Advances in Social Science, Education and Humanities Research (ASSEHR), volume 227
1st International Conference on Advanced Multidisciplinary Research (ICAMR 2018)

The Effectiveness of Experiential Learning Models with Scaffolding Techniques (MELS) in Biology Learning

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***Abstract*—The study aims to investigate the effectiveness of MELS in general biology lectures of students in the biology education program of Universitas Negeri Makassar. This pre-experimental study implemented One-Group Pretest-Posttest Design by involving one group of students to be given a pretest and a posttest. The independent variable of this research is the application of MELS, and the dependent variable is the learning achievement. The research instrument is a multiple choice test. The data collection technique is done through pre-test before the implementation of MELS and post-test after the implementation of MELS. Data analysis techniques are descriptive statistical analysis and inferential statistical analysis with t-test and normalized gain test. The average of students' learning achievement on pretest and post-test is 29.61 and 78.45, respectively. The average gain score of students' learning achievement was 0.72. The result of SPSS posttest analysis showed that t count = 5.963 (db = 66) and p = 0.000, meanwhile the value of the t distribution table (0.95; df = 66) = 1.78, which means that the posttest result average is greater than the class mastery criteria. Gain value of students' learning achievement showed that t count = 22.612 (db = 66) and p = 0.000, meanwhile the value of t distribution table (0.95; df = 66) = 1.78, which means that the average value of unrealized gain is greater than 0.3 (0.6790 = medium category).**

Keywords—effectivity, learning outcomes, experiential learning

I. INTRODUCTION

Higher education plays an important and strategic role in generating and developing human resources to build humanitarian civilization, in line with the development of science, technology, and art in this XXI century. A major challenge in higher education is to enhance students' thinking skills by mastering the higher order thinking HOST skills on the other hand. Learning conditions in general biology lectures are now capable of guiding the students to "know" the things being taught but have not been able to guide them to "discover" the range of knowledge dimensions that can be obtained. Therefore, students need to be equipped with several generic solutive abilities through a learning process that prioritizes reasoning based on experience.

Nowadays many learning models have been produced and known by the lecturer, among them are the model of achievement concept, laboratory, *Project Based Learning* (PjBL) and *Problem Based Learning* (PBL) [1], *Direct Instruction* (DI) [2], *Cooperative Learning* (CL) which has many types [3], and *Experiential Learning* with *Scaffolding* technique (MELS). Among the models mentioned above, MELS model is one of the newest learning models which are researched and produced in higher education, yet has not been widely recognized by educators and has not been tested through experiment. MELS can maximize the use of process skills and student learning time [4]. MELS is designed using a pedagogical, social, and technological based education system approach. This is in line with Kirschner et al. [5] who explained that the education system is a unique combination of three components, namely pedagogical, social, and technological. [6] said that the pedagogical design of MELS embraces a constructivist paradigm. The construction of knowledge is the process of internalization and reconstruction of external reality. The interaction of individuals with content plays a very important role.

Pedagogical design of the constructivist learning environment must meet three criteria, namely: 1) support and meet various students' learning needs, and interest, 2) be flexible with regard to content and learning objectives, 3) utilize learning resources and activities which promote active learning [5], [7]. MELS learning environment has been conditioned to promote the active participation of students during the teaching and learning process through the support of students' worksheet which has been developed based on constructivist learning paradigm [4]. Through a constructivist learning environment, learners' needs, expectations, and interests are met, and learners participate actively in learning and social interaction among their peers [8]–[11].

MELS was developed based on the social constructivist theory. The theory argues that knowledge is the result of collaborative construction in social-cultural contexts which is obtained through interactions with one another. Learning is a social process that requires learners to build knowledge collaboratively through an interactive process of information exchange, negotiation, and modification [12]. Classroom setting in MELS is conducted in a group with the presentation of work to enable the formation of group relation. This is reflected on students' learning experience, as they are provided with various learning facilities such as teaching materials, worksheets, and laboratory tools and materials, which enable them to do exploration, elaboration,

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and confirmation freely and openly. The social dimension of learning has become an integral part of many learning environments [13]. The social design of the constructivist learning environment aims to provide and maintain a friendly and interactive environment so that learners can feel safe , comfortable , and be able to interact with each other [14]–[16].

