Active Learning Strategy on Higher Education Biology Learning: A Systematic Review

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Article History:

Received: October 24th, 2020

Revised: January 13th, 2021

Accepted: February 9th, 2021

Published: June 29th, 2021

Keywords:

Active learning,
Higher education,
Systematic review.

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Abstract: Student-centered learning intends to increase student participation. Biology subject is a broad scope and has a level of abstract concepts. Active learning has the potential to maximize the learning process of biology subjects. The purpose of the research is to describe the implementation and strategies of active learning applied to biology learning in higher education. The method used descriptive and systematic review. Selecting articles used the ERIC database. The search was carried out with predetermined categories, then a manual selection of the article to ensure the selected one. There are nine journals with nineteen articles analyzed at the higher education level of biology subject matter. This study's results, the implementation of active learning strategies, require support from lecturers and university stakeholders so that active learning runs effectively. An Active learning strategy used in biology material in higher education consists of the use of low-cost technology (virtual cell learning module) to high cost (SCALE-UP, clicker), low-cost learning without involving technology (card games, card organisms, kinesthetic physical models, 5E lesson plan, and pre-class reading guide) to outside the classroom (field training). The university's role and the understanding of lecturers in implementing active learning strategies have a crucial role in determining student learning outcomes. Lecturers and university stakeholders need to build cooperation, including a learning policy system and classroom implementation.

INTRODUCTION

Biology is the science that studies all forms of living things and has a strong relationship with the environment. Biology is a science branch focusing on genetics, bacteria, virus, ecology, evolution, microbiology, environment, and other subjects (Behzadi, 2016; Fleischner et al., 2017; Sudarisman, 2015). Biology is an essential part of education because biology provides information that people can use in daily life (Sayan & Mertoğlu, 2020). The developments and advances in biology need to be delivered in learning biology in

class (Khalil et al., 2014; Novick & Catley, 2016). At the university level, Biology is learned by students as an introduction and taught in more depth.

The nature of science consists of scientific processes and scientific attitudes (Juhji & Nuangchalerm, 2020). Processes in science, such as biology, contain scientific attitudes that students need to understand the relationship between learning concepts and what they experience in real life (Cabbar, 2020). Biology interest is prior knowledge, focus on concept, and the process of discovery (Southard, Wince, Meddleton, & Bolger,

2016). This condition necessary to carry out so that students know the benefits of life, including conserving natural resources, improving health, and advancing community social welfare. However, the Biology subject is commonly considered a difficult subject to learn and impacts learning outcomes; for example, students do not conceive the chromosome structure in a cell nucleus (Diki, 2013).

Biology subjects are classified as difficult to understand. (Çimer, 2012) Several concepts are considered difficult to understand, including cell division, genetics, the nervous system, respiration and photosynthesis, and organ systems. According to (Lazarowitz et al., 2010), the difficulties are caused by the level of organizational division or grouping on biology topics and different abstraction levels on topics or concepts in Biology. The conceptual classification of ecosystems is understood more quickly than the explanation of cell division by mitosis and meiosis. Biology subjects difficulties not immediately resolved can lead to ongoing misunderstandings (Kubiatko, 2017). Students who have difficulty understanding theories and concepts in Biology will have an impact on acquisition learning outcomes. The complexities of the involved and the specialized language create a frightening environment for students and a challenging task for the lecturer (Southard et al., 2016). However, a transition towards deep understanding is not a simple thing.

The lecturer is one of the crucial things in education has a great responsibility and determination in achieving students' learning. The lecturer needs to master teaching methods to support classroom learning because learning activities at the university level remain dominated by expository learning strategies (Muhtadi, 2009). This condition leads students to tend to accept the explanations provided by the lecturer and

to be passive when creating interaction in learning. The application of learning strategies involving students can be a solution in the process of improving learning outcomes.

