learning activities that are completed collaboratively by students in groups.

The first scenario is applied in the first week, the second scenario is in the second week, and the third scenario is in the third week. The following is an example of the activities of two students monitored through the IDE, a pattern that represents the general pattern of other students.



Picture 5. The activity report for two students from IDE

The general pattern in the first week, students access online learning material with high intensity, there are even a few days that reach more than 100 hits. In the second week, the activity tends to be carried out offline and cannot be monitored by the lecturer. Whereas in the third week, there is an online activity again because there are assignments that must be completed online, but the intensity is not as much as the first week. Thus the choice of learning design determines student online activities in the IDE.

From scenario one, it is also observed that the average student completed the lesson is 3 hours and 26 minutes, which is in accordance with the design for 4 credits lecture. The completion time range is very long, between 8 minutes and 39 secs until 1 day and 13 hours (see Picture 6). Similarly, lecturer can monitor the progress of each student, including learning trajectory that is passed by the student. Even though the learning flow has been determined by the lecturer, each student chooses his own path that is appropriate to him. It can be said that the learning process with the help of IDE can treat students personally (personalized learning).

Lesson statistics

Average score	Average time	High score	Low score	High time	Low time
68.58%	3 hours 26 mins	100%	50%	1 day 13 hours	8 mins 39 secs

Picture 6. The lesson statistics

The second scenario uses a conventional approach, although utilizing the IDE turns out that student activities in the IDE are only to download lecture materials and upload assignments. Even lecturers cannot monitor student activity in this scenario. The third scenario is designed to monitor collaboration that occurs in groups in completing assignments. Lecturers can monitor how effective collaboration is in groups, by monitoring how active group members are, and also lecturers can assess the quality of students' contributions to their groups. So far, it is difficult to monitor students' contributions in a collaborative assignment.

Conclusions

Every student is unique, he or she has different learning styles and own learning speeds. So for a lecturer to apply several learning methods to achieve the desired skills is a difficult thing to do, especially for classes with a large number of students. How to monitor students' learning process outside the classroom becomes a big problem for a lecturer. If a lecturer can monitor the student activities that support the achievement of the desired skills then the learning process can work well. The importance of planning learning process in lectures utilizing the digital learning technology will help the effectiveness of achieving the 21st century learning goals. IDE as a digital learning platform supports these goals.

References

[1] Barzel, B., Drijvers, P., Maschietto, M., & Trouche, L. (2005*). Tools and technologies in mathematical didactics*. Proceedings of the Fourth Congress of the European Society for Research in Mathematics Education (pp. 927–938).

[2] British Council (2015). *Connecting classrooms: teaching critical thinking and problem solving, participant resources*.

[3] Lee, O., & Im, Y. (2014). Innovation of higher education in the globalized era. In: Huang R., Kinshuk, Price J. (eds) ICT in Education in Global Context. Lecture Notes in Educational Technology. Springer, Berlin, Heidelberg.

[4] Nagowah, L., & Nagowah, S. (2009). *A reflection on the dominant learning theories: Behaviourism, cognitivism and constructivism*. The International Journal of Learning, 16 (2), 279–285.

[5] Ruthven, K., & Hennessy, S. (2002). *A practitioner model of the use of computer-based tools and resources to support mathematics teaching and learning*. Educational Studies in Mathematics, 49 (1), 47–88.

[6] Spencer, E., Lucas, B., and Claxton, B. (2012). *Progression in creativity: developing new forms of assessment*. CCE, Newcastle (online).

[7] World Economic Forum Project Team (2015). *New Vision for Education: unlocking the potential of technology.*

Acknowledgement

This paper is part of our research on how to enhance the 21st century skills using digital learning technology. We would like to thank the Learning Innovation Center, Parahyangan Catholic University through learning grants and related workshops.