MELS is a learning environment that utilizes technology since some of the learning activities are conducted with the help of computer media which facilitates the progress of constructivist learning, so the learning model can be easier and more feasible to be implemented. In a teaching and learning which implement MELS, lecturers utilize a number of learning technologies in the form of animation and video. The media is utilized from the beginning until the end of the learning process, particularly as a tool to assist lecturer in doing scaffolding. While technology is not a panacea to solve all educational problems, it is a useful tool that allows the connection among different learning communities in new and different ways [12].

The advantages of MELS including, (1) lecturer can control the sequence of learning activities which is full of science process skills, (2) receiving information from the learning activities and learning support systems performed continuously until the end of learning activities, (3) is an effective way to teach concepts, skills, as well as scientific attitudes to students, (4) can be used to accommodate the characteristics of various learning styles simultaneously, (5) facilitates the achievement of learning objectives through the inclusion of learning tools which are needed by students, (6) can be applied in small class as well as in large class, (7) students performance can be monitored carefully through individual and group activities based on the prepared learning devices [4]. This study aims to determine the effectiveness of MELS implementation on general biology lectures to teach Biology Education students in UNM.

Some of the findings in behavioral theory are related to the time used by students in learning, doing the task, and the speed of the students to succeed in doing the task of explaining these characteristics [17]. In line with, MELS push his copyright structured learning environment closely and remains, to provide flexibility to express themselves, and academically oriented in total [4]. Looking at the situation, the researcher is interested in examining the effectiveness of MELS application on enzyme, photosynthesis, respiration and the relationship between carbohydrate, fat, and protein catabolism in the students of biology education program at UNM, in order to give more accurate information related to the effectiveness of MELS implementation on campus.

Several findings on behavioral theory are related to the time used by students for learning, doing the task, and the speed of students to succeed in finishing their task can explain these characteristics [18]. Thus, MELS promotes the formation of structures learning environment, provides opportunities for students to express themselves, and posed a totally academic oriented characteristic. Accordingly, the researcher is interested in investigating the efficacy of MELS implementation to teach enzyme, photosynthesis, respiration, and the relationship of carbohydrate, fat, and protein catabolism for undergraduate students in Biology Education Program UNM, as an effort to provide more accurate information on the efficacy of MELS implementation in higher education.

II. METHOD

The study is a *pre-experimental* (research that has not been a real experimental study), as there are external variables in addition to the implementation of MELS which influence the dependent variable (learning achievement). The population in this study is all students registered in Biology Education Department at Universitas Negeri Makassar. The sample in this study are students registered in General Biology Course in the academic year 2017-2018.

The research design used is *One-Group Pretest-Posttest Design.* A pretest is given before the intervention, hence the result of a given intervention can be determined more accurately, by comparing the state before and after the intervention. Formulation of the research design used a group which is given pretest-posttest. The research variable consists of the implementation of MELS as an independent variable, and students' learning achievement of students in Biology Education Department at Universitas Negeri Makassar as the dependent variable.

The research instrument used is an achievement test, which consists of multiple choices questions to assess cognitive skills and mastery of students on enzyme, anabolism, and catabolism concepts.

Descriptive statistical analysis is used to analyze the data of students learning achievement on the general biology course. Meanwhile, inferential statistical analysis is used to test the hypothesis with the prerequisite test of normality and homogeneity test. Inferential statistical analysis in this study used t-test and normalized gain to test the hypothesis.

III. RESEARCH RESULT

Student cognitive learning achievement data on general biology material at the pretest shows an average score of 31.41 of the ideal score of 100 that can be achieved by students. Scores achieved by students ranged from the lowest score of 12.5 to the highest score of 43.8 with a range of 31.3. Meanwhile, the average score of student achievement in the posttest ranged from the lowest score of 59.38 to the highest score of 93.75 with a range of 34.37. In detail, descriptive statistical data are presented in Table 1, while for data on the frequency distribution of student learning outcomes taught using the MELS Model are presented in Figure 1.

Based on the descriptive analysis in Table 1, it can be concluded that the learning achievement classically exceeds the mastery standard. Thus, it provides a picture of an effective learning process which has been implemented during the teaching and learning of enzyme, anabolism, and catabolism concepts in General Biology course of students in Biology Education Department at Universitas Negeri Makassar.