Student-centered learning activities are often referred to by experts to get meaningful learning (Attar et al., 2016). One of the student-centered learning activities is active learning. Active learning is a form of studying in which lecturers try to involve students in the learning process who are more directly involved than other studying (Kubiatko, 2017). In student-centered learning, students are required to be more active and train to build the concepts they must have so that active learning helps them understand the learning activities in class. Active learning can provide an influence to carry out meaningful and dynamic studying (Akmal et al., 2015). (Prince, 2004) assumes that active learning is accomplished by involving students in the authentic learning process. Active learning has been applied to carry out different learning forms in the student population (Rosier, 2017). This situation assumes that active learning has applied to biology topics in various situational and students. For example, to understand the biomimicry potential of old and modern life, students a field-based, paleontology-focused exercise (Soja, 2014). The student did field training in investigating more and promote active learning. In an active-learning environment, the student would interact with their peers to constructing knowledge (Wiggins et al., 2017)

The study on active learning strategy in Biology subjects learning in higher education: systematic reviews conducted to determine the implementation of active learning at universities and find strategies on biology used when teaching students. The research results have expected to provide benefits to the lecturer (lecturers), students, and faculty to improve learning

quality by applying various forms of active learning that recommended. The study on active learning has expected to have an impact on students in overcoming learning difficulties.

METHOD

The articles were selected using the steps described by (Álvarez-García et al., 2015) and qualitative methods. The systematic review process conducted using a search strategy approach that fits the criteria by setting predetermined conditions. The requirements for articles to be analyzed were determined not only by keywords but also by the category of Biology students who were trying to implement active learning in lectures. Article search used scientific databases (ERIC). ERIC is a type of database that discusses articles on science education, which fully cover the categories of biology, physics, and chemistry in English. However, the Author does not use the Fachportal Pädagogik database because this focuses on discuss articles on science education in the German language. The search strategy referred to categorizing and selecting keywords related to biology, science instruction, and

active learning. They have consecutive to the topics discussed in the article. However, the Author also chose them manually by selecting that article one by one on keywords at the higher education level. When determining constraints, the Author only used a selection of keywords that were already available in the ERIC database column.

The Author set the limit by choosing only articles to be reviewed, not included other documents such as theses or dissertations. In the initial search process, the papers have obtained using predefined keywords amount 131. A re-selection process was then carried out because there were no articles included in the higher education level and the article category's scope. Furthermore, 19 papers have been select to be analyzed as they met the requirements and originated from 9 journals (Table 1).

Description of the criteria for selecting articles on active learning includes: scope of the journal using international research; research is empirical research on active learning in biology; period 2011-2020; target groups are active learning-students in higher education language is English.

Table 1. Selected Articles and Journals

Selected Journal	Analyzed article
Life Science Education	1. (Cooper, Ashley, & Brownell, 2017)
	2. (Soneral & Wyse, 2017)
	3. (Goff et al., 2017)
	4. (Andrews, Auerbach, & Grant, 2019)
	5. (Elliott et al., 2016)
	6. (Lieu, Wong, Asefirad, & Shaffer, 2017)
	7. (Gregg, Ales, Pomarico, William Wischusen, & Siebenaller, 2013)
	8. (Stoltzfus & Libarkin, 2016)
Journal of Geoscience Education	9. (Soja, 2014)
Journal of Biological Education	10. (Lax, Morris, & Kolber, 2017)
	11. (Luttikhuisen, 2018)
Advances in Physiology Education	12. (Felege & Ralph, 2019)
	13. (Breckler & Yu, 2011)
Biochemistry and Molecular Biology Education	14. (McDonnell, Barker, & Wieman, 2016)
The American Biology Teacher	15. (Cherif & Jedlicka, 2012)
	16. (Metzger, 2013)
The Canadian Journal for the Scholarship of Teaching and Learning	17. (Hymers & Newton, 2019)
Journal of College Science Teaching	18. (Cotner, Loper, Walker, & Brooks, 2013)
	19. (Idsardi, Hahn, Bokor, & Luft, 2019)

RESULT AND DISCUSSION

The Implementation of Active Learning at Higher Education

Higher education as a level of further education aims to optimize knowledge and skills (Naithani, 2008). Changes in higher education policies and systems are common, but one thing is obvious: studying in large groups (Roberts, 2019). The majority of student needs, such as relatively long learning time in a class, are dominated by the same teaching methods (Wolff, Wagner, Poznanski, Schiller, & Santen, 2015). It contradicts the conditions required by students for better learning. Meaningful learning and active involvement of students in the classroom environment while studying are indispensable since students' challenges while in college and post-graduation are very high. The university is experiencing high pressure in preparing for dynamic work needs (Lawson, Sanders, & Smith, 2015). It causes efforts to implement active learning in higher education.

