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Using Gamification-based Program to Increase Student Creativity Skills in Sustainable Development Topics

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Abstract: Creativity skills are one of the essential skills to face the VUCA World. Improving creativity skills is hampered by the large number of students and learning conditions that are less demanding of the creative process in the class. This research aims to measure the effectiveness of the Botanical Eco-gamification program to improve creativity skills. The ADDIE research approach was used to redesign the Botanical Eco-gamification program so that it can improve creativity skills. This research produced test instruments, e-LAD and questionnaires to measure creativity skills in the program. The instrument developed has been proven valid and reliable for measuring originality, divergent thinking, convergent thinking and mental flexibility skills. The results of program implementation show that students' creativity skills have increased from before treatment in the sufficient category (54.2) to the good category (71.16) with the N-Gain achievement being categorized as medium (0.37). The majority of students (55.71%) reached mastery level after being given treatment. Almost all students (76.29%) stated that the program was good for improving creativity skills. Further research is needed to examine other 4cs competencies, ESD competencies, mastery learning and student's engagement in the Botanical Eco-gamification program.

Keywords: ADDIE; Botanical eco-gamification; Creativity skills; Gamification; Outdoor learning

Introduction

Life in the 21st century is characterized by a VUCA World which consists of volatility, uncertainty, complexity, and ambiguity (Mack et al., 2015). To be successful in life or career in the 21st century, 21st century skills are needed which are often known as 4Cs (creativity, critical thinking, communication and collaboration) (Thornhill-Miller et al., 2023; Trilling & Fadel, 2009). The 21st century skills are essential skills needed to realize a sustainable life in the future (González et al., 2020). It is hoped that by mastering 21st century skills, students will be better prepared to face the VUCA World. One of the important skills for facing the VUCA World is creativity skills.

Creativity can be defined as something that reflects two criteria, originality and effectiveness (Runco & Jaeger, 2012). There are four basic, measurable dimensions which is the act of creating (process), the result of a creative process (product), the characteristics of the creative agent carrying out the process (person), and the social and physical environment that enables or impedes the creative process. (Thornhill-Miller et al., 2023). Creativity must be prioritized when developing young generations to face an ever-changing world of work with complex, multifaceted and interconnected problems (Lemmetty et al., 2021). The OECD even shows creativity skills as one of the skills that must be possessed to face the world of work in 2025. The urgency to improve creativity skills is also demonstrated by the framework developed by OECD, namely the PISA 2022 Framework (OECD, 2021; PISA, 2023). Learning strategies are needed that can improve creativity skills and instruments to measure students' creativity skills (Susilowati et al., 2022). These strategies need to be adapted to students' learning styles and conditions so that they are more effective. In this case, learning styles and learning conditions in Indonesia.

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Curriculum implementation in Indonesia tends to be oriented towards mastering concepts (cognitive domain) rather than attitudes or skills. Educators tend to focus on pursuing the completion of the material rather than using learning strategies that can improve creativity skills (Mardiyah et al., 2020; Zidan, 2019). Today's Indonesian students are generally categorized as Generation Z, who grow and evolve with technology. Gen Z students are generally less motivated and engaged than previous generations (Baydas & Cicek, 2019; Saxena & Mishra, 2021). Gen Z needs active learning that is rich in learning experiences to get more optimal learning results (Othman et al., 2021). Furthermore, an active learning can be implemented not only to improving the cognitive domain, but also improve attitudes and psychomotor skills. In this case creativity skills.

Creativity skills are one of the skills that are difficult to develop in Indonesia (Mutohhari et al., 2021). Large number of students in one class (>30) is one of the difficulties factor in developing creativity skills (Strom & Strom, 2002; Zidan, 2019). Student creativity will increase when teachers create an environment that requires students to think or act creatively. It is important for teachers to provide feedback or reinforcement so that students continue to strive to develop their creative potential (Lemmetty et al., 2021; Sadikin & Yelianti, 2021; Suskie, 2009). Meanwhile, too many students can make it difficult for teachers to provide feedback or require students to think and act creatively. Therefore, conditions are needed that are able to support increasing students' creative potential. One condition that is suitable for stimulating creativity is an outdoor learning.

