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To cite this article: D Muawiyah *et al* 2018 *J. Phys.: Conf. Ser.* **1097** 012058

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Higher education 4.0: assessment on environmental chemistry course in blended learning design

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Abstract. This study was intended to determine the readiness of blended learning implementation and how to do a meaningful assessment on environmental chemistry course in blended learning design. This study was the first step of a design-based research. Questionnaires were distributed to 43 participants who are undergraduate science students in the fourth year above at one of public university in Surakarta. Interviews were also conducted to the 2 lecturers of environmental chemistry course and one lecturer who had applied blended learning. Questionnaires are analyzed quantitatively and used Rasch Model to determine the quality of the instruments. Both questionnaires and interviews were also analyzed qualitatively. The results showed that blended learning is ready to be implemented and urgently needed in higher education because they should prepare the students to ready for work in global market, and the meaningful assessment must related to real-life problems for sustainable learning. The assessment can be done in various ways, including the provision of project tasks, online quiz, and test at the end of the learning. Implication for undergraduate science students are to gain new learning experience, to have more flexible study time with deeply courses, and to get a meaningful task through project task.

1. Introduction

The world is in an era where time and place don't become human barriers to interact each other. Interaction, communication, and all of activities were facilitated by Information, Communication and Technology (ICT) that take over the role of human beings. This is the impact of the fourth industrial revolution (4IR) where everything is based on the use of cyber-physical systems [1]. The 4IR had an impact in all sectors, including education and higher education. Globalization in education and higher education in the 4IR is also known as Education 4.0 or Higher Education 4.0 (HE 4.0). The changing skills required in the industry demand change to the learning system [2]. This change requires the university to create competent resources in accordance with its field, as well as strengthening cross-school education. The university should assist in the development students' problem solving and decision-making skills [2]. The way of teaching in HE 4.0 is different from the previous age. In this era, teaching should pay attention to the following things, such as: (1) using the device that can support learning, teaching, and training; (2) using Massive Open Online Courses (MOOCs); (3) development of students' skills; and (4) using blended learning [3]. Due to the explanation, the university should begin to set its learning strategy in order to follow the globalization of education.

One of the solutions in facing the globalization of education is to apply 21st century learning, where ICT is one of the skills that must be possessed by students. Implementation of ICT in learning can improve basic skills in 21st century learning, such as critical thinking, innovative thinking, creativity



enhance and digital literacy [4]. To deal with 4IR, HE 4.0 must carry out the academic development and development of 21st century learning skills together [5]. Blended learning is one way of applying ICT in education. Blended learning is a learning design that integrates traditional learning (face to face) with online learning. Other research result indicates that 35% of higher education has provided courses in blended learning design and 12% of 12.2 million online teaching materials are part of the blended course [6]. Blended learning even can facilitate the learning process between continents. Collaboration in Environmental Science course between Hawaii University at Honolulu (USA) with Kansai University at Osaka, Japan can be accomplished with blended learning [7].

Environmental chemistry is one of the mandatory courses that was given to the Chemistry Education students in the third year at Universitas Sebelas Maret (UNS), Surakarta, Indonesia. Environmental Chemistry is an applicative course and related to the environment. This course discusses all the important aspects of life, like the anthrosphere, the biosphere, the hydrosphere, the geosphere, and the atmosphere [8]. In order for this course to be sustainable learning, it requires an appropriate assessment in blended learning design. Assessment in HE 4.0 should be able to measure students' knowledge and skills according to 21st century learning skills. The Challenge of developing assessment in 21st century learning is the difficulties in developing instruments that can measure cognition as well as skills simultaneously [9]. The greatest challenge was development assessments in HE 4.0 should include 4 perspectives: (1) provide feedbacks to students; (2) students' improvement in decision-making; (3) enhancement students' active learning and knowledge; and (4) test results which are to be useful for students [10]. Based on all the explanations, this study was intended to determine the readiness of blended learning and how to do a meaningful assessment on environmental chemistry course in blended learning design at university level.