The discussion of active learning has been researched and put forward by experts. Bonwell Eison and Silberman proposed a well-known theory. This situation is starting to show learner-centered learning changes and has received researchers' attention over the past two decades. Active learning is a student-centered learning approach that could change learning, listens to the lecturer in class, and actively involves students in learning activities. On active learning, student activity and commitment to the teaching and learning process are the most important (Prince, 2004). The student to participate actively must be involved in higher-order thinking tasks such as analysis, synthesis, and evaluation (Chan, Sidhu, & Lee, 2015). Active learning leads to better student attitudes and improved student thinking and writing (Mathias, 2014).

The report's findings at the university level that there is still learning

that is not center on students (such as active learning) as an introduction to learning in the classroom (Muhtadi, 2009; Irianti, 2004; Akmal, N., Nurmaliah, C., 2015). Learning activities other than active learning like lectures still become the dominant way of teaching, while active learning remains considered an alternative method. It needs to be understood that lecturers should not apply lectures as the only way of teaching because it will lead to one-way learning coming from the lecturers.

The option of teaching methods for active learning is crucial for lecturers because many things must be considered and planned in choosing strategies (D'Avanzo, 2013). The process of building active learning in universities as the approach used during lectures can help maintain the unique role of the university as an active and professional citizen education (Christersson & Staaf, 2019). University and faculty support in providing active learning training to instructors is crucial so that instructors facilitate an active learning environment and explore appropriate ways of delivering material and provide the support needed to be active during learning. An institutional shift towards student-centered learning, such as active learning, needs to be regulated, consistent, and transparent in improving the quality of education facing the global challenge (Aksit, Niemi, & Nevgi, 2016).

Active Learning Strategies in the Field of Biology at the University

Meaningful learning for students becomes a theory that experts often deliver to increase understanding, particularly in biology. The transition of teaching to be meaningful sounds simple, but it encountered some challenges in practice, such as the inability of students to explain Biological concepts (Diki, 2013), scientific biology vocabulary that often becomes a burden for students to learn (McDonnell et al., 2016), and the

instructor's teaching style (Çimer, 2012). A literature study explained that an active learning approach is applied in Biology learning because it is considered the proper way to teach biology (Freeman et al., 2014). This condition emerges because active learning has a variety of possible ways to suit learning conditions.

The results found that a variety of active learning was applied during higher education in Biology subjects. Biological concepts taught varied, from the base level of introductory Biology for the college student, cell concepts, biomimicry, animal physiology, a concept evolution has a complexity to understand (Breckler & Yu, 2011; Cooper et al., 2017; Goff et al., 2017; Soja, 2014). The learning environment conditions faced were described in the articles, starting from class size, number of students, and technology resources. Active learning had variations in its implementation and levels, so the instructors were obliged to determine the appropriate method learning strategy during its application.

The college students who were actively involved and experienced changes in learning methods could sign language strategies that the instructors had been well accepted. Freeman et al., (2014) compared types of active learning for studying in higher education other than active learning (predominantly using lectures) were included in the "first generation" category, and it is time to move beyond the comparison of learning other than methods called the second generation. The study conducted by the Author was in the second generation to find out variations in the forms of active learning strategies used by instructors in various countries and different conditions. Based on the articles reviewed, the Author grouped the learning strategies used in biology in Table 2.

Those are three countries that have used various active learning strategies in teaching and learning. The Netherlands, Canada, and the US apply the Active

Learning strategy for higher education and inclusion in the ERIC database. The US is the country that dominates in publishing the apply of 17 articles, then Canada 1 article, and Netherland 1 article.

In the results of systematic review analysis, the use of active learning strategies has been dominated by large class populations than small classes. The number of students in the classroom impact the strategies used. The solutions offered by lecturers in implementing active learning in large classes include pre-class study programs (Cooper et al., 2017), technology-based learning (Goff et al., 2017; Lax et al., 2017), demonstration model (Breckler & Yu, 2011), pre-class reading guide (Lieu et al., 2017), outdoor exercise (Soja, 2014), and learning frameworks (Elliott et al., 2016). Large class populations arise because the room included in the transition program from high school to higher education or have classified as material adjustment classes (Cooper et al., 2017) and large classes include had limited knowledge about the primary major (Soja, 2014).