The application of outdoor learning is considered capable of increasing students' creative potential (Aladağ et al., 2021), problem-solving abilities (Saefudin et al., 2022) or environmental literacies (Khairani et al., 2023). Activities such as outbound or challenging games can stimulate students' creativity. In this case, teachers can combine playing and learning activities or teach a concept through games (Mystakidis et al., 2019). Through an environmental approach, teachers can teach scientific knowledge by utilizing everything that is in the environment (Widodo, 2021). Students are invited to determine, develop and build meaningful knowledge by interacting with the environment (Gray, 2018). Outdoor learning can show objects or phenomena to be more real so that they can explain abstract concepts (Hastika & Supriatno, 2023; Supriatno, 2013). This process then form a connection between the visible object and the ideas or conceptions that exist within the student (Zidan & Supriatno, 2023). One interesting learning strategy that can be applied outdoors is the gamification strategy.

Gamification strategy is one way to apply game elements in a non-game context (Ibarra-Herrera et al., 2019; Ordov et al., 2019). Gamification makes it possible to increase student involvement in learning because there are interesting and fun game elements (Bouchrika et al., 2021). Game elements such as scores, competition, achievements, are considered capable of increasing motivation and involvement which in turn improve learning outcomes not only in the cognitive domain, but also affective and psychomotor (Guillén et al., 2021; Mystakidis et al., 2019; Zainuddin et al., 2019). The application of gamification strategies can then be used as active learning and create an environment that supports improving creativity skills. One interesting application of gamification strategies in learning is through the Botanical Eco-gamification.

The Botanical Eco-gamification program has been developed by integrating gamification elements and ESD competencies. The research results show that students responded very well to the implementation of the program (Saefudin et al., 2023). This program contains learning resources related to SDGs, practical activities related to Biology concepts and fun games integrated with game elements. This program has the potential to be further developed to improve students' creativity skills. This research aims to see the effectiveness of the Botanical Eco-gamification program in improving students' creativity skills. The research question for this research is 'How effective is the Botanical Eco-gamification program in improving students' creativity skills?'

Method

This research uses the ADDIE research approach (Analysis, Design, Development, Implementation and Evaluation) (Branch, 2010). At the analysis stage, case study research was carried out on 23 students and 2 high school teachers. Meanwhile, at the development stage and implementation stage, experimental research was carried out with a one group pretest-posttest design (Fraenkel & Wallen, 2009). These two stages involved 70 prospective biology teacher who took Biodiversity, Conservation and Environmental Science courses. Research was carried out on the topic of sustainable development with a time allocation of 100 minutes in the UPI Botanical Garden. The evaluation stage is carried out at each stage.

The instruments used consist of test instruments (essays), questionnaires and practical worksheets called Electronic Laboratory Activity Design (e-LAD). An essay test is used to measure creativity skills (8 items) and is given at the beginning and end of the meeting. A creativity questionnaire instrument (12 items) with positive and negative items was also developed to

measure student responses regarding the effectiveness of the program in improving creativity skills. Specifically, questionnaire instruments are only given after the activity has been carried out. All instruments are given to students via Google Form. Data analysis was carried out with the help of SPSS ver.24 software to measure the validity and reliability of developed instruments. Increasing students' creativity skills is measured by N-Gain achievements. The scores obtained were analyzed using the mastery learning category with an achievement of more than 70% for the Mastery category (Kulik et al., 1990). Questionnaires in the form of a 4-point Likert scale were analyzed and discussed descriptively based on the percentage of answers obtained.

Result and Discussion

Analysis Stage

At this stage, case study research is carried out with the aim to describe weaknesses, potential and recommendations for things needed for the next stage. The focus of observations in the case study is learning strategies that have been implemented in the Botanical Garden and whether these strategies can improve creativity skills. The case study was carried out using a purposive sampling technique using questionnaire instruments and semi-structured interviews. The questionnaire consists of 8 question items to measure students' perceptions of learning in the Botanical Garden and 8 items to measure the relevance of learning in the Botanical Garden in improving creativity skills.

The results of the case study show that in general the average student responded well (77.99%) to learning strategies in the Botanical Garden. Even though it is good, learning strategies can be made more challenging, in groups and integrated with technology so that they respond better. Both teacher and student respondents stated that learning was not yet systematic and interesting. The teacher stated that learning needs to be made in the form of active learning, either with games or activities that use a lot of hands-on. Based on the analysis of the results of the creativity questionnaire, it was found that almost all students agreed (74.32%) that the learning carried out in the Botanical Gardens needed to be improved to support the development of creativity skills (Zidan et al., 2024). Analysis shows that learning is needed that is more challenging and requires students to think creatively.