2. Method

This study was a mixed method research and the first step of a design-based research. Participants in this study consisted of three categories: (1) Chemistry Education students in the fourth year above at UNS who have enroll Environmental Chemistry course (labeled as S); (2) the lecturers of Environmental Chemistry course at UNS (labeled as L); and (3) the lecturer who has applied blended learning at UNS (labeled as P, practitioner). Data collection techniques were conducted by non-test with questionnaires and interviews. The results of questionnaires analyzed quantitatively and used Rasch Model to determine the quality of the instruments. Both the questionnaires and interviews explained in qualitative.

The first and second set of questionnaires given to the 43 students as participants. The sampling technique was done by random sampling. The first set of questionnaire was about ICT and electronic learning (e-learning) and divided into 4 categories. The first category was about students' perception on ICT and e-learning. The second category was about correlation between ICT and e-learning toward thinking skills. The third category was about multimedia learning, and the fourth category was an open-ended with 4 questions about students' perceptions in blended learning design. The second set of questionnaire was about process and evaluation of learning in environmental chemistry course, which was given to the students. The first interview was about process and evaluation of learning in environmental chemistry course with 2 lecturers as respondents. The second interview was about the application of blended learning and given to the practitioner.

The results of questionnaires analyzed quantitatively than qualitative. The first quantitative analysis by calculating the percentage level of participants' agreement for each statement. The second quantitative analysis was carried out using the Rasch Model to determine the quality of the instrument. The conclusions obtained can be more accurate if the quality of the instrument is good. Then all the quantitative results are explained qualitatively. All interview results were analyzed descriptive-qualitatively.

3. Result and Discussion

3.1. Blended Learning

The first important thing before implementing blended learning is measuring students' and lecturers' readiness about ICT and e-learning. The basic knowledge about ICT and computer is one of the success factors of blended learning. Figure 1 shows an open-ended questionnaire on the use of internet and computer/laptop in a day by students.

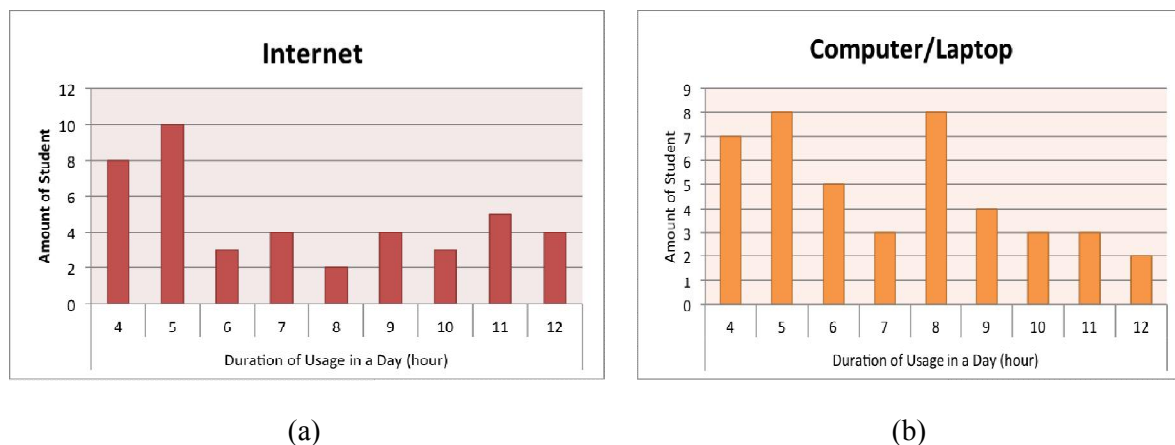


Figure 1. The usage of (a) internet and (b) computer/laptop in a day by the students

Figure 1 shows that the average of using internet and computer in a day are ± 7 hours. This indicated that the students are familiar with ICT and have been fluent in using computer. This is an advantage in blended learning because they will not be hampered when using ICT and computer. Another data suggest that 73.68% participants have studied some topics via e-learning, such as Chemistry course, Instructional Media course, etc. But, 26.32% participants disagree because they stated that it was not doing e-learning, just using the internet, instead, as supplement.