Small class populations have technology-based learning using the SCALE-UP design strategy. When carrying out a systematic review, this strategy found in several different articles, but SCALE-UP has the same goal of making the transition from instructor-centered learning to learner-centered learning and producing meaningful learning (Felege & Ralph, 2019; Soneral & Wyse, 2017; Stoltzfus & Libarkin, 2016). SCALE-UP model is to redesign learning spaces to promote teaching and learning as a place of students at the center of the learning process, working in groups, applying concepts, and solving problems. These findings explain SCALE-UP increased student engagement, attitudes, and performance (Soneral & Wyse, 2017). The difference in the SCALE-UP study in several articles lies in the scope of research and the concept of biology. Students show a

beneficial view of technology and layout in the SCALE-UP classroom to encourage group members' interaction.

The classification of technology-based learning consists of 2 types: the number of students and operational costs. Costly technology appears in clicker learning strategy. The clicker is an interactive technology that allows instructors to ask questions to students who can immediately see the entire class's responses. Clickers use a remote control to answer questions interspersed during lectures and positively impact students in learning interactions, indeed being a combination of learning techniques (Hymers & Newton, 2019). SCALE-UP is one of the costly technologies. Applying the SCALE-UP learning strategy in classrooms using technology and class reshuffling is not the most effective way to produce better results for students. The expenditures spent by colleges are well expensive when technology has integrated into lessons (Stoltzfus & Libarkin, 2016), and the same conditions are used in reverse instruction development (Lax et al., 2017). Low-cost technology is applied to learn, such as the virtual cell learning module (Goff et al., 2017). The virtual module aims to provide high-quality online resources designed to convey biological concepts so that students can independently learn both inside and outside the classroom. Higher education needs to pay attention to the budget used when implementing technology to implement active learning strategies.

Low-cost learning without involving technology could hold with instructors in teaching and learning, such as Card games (Luttikhuizen, 2018), card organisms (Metzger, 2013), kinesthetic physical models (Breckler & Yu, 2011), 5E lesson plans (Idsardi et al., 2019), and pre-class reading guides (Lieu et al., 2017). Card games and card organisms have the same way of using cards as a strategy to engage students in active learning, but what distinguishes It lies in

the type of card and the scope of the subject matter. The subject matter has applied in card organisms and card games are biophilia and evolution. Each card organism displays an organism's picture, common name, scientific name, and other organism information. In traditional card games played cards, all kings, queens, jacks, and jokers were removed. The card game is done with initial questions and making hypotheses. Players need to collect data for sharing the second point of the game. The Kinesthetic Physical model demonstration for the study has been applied to understand the prime concept of cardiopulmonary physiology (known as oxygen-carrying capacity). This demonstration model's application focuses not only on the content of cardiopulmonary physiology but also on other content using simple materials. Inexpensive and straightforward being the advantage of this strategy. In another content, students use the demonstration to understand the process of split molecular biology (Kao, Liu, & Bai, 2020). This strategy being the solution to teaching difficult abstract concepts.

The remaining active learning strategies like the 5E lesson plan and pre-class reading guide could be applying to other biology materials by paying attention to each step. The 5E lesson plan development consists of 5 parts: engagement, exploration, explanation, elaboration, and evaluation. 5E lesson plans create interactions between students and lecturers that allow them to exchange unique perspectives that respond to the experience of science (biology) that requires collecting and analyzing data in understanding the concept of science. The pre-class reading guide strategy can be used by lecturers to "hit the ground running" to help students read textbooks before each class session begins, test what they have learned, investigate scientific problems, and practice scientific literacy. Lecturers find the pre-class reading guide action to align learning objectives

between pre-class assignments and classroom activities.