Design Stage

The focus at this stage is to redesign the Botanical Eco-gamification program to stimulate increased students' creativity skills. Creativity indicators are adopted from the creativity framework which consists of indicators of originality, divergent thinking, convergent thinking, and mental flexibility (Lubart et al., 2013). The framework is then designed to be applied in games which are one of a series of Botanical Eco-gamification. The application of the creativity framework to games refers to research by Thornhill-Miller (2023). The flow of learning activities is designed in such a way that students are challenged in trying new ways, finding ideas, collaborating and thinking divergently and convergently.

Creativity is also enhanced, especially in the form of creative potential found in e-LADs. This e-LAD is a guide for students to do practical work. The knowledge gained from practical activities is then used to increase student creativity through the 'Project Plan' on the E-Worksheet. This project plan requires students to generate ideas, divergent and convergent thinking and mental flexibility in predetermined scenarios. For example, in the Trigona Bee Cultivation e-LAD, students are required to plan a product made from honey bees, including the product name, product design and how to market the product. There is 5 e-LAD with different project plan scenarios depending on the learning resource posts studied by students. These learning resource posts include Stingless Bee Cultivation Post, Aquaponic System Posts, Oyster Mushroom Cultivation Post, Black Soldier Fly (BSF) Maggot Cultivation Post, and Soil Erosion Model Post. The entire flow of learning can be seen in Figure 1.

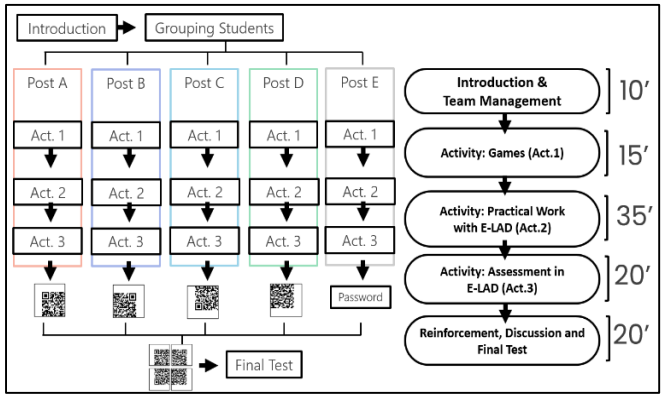

Figure 1. Botanical Eco-Gamification learning's flow

Botanical Eco-Gamificaiton program involved 5 teachers (game masters) and 70 students (players) who were divided into 2 classes (Big Group: Team A & B). Each class is divided into 5 groups (small groups) and occupy different posts. Each team competes in the game to get an e-LAD. The e-LAD is used as a guide for practical work and assessments according to the material in the learning resource post. Groups that have completed all activities in E-LAD will receive a QR Code fragment or password that will be used to access the final test. The small group will return to the big group

(Team A or B) to combine the QR Code fragments and discuss the findings at each learning post. The teacher will provide reinforcement before students take the final test. For further explanation regarding the flow of the Botanical Eco-gamification program, you can refer to research by Saefudin (2023).

Development Stage

The development stage focuses on instrument development and instrument testing. The draft instrument that has been prepared is then converted into digital form either in the form of Google Forms (Questionnaire & Pretest-Posttest) or Google Docs (E-Worksheet). The instruments that have been prepared are then tested in trials of Botanical Eco-gamification program. The validity of instrument items was analyzed using the Pearson's product correlation test. The reliability itself was tested using the Cronbach's Alpha test (Taber, 2018). The results of the analysis will determine whether the items in the instrument are suitable for use, repair or discarded for the implementation stage. The results of instrument testing can be seen at Appendix. 1.