Other findings on students' perceptions of ICT and e-learning provide the percentages above 80% such as: 100% often using the internet to find some supporting material, 90.69% believe that learning using internet give them a chance to gain more knowledge, 90.69% believe that e-learning can enhancing their experience in learning, etc. Other students' perceptions that below 80% are shown in Table 1.

Table 1. Students' perception of ICT and e-learning

Statement	Percentage (%)
I believe that e-learning needed in 21 st century learning	79.06
I'm interested to learn something via e-learning	69.76
E-learning can improve my thinking skills	69.76
E-learning can improve my critical thinking skills	69.76
E-learning can improve my problem solving skills	74.41
E-learning provides various solutions in problem solving	74.41

Based on Table 1, the percentages below 80% due students never did structured e-learning or blended learning. Structured e-learning and blended learning always pay attention to the development of students' thinking skills. The development is in the learning process, then measured when the students do the test. About 69.76% of participants are interested in blended learning because it's very effective, efficient, and flexible. Only 30.24% of participants disagree because they don't want the

exact course taught with blended learning. One of the solutions is applying blended learning toward the course that has many theories and application such as environmental chemistry course.

Rasch model was also used for close-ended questionnaire data analysis in this study. It aimed to explain the quality of the questionnaire. Rash analysis was done using Winstep and gives some data showed in Table 2.

Table 2. Rasch analysis for the first set questionnaire

Analysis	Score
Alpha Cronbach (reliability)	0.82
Item reliability	0.80
Raw variance explained by measures	27.30%

Score of alpha Cronbach in Table 2 shows the overall interaction between participant and items in questionnaires. If the score of alpha Cronbach is more than 0.80, it means the overall interaction between participants and items are very good. The item reliability shows the quality of the items in the instrument. If the score of item reliability between 0.67-0.80, it means that the quality of items in the instrument is good enough. The score of raw variance explained by measures or unidimensionality aimed to know that the instrument can measure the exactly variable that want to determine [11]. A good instrument must have the score of unidimensionality more than 20%. Due to the results, the instrument is good so can use it to make a conclusion. It can be concluded that students are ready to implement blended learning.

The results of interviews to the practitioner showed that blended learning was applied as an educational material about the application of technology in learning. It aimed to enable students to be more active and support Discovery Learning theory by Bruner and Theory of Behavior by Thorndike [12]. The response of students who have got blended learning was also excellent. Students who were usually passive can more actively express their opinion through the Forum facilities in blended learning. The practitioner said that blended learning is more needed than just e-learning because traditional learning is still needed for course that are difficult to explain through online. The practitioner also said that the university has provided blended learning training for lecturers. It aimed to improve lecturers' skills in developing online learning. When the university has provided support, it can be said that the lecturers are ready to develop blended learning.

3.2. Assessment in Blended Learning Design

Assessment in 21st century learning is categorized into formative and summative test. Formative test occurs during the learning process and summative test occurs at the end of the learning. Both tests are important and must be balanced in learning [13]. The second questionnaires given to the students showed that both test have been carried out. Two lecturers who managed environmental chemistry course were L1 and L2. L1 gave formative test by group discussion about some topics, and L2 gave formative test by project task. Both lecturers gave summative test with an assignment. Students thought that group discussion in environmental chemistry course was applicative in theory but not applicable in real-life. They wanted to practice directly and do some experiments like in project task. About 95.34% participants thought that they need an assignment like project task that relate to the material taught to be more applicative and contextual in real terms. As many as 69.76% of participants agree to use online assessment, in addition to make more flexible and can save paper usage.

Rash analysis was done using Winstep and gives some data for the second set of the questionnaire that show in Table 3.

Table 3. Rasch analysis for the second set questionnaire

Analysis	Score
Item reliability	0.93
Raw variance explained by measures	31.90%

Score of the item reliability shows that the quality of items in the instrument is very good (between 0.91-0.94) and the score of unidimensionality more than 20%. It means the instrument can measure the exactly variable that want to measured. Due to the results, the instrument is good so the results from participants can use to make a conclusion.