TABLE I. DESCRIPTIVE STATISTICS OF BIOLOGY EDUCATION STUDENTS' ACHIEVEMENTS TAUGHT BY USING MELS ON GENERAL BIOLOGY COURSES

Statistics	Statistics Value	
	Pretest	***Posttest***
Sample Size	67	67
Mean	31.41	78.454
Median	31.10	78.130
Std. Deviation	10.27	9.899
Variance	95.55	97.989
Range	31.3	34.37
Minimum	12.5	59.38
Maximum	43.8	93.75

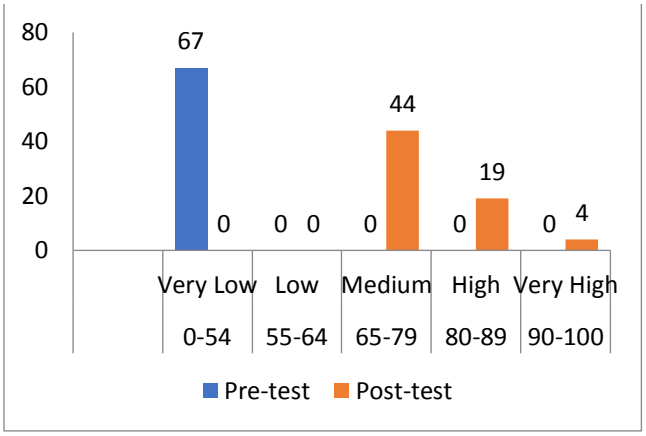

Fig. 1. Distribution of Learning Achievement Frequency of Students' Taught by Using MELS Model in General Biology Course

The result of t-test analysis on the gain value of students' learning achievement showed that t_{count}=3.561 with a free degree = 66 dan p = 0.000. Based on the the table of t distribution value, obtained $t_{(0.95;df=66)}$ = 1.78. Since 3.561 > t_{table} = 1.78 and p < α = 0.05, the H_0 is rejected or the H_1 is accepted. This means that the average achievement score of Biology Education students' on General Biology course who are taught with MELS model is greater than 73 (K3). The gain value of learning achievement showed that t_{count}=22.612 with a free degree = 66 dan p = 0.000. Based on the the t_{table} distribution value, obtained $t_{(0.95;df=66)}$ = 1.78. Since 22.612 > t_{table} = 1.78 and p < α = 0.05, the H_2 is rejected or the H_1 is accepted. Data of normalized gain classification is shown in Table 2. The result showed that the average value of normalized gain is in medium category (0.3 < g < 0.7).

TABLE II. CLASSIFICATION OF NORMALIZED GAIN IN GENERAL BIOLOGY COURSE IN BIOLOGY EDUCATION PROGRAM THROUGH THE IMPLEMENTATION OF MELS MODEL

The coefficient of Normalized *Gain*	**Number of Students**	**Percentage (%)**	**Classification**
g ≤ 0.3	0	0	Low
0.3 < g < 0.7	12	17.91	Medium
g ≥ 0.7	55	82.09	High
Average		67.90	Medium

IV. DISCUSSION

The results indicate that the implementation of MELS is effective in improving students' cognitive learning achievements. After the implementation of MELS on the teaching and learning process of the students Biology Education program, the students' learning achievements exceeds the minimum mastery standard required in general biology course. This indicates that there has been a change in behavior due to the application of MELS. The finding is in accordance with the assertion of Cronbach [19] that learning can be observed from the changes in behavior due to the experiences gained, in which "learning" refers to the process acquired through the use of the five senses.

The improvement is due to the learning activities in a general biology course which help students to be accustomed to using deep learning approach, i.e. maximizing understanding by thinking, reading/ experiencing, reflecting, abstracting, testing and communicating, thus widen the opportunity of students to achieve a better learning achievement compared with their achievement if they follow a surface, i.e., less attention to maximizing students' learning and interest.

Based on the result, it can be seen that the cognitive learning result is classically completed, in which the normalized gain value is in the medium category, close to the high category. Thus, the application of MELS has been effectively applied to teach the concepts of enzyme, anabolism, and catabolism for biology education students registered in a general biology course. The average gain value obtained by the students on the post-test which is in the medium category reflects the efficacy of MELS implementation during the lecture, as asserted by Hake [20] that the normalized *gain* values show the efficacy of a treatment, judging by the results of the final score or *posttest* .