The results of instrument analysis with 8 question items show that all the essay questions developed can be used by Sig. < 0.05 (df:70). Cronbach's Alpha testing showed that 8 essay questions were categorized as high (0.79). It can be concluded that 8 essay questions are suitable for measuring student creativity. The results of the questionnaire instrument analysis show that all items on the creativity questionnaire (12 items) have a Sig value. < 0.05 (df:66). This means that all the items used are valid in measuring student creativity. The results of further analysis showed that all valid questionnaire items had a Cronbach's Alpha value of 0.838 or were categorized as high. In general, it is known that all 12 questionnaire items were selected to measure students' responses regarding the influence of the Botanical Eco-gamification program in improving creativity skills.

Implementation Stage

The discussion at this stage focuses on the results of the average score, N-Gain and Mastery Learning achievements from the students' creativity skill scores. These results were then compared with the percentage of student responses obtained from the creativity questionnaire. The recapitulation of the results of the average scores, N-Gain and Mastery Learning achievements are explained in Table 1.

Based on Table 1, it is known that the average score of students' creativity skills before the treatment was categorized as sufficient (54.29) and changed to a good category (71.16) after the treatment. This change shows an increase in N-Gain achievement which is categorized as medium (0.37). These results show that the treatment given is able to improve students' creativity skills. The assignment (Project Plan) given requires students to think creatively. For example, in the Project Plan assignment, students are required to formulate a product name and design a product concept that can be sold (Figure 2).

Table 1. Overall Value, N-Gain and Mastery Learning of Creativity Skills

Calculated factors	Before	Interpretation	After	Interpretation
Max. score	84.40	Excellent	100.00	Excellent
Min. Score	25.00	Poor	37.50	Poor
Average score	54.29	Sufficient	71.16	Good
N-gain			0.37	Medium

Figure 2. Examples of product design results from E-LAD assignments

One of the product designs developed by students is Beeuty and Omupy. Beeuty was developed based on the knowledge gained at the Stingless Bee Cultivation Learning Post. Meanwhile Omupy was developed based on Oyster Mushroom Cultivation Post. Another question in project plan requires students to plan community service programs. The program design is expected to show students' creative potential, especially with knowledge related to learning resource posts in Botanical Eco-gamification program. These activities are structured using a creativity skills framework that requires originality, divergent thinking, convergent thinking, and mental flexibility. The creativity scores obtained for each indicator were then compared from the pretest-posttest results and also the scores on the Project Plan (e-LAD). The comparison of creativity scores is explained in Figure 3 (below).

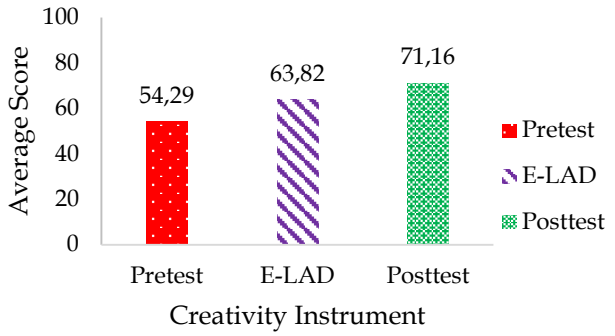

Figure 3. Comparison of creativity average scores

Based on Figure 3, students have creativity skills in the sufficient category (54.29). The treatment given improved creativity skills in the good category (63.82) based on the results of the e-LAD analysis. At the end of the activity, students' creativity skills increased although they were still in the good category (71.16). Increasing creativity skills is not only through e-LAD assignments, but also through games. For example, in the Oyster Mushroom Cultivation learning resource, students are asked to put together a puzzle and find hidden objects. Hidden objects can be found when students are able to solve the puzzle after completing the puzzle. There are 5 different games at each learning post that challenge students to practice their creativity skills. Creativity skills have increased differently from one indicator to another. An average score comparison between before and after treatments for each creativity indicator can be seen in Figure 4.

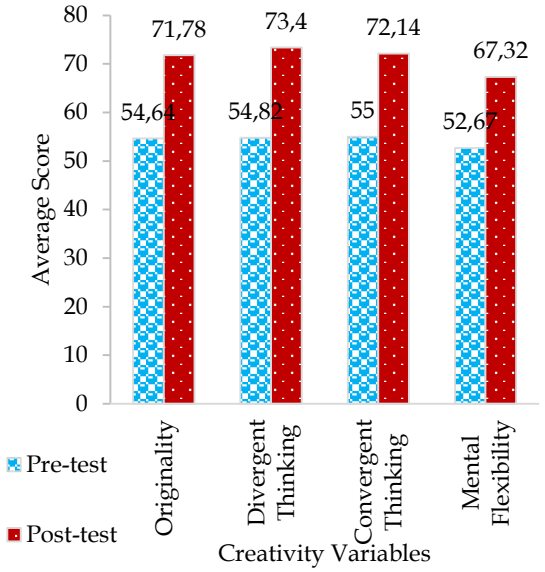

Figure 4. Comparison of average creativity scores before and after for each indicator