Table 2. Selected Biology Active Learning Strategies

Active Learning Strategies	Implementation at the University	Types of Class Size		Benefits
		Large	Small	
Summer Bridge Program	University in the southwestern United States	√	-	This program can maximize students' active learning experience in biology who are experiencing a transition from high school to university.
Field Exercise	Colgate University, US	√	-	Students gain confidence related to biological anatomy as the basis for assessing the biomimicry potential of a species.
Flipped Classroom	Duquesne University, Pittsburgh, US	√	-	Assisting students in formative assessment and can be a useful technique when applied compared to traditional lectures.
Scale-Up Design	North Carolina State University	-	√	Space design planning of SCALE-UP has several crucial aspects for student success, such as collaborative seating and writable space that can enhance the learning experience.
FLC Framework	Iowa State University	√	-	The FLC framework becomes a student-centered change agent to supports learning.
The 5E Lesson Plan	University of Georgia	-	√	This learning design can be considered in increasing awareness of active learning.
Kinesthetic Physical Model	San Francisco State University (SFSU)	√	-	This activity uses inexpensive and straightforward materials by presenting a useful model to demonstrate the pathophysiology to increase student understanding and involvement.
Concept First Jargon Second	University of British Columbia	√	-	Simple instructional change by introducing new concepts as the first step, following by explaining jargon as the second step, can improve student learning.
Virtual Cell Learning module	University in the Southeast United States	√	-	The potential of online learning modules to provide cognitive effects to improve conceptual understanding.
Clickers, in-class discussion, and lab-seminar activities	University of Guelph	√	-	Superior student performance in learning using a clicker because they obtain benefits from the form of answered questions.
Active Learning Group	University of Tennessee	√	-	Instructional changes in increasing active learning in a large biology course class may occur, although it may take time for changes to take effect.
Active Learning Classroom	University of Minnesota	√	-	The application of active learning classrooms (ALC) has a positive impact on students. However, considering that the technological resources spent are quite a lot and impractical, then its implementation is recommended for steps that can be taken to traditional spaces, such as small groups with focus group dialogues and adjustable chairs to move.
SI Model	Louisiana State University	√	-	The SI model can be used for faculty training for science and extended to various higher education institutions.
Card Games	University of Amsterdam	-	√	This type of game can be used as an active learning tool for small groups' topics and stimulates student discussion.
Pre-class	Institution in	√	-	The results indicated that more than 80% of

Active Learning Strategies	Implementation at the University	Types of Class Size		Benefits
		Large	Small	
Reading Guide	the western United States			students completed the reading guides before class. Full completion of the reading guides before class is significantly positively correlated with test performance.
Organism Card	University of Minnesota Rochester	-	✓	This strategy can create a positive learning environment where students engage with each other, including instructors, and produce significant learning experiences.

Based on the analysis results, the learning strategy is dominant by implementation in the room or class. There is only one strategy that applies to learn outside the classroom, namely field training (Soja, 2014). Biological field training is a kind of outdoor learning which provides student interactive experience and opportunities. Students' engagement in field-based activities has an essential role in learning biological issues (Jeronen, Palmberg, & Yli-Panula, 2017). The strategy options both indoors and outdoors do not become trouble for lecturers in teaching and learning because the core of the learning objectives is to create student-centered learning. In Student center learning, there is a concern on skills and competencies that have responsibility for one's learning, independence, and cooperation, understanding, thinking for oneself, and there are several ways used in instruction to encourage this type of learning: making students more active in acquiring knowledge and skills; making students more aware of what they are doing and why they are doing it; focusing on interaction; focusing on transferable skills (Attard, Ioio, Geven, & Santa, 2010). The learning process that supports students in finding their concepts and builds the framework with a solid structure only receives information passively through the lecture format (Mathias, 2014). Instructor skills in choosing active learning strategies have a crucial role because learning effectiveness seems from learning activities.

CONCLUSION

Efforts to improve the quality of learning in tertiary institutions had needed as a form of change in the learning process for a better and more meaningful direction. The use of active learning strategies directs student-centered activities in developing cognitive potential and constructing its concepts. Lecturers have a crucial role as a planner and determinants in realizing active learners in learning. Active learners could emerge from the right choice of learning strategies, not only relying on lectures in delivering subject matter. A good understanding from the lecturer in determining the Strategy will impact the emergence of various types of strategies that are right with the material to be delivered.

The active learning strategies used by biology classes are very diverse. This condition proves that lecturers have had changes in implementing the best learning system for students. Students feel changes in learning for the better, more fun and understanding the complicated subject matter. The application of active learning strategies varies at each campus. Some using technology that is cheap and expensive when studying, demonstration models, learning formats, learning in nature, card games, and familiar active learning strategy formats. The factors that influence her range from campus facilities, the number of students, and the subject matter's difficulty level. University and lecturer support is a primary factor in the realization of active and effective teaching and learning.

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