The effective implementation of MELS in improving students' learning achievement has also been attributed to the potential of MELS in empowering critical thinking skills. Critical thinking skills of students in MELS models are obtained through strategies that are summarized in Mels syntax, i.e., motivation and orientation phase, concrete experience phase, reflective observation phase, abstract conceptualization phase, active experimentation phase, and networking phase. The phases in the syntax of MELS model can be conducted by a lecturer, consisting of a logical sequence of learning activities, characterize the experience-based learning, stimulates critical thinking skills, empower science process skills, and clearly require the role of lecturer and students during the learning.

During the motivation and orientation phase, lecturer motivates and orients students on learning problems and guide students to pose questions and to formulate problems based on their observation. This means that the students are conditioned since the very beginning to think critically on certain condition which can lead them into the learning topic. This is in line with the assertion of [21]–[24] who define critical thinking as: (1) a willingness to think deeply on problems and things within the reach of one's experience, (2) knowledge of logical reasoning and investigation methods, (3) a skill to apply those methods.

During concrete experience phase, lecturer provides guidance by organizing students' task through the utilization of students' worksheet, guiding students to read lectures in teaching materials and to observe biological objects. Students are equipped with teaching materials as the guidance during teaching and learning process and required to mark important idea and words. The students are then required to write concepts they can understand along with the concepts they do not understand. Furthermore, they are

required to formulate the solution to the problems they encounter through group discussion. In the context of this activity, the lecturer can do scaffolding when deemed necessary. Through scaffolding, learners are provided with assistance as needed, and the assistance is reduced along with the increase of their competence [4], [12]. Thus, scaffolding is required to stimulate and to direct students' critical thinking activities and reasoning in learning.

Students conditioning during concrete experience phase as explained above is in accordance with the explanation of [24]–[26] which defines critical thinking in 5 aspects, i.e.: (1) critical thinking is a productive and positive activity, (2) critical thinking is a process, not a result, (3) the manifestation of critical thinking varies according to the environment in which the process proceeds, (4) critical thinking is triggered by positive or negative events, (5) critical thinking is emotional and rational.

During reflective observation phase, students are required to observe a demonstration exhibited by the lecture. The characteristics of the third phase of MELS is in line with the explanation of Schafersman [27] who views critical thinking as a process to think logically, reflectively, responsibly, and proficiently which is focused on determining the things that are believed and should be done. Learners are not able to develop their thinking skills without practice using it in subject matter context. Thus, the effort to develop students' thinking skill in learning cannot be made by merely asking the students to remember and memorize the concepts, but they should integrate, apply, and communicate the concepts that have been owned.

During abstract conceptualization phase, the lecturer requires the students to implement higher order science process skills (e.g., setting goals, formulating problems, generating a hypothesis, identifying problems, defining variables, plotting procedures) based on the concepts they acquired during reflective observation phase. Accordingly, the essence of this phase is that students design an experiment based on the result of their learning experiences.

This phase is in line with the view of Bhagi, that a critical thinker has a number of characteristics, namely: (1) raising important questions and issues, formulating them clearly and thoroughly; (2) generating new ideas which are useful and relevant for performing tasks; (3) collecting and assessing relevant information, using abstract ideas to interpret them effectively, (4) drawing conclusions and solutions with solid reason and evidence and testing them using relevant criteria and standards, (5) thinking openly using various alternative systems of thought, while recognizing, assessing, and seeking relationships between all assumptions, implications, and practical consequences, (6) posing the ability to overcome confusion and to distinguish between facts, theories, opinions, and beliefs, (7) communicating effectively to others in an attempt to find solutions of complex problems, without being affected by the thinking of others regarding the problems encountered, and (8) showing self-righteous, rejecting manipulation, holding credibility and scientific integrity, and intellectually independent, impartial, and neutral [28].