Based on Figure 4, it is known that the average initial skills of students from highest to lowest are convergent thinking (55.00), divergent thinking (54.82), originality (54.64) and mental flexibility (52.62). All students' creativity skills at the beginning of the activity were categorized as sufficient. Based on posttest data, it is known that the program can improve creativity skills with the highest to lowest average N-Gains are divergent thinking (73.4), convergent thinking (72.14), originality (71.78) and mental flexibility (67.32). All creativity skills increased to the good category at the end of the activity. Furthermore, to find out which skills experienced the highest improvement after the program was implemented, it can be identified by comparing the N-Gain achievements for each indicator described in Figure 5.

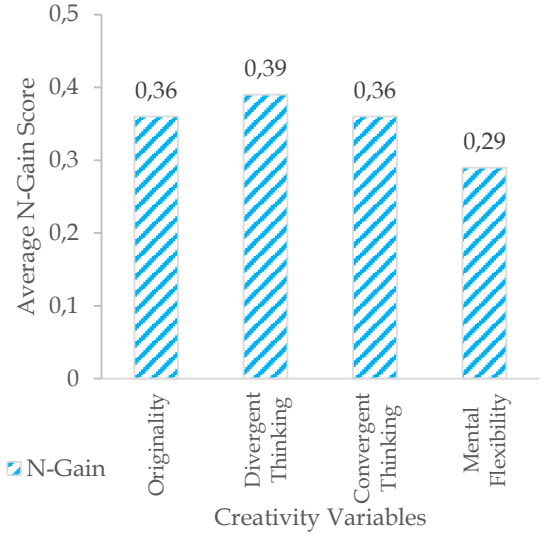

Figure 5. Comparison of average n-gain scores for each indicator after treatment

Based on Figure 5., it can be seen that the program implemented was most effective in improving divergent thinking skills (0.39) in the medium category. The program is also considered effective in improving originality (0.36) and convergent thinking (0.36) skills, both of which are categorized as medium. However, in contrast to these three skills, the program is considered effective in improving mental flexibility skills in the low category (0.29). Improving divergent thinking skills is considered the most effective because in the program students are required to come up with lots of ideas to get good grades e-LAD or to be able to finish the game the fastest. The program increasing mental flexibility in the low category allegedly because of the grouping and time allocation provided. The results of activity observations showed that students did not take risks or challenges because they did not want to cause trouble to their group. The short game time (15 minutes) also causes students to explore less of the challenges available throughout the Botanical Eco-gamification program.

The overall effectiveness of the program in increasing creativity can also be seen from the percentage of students who reach mastery level as shown in Figure 6.

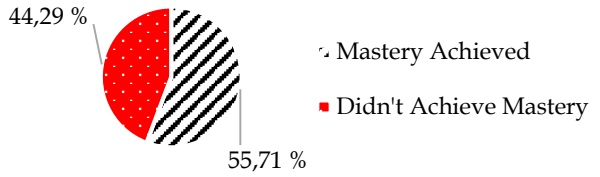

Figure 6. Comparison of mastery of creativity after treatment

Based on Figure 6., it is known that the majority of students (55.71%) have achieved mastery of creativity and almost half (44.29%) have not achieved mastery of creativity. These results are supported by the results obtained after treatment (Table 1) which reveal that the average student creativity score is 71.16. This value is slightly higher than the specified minimum mastery level, namely 70.00. In line with this in Figure 5, it is known that the program is effective in improving creativity skills, but only in the low and medium categories. Creativity skills are considered skills that are rarely trained and good concept mastery is not always directly proportional to the creativity skills possessed (Zidan, 2019). The effectiveness of the program to improve creativity skills can also be seen from students' responses to the implementation of the program as shown in Figure 7.