Results of interviews to lecturers obtained information that the constraints in teaching the subject of Environmental Chemistry is the breadth of material coverage but the limited time in the classroom. Another obstacle faced is the lack of awareness of students to the environment despite studying the subject of Environmental Chemistry. The purpose of learning is not only in terms of knowledge but also in terms of attitude. The purpose of students' knowledge has been fulfilled, but the goal attitude has not been met and become an important task to be fixed immediately. This causes blended learning is a workable solution. Lecturers can deliver the core material face to face and provide supporting materials and quiz online. Project tasks can also be provided in order to meet the concept of blended learning. Evaluations of learning that can be done are in the form of quizzes, presentation tasks, and tests when the final test. Quiz has been given online but not yet structured, while the final test was done in paper using pencil technique.

Based on the description, an assessment is required that is not only for measuring students' cognitive but for measuring their thinking skills. Assessment can also be given online but should be developed to reduce the tendency of students to cheat or guess the answers. One of the solutions that can be used is the use of dependent testlet instruments. The testlet is a group of questions consisting of a major problem (stem) followed by several items [14]. Testlets are not only used to measure knowledge, but can measure students' skills and personality. Testlet can also measure the skill of science process [15], develop in psychological test, and measure reading comprehension [16]. This instrument can reduce the tendency of students to cheat during the exam because the previous answer numbers affect the answer to the next number. The dependent testlet scores are listed in Table 4.

Table 4. Dependent testlet scoring guideline

Guideline	Scoring
If in one testlet, the first answer is wrong	0
If in one testlet, only the first answer is correct	1
If in one testlet, only the first and the second answers are correct	2
If in one testlet, all the answers are correct	3

The development of this assessment should be performed in the concept of blended learning. The assessment can be done by project tasks, then give the online quiz related to the given project task. It aimed to examine the students' understanding. The final step was the development of final assessment instruments such as dependent testlet. The task of a given project can be derived from something that characterizes a region. The project task that can be given in this research is the preparation of batik waste sample. Surakarta is famous as the City of Batik. Almost all batik industries use textile dyes, and produce colored waste due to the use of textile dyestuffs. The waste must be managed so that the heavy metal content derived from the dye doesn't enter the environment. At this stage students are assigned to take samples of batik waste and conduct sample preparation for waste treatment. The aimed with this task assignment will make learning and assessment more meaningful according to Learning Theory of Meaning by Ausubel [12]. The steps that can be done if you want to develop blended learning is as follows: (1) Determine the course to be delivered within a certain timeframe, for example for 8 meetings. Blended learning has a clear division of time between face-to-face and online,

depending on each institution. For UNS, the division is 60% face-to-face (5 meetings) and 40% online (3 times online learning); (2) Prepare courses and divided courses to face-to-face and online learning; (3) Determining the learning objectives of each course; (4) Determine the instruments, learning techniques, and techniques of assessment to be used; (5) Developing learning instrument, including media and evaluation instruments; (6) Validate the instruments of learning, revision, and use the instruments; (7) Reflection on learning activities that have been done.

4. Conclusion

The study indicated that blended learning is ready to apply and urgently needed on higher education in order to face education disruption due to the IR 4.0. Blended learning is able to improve the skills of lecturers and create an interesting learning experience for students. In addition, blended learning also supports the creation of meaningful assessment for sustainable learning on the Environmental Chemistry course and other subjects requiring direct practice. Assessment in blended learning can be initiated by giving project tasks that support discovery learning theory by Bruner [12], followed by giving test or quiz to know the students' understanding of project task. The final assessment can use a dependent testlet instrument to determine the overall understanding of the students. Dependent testlet used aims to reduce the chance of learners to guess the answer so the score obtained is accurate. Based on the findings, higher education should provide plenty of blended learning training to improve lecturers' skills. Lecturers can begin to apply blended learning and meaningful assessment in learning. The resulting data can also be used as reference for further development research on learning process and assessment in blended learning design.

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Acknowledgments

The authors would like to thanks to Institute of Research and Community Service (LPPM) Universitas Sebelas Maret, Surakarta, Indonesia for providing funding for the research through The Research Group Maintenance; International Publication Grant 2018.