During active experimentation phase, lecturer conducts scaffolding and requires students to do an experiment based on the designed procedures in abstract conceptualization phase. The students then asked to make an experiment report. This phase is in line with O'Halloran et al. [29] an opinion that the core of critical thinking includes: interpretation, analysis, evaluation, inference, explanation, and self-regulation. They also explain that interpretation is to understand and express the meaning of various experiences, situations, data, events, decisions, conventions, beliefs, rules, procedures, or criteria. Analysis means identifying the inferential and actual relationship between statements, concepts, description, or other forms of representation that is intended to express convictions, judgments, experiences, reasons, information or opinions. Evaluation means to judge the credibility of a statement or other representation that describes a person's perceptions, experiences, situations, judgments, beliefs, or opinions; and to assess the actual logical strength or inferential relationship between statements, descriptions, questions or other forms of representation. Inference, means to identify and to secure the necessary elements to draw a reasonable conclusion, to form conjectures and hypothesis, to consider relevant formulation, and to decide the consequence of the data, statements, principles, evidences, judgements, beliefs, opinions, concepts, descriptions, questions, or other forms of representations. Self-regulation, means self-awareness to monitor or supervise a person's cognitive activities, relating to the elements used in those activities and their development outcomes, especially by applying skills in analyzing and evaluating decisions based on questions, confirmations, validations, or improvements of the results of reasoning.

During the networking phase, lecturer asks students / group of students to make presentation material (poster) and to present it, which will be followed by a classroom discussion. Based on the above description , it becomes a rational argument when the MELS model can improve students' critical thinking skills. Costa [30], explained that the thinking process is a gradual process from lower order thinking to higher-order thinking. A basic thinking process is a thinking process to find relationships, connect causality, transform, classify, and clarify. The complex thinking process which is known as higher-order thinking processes is categorized into four groups, namely: problem-solving, decision making, critical thinking, and creative thinking.

Critical thinking is seen as an important life skill that is needed. The enhancement of the thinking process is basically creating a reflective behavior and questioning each aspect of life [21], [23]. In the MELS model, students are engaged in critical thinking when they: (1) Find a clear statement of the problem or question, (2) collecting, selecting, and linking relevant information to find information, (3) monitoring their own thoughts and progress, (4) restraint, (5) open-minded, (6) identify and challenge the assumptions, (7) consider point by point, (8) looking for alternatives, (9) detect bias, (10) identifies the variables, facts, opinions and reasons for judgements, (11) determine the factual accuracy and strength of an argument or claim, (12) determine credibility of a source, (13) honest and sensitive to others, (14) deal with ambiguity, (15) strive for precision, definition, and clarity, (16) remains on the main point, and (17) suspends judgment until the evidence is sufficient.

The whole process of MELS models helps students to be an independent learner who believes in their own intellectual skills. This provides space for students to do an

investigation through the inquiry process. In the learning process, learners not only act as the recipients of the lessons through verbal explanations of lectures, but they also play a role in finding the essence of the subject matter. All activities undertaken by the students are directed to seek and find answers to the problems in question independently, so it is expected to grow their self-belief. Thus, the learning strategy in MELS does not place the lecturer as a learning resource, but as the students' facilitator and motivator. Learning activities are usually done through a question and answer process between lecture and students. Therefore, lectures' ability in using various questioning techniques is a major requirement in implementing MELS model as a form of *scaffolding.*

Things that need to be considered when implementing MELS model in learning, including: (1) The lecturers are obliged to create a conducive learning environment that allows all students to engage in learning process, both physically and emotionally, (2) lecturers do *scaffolding* during the learning process, (3) provide and manage learning resources that are relevant to support the smooth process of learning, (4) organizing students in heterogeneous learning groups, (5) organizing tasks that support learning based on experience, (6) guiding students in completing the given tasks during the implementation of group work (construction of knowledge) by referring to the basic principles of learning based on experience, (7) guiding students to do groups / class discussion, meanwhile the lecturer conduct evaluation and provide reward.

V. CONCLUSION

It is concluded that learning achievement of biology education students of Faculty of Mathematics and Natural Science UNM after being taught by using the Model of Experiential Learning with Scaffolding techniques reached a high category with an average score of 78.45. *Experiential learning* model with *scaffolding* technique is effective to be implemented in general biology course to teach biology education students in UNM based on the improvement of the students learning achievement with an average of the normalized gain value of 0.6790 which is in a medium category close to high category.

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