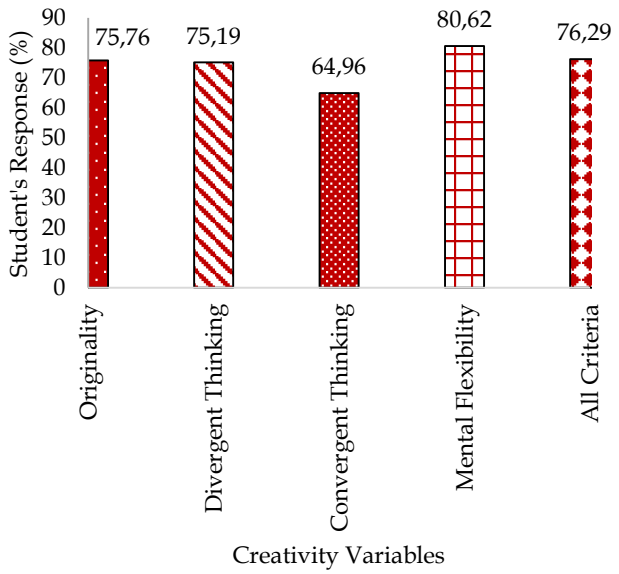

Figure 6. Comparison of average student responses regarding the effectiveness of program to improve creativity skills

Based on Figure 6, it is known that almost all students (76.29%) stated that the program was good for improving creativity skills. The interesting thing is that almost all students (80.62%) think the program can improve mental flexibility skills. This result is inversely proportional to the score obtained which shows that mental flexibility skills are the lowest compared to other skills (Figure 4). It can be interpreted that the program provides new learning experiences to students with games that challenge and demand students' mental flexibility. However, the short game time (15 minutes) makes students less trained in taking risks or activities that require mental flexibility. Too many students also reduce students' opportunities to be more active in trying challenges or taking risks in games (Strom & Strom, 2002). Can be noted that all students who take part in the activity are divided into 5 learning posts, where each post has 7-8 people.

The Botanical Eco-gamification program can be an alternative learning strategy solution to improve students' creativity skills. Outdoor learning conditions that are integrated with gamification can stimulate students' creative potential (Thornhill-Miller et al., 2023) while maintaining student motivation (Chans & Portuguez Castro, 2021). Direct outdoor learning experiences can improve skills in the field for both individuals and groups (Permana et al., 2020). The designed learning post require groups to work together creatively while supporting sustainable practices. This is also important considering that collaboration skills through mushroom cultivation activities or other post can support the SDGs practices (Widodo et al., 2023). Sustainability practice training helps prepare students to deal with VUCA World (Araújo et al., 2021).

Increasing creativity skills through the Botanical Eco-gamification program can be further optimized. First, the number of students involved can be smaller (<30) so that the teacher's feedback can be more focused. Smaller numbers also allow each student to pass all learning posts, not just one post. This can help mapping students' creativity scores changes from the first post to the last. Second, the games implemented need to be more systematic and require students to think and act creatively. Teachers can make rules such as to proceed to the next phase, students need to complete activities that require a creative process. If not, students will lose to the other team or get a lower score. Third, the program should be implemented more than once. Teachers can provide better feedback regarding the project plans that students have made. This feedback can be in the form of directions so that product plans are more creative. Through this, teachers can compile student project plans into portfolios which can then be assessed as the development of student creativity.

This research has benefits for developing similar learning programs or strategies. Future research can raise different 4C's variables or discuss ESD competencies. The gap in this research is the lack of data

to reveal the relationship between students' mastery on selected topics and students' creativity. Research also does not discuss student motivation before and after, or student involvement both individually and in groups.

Conclusion

This research using the ADDIE approach produced test instruments, e-LAD and questionnaires to measure creativity skills in the Botanical Eco-gamification program. The instrument developed has been proven valid and reliable for measuring originality, divergent thinking, convergent thinking and mental flexibility skills. The results of program implementation show that students' creativity skills have increased from before treatment in the sufficient category (54.2) to the good category (71.16) with the N-Gain achievement being categorized as medium (0.37). The majority of students (55.71%) reached mastery level after being given treatment. Almost all students (76.29%) stated that the program was good for improving creativity skills. Further research is needed to examine other 4cs competencies, ESD competencies, mastery learning and student's engagement in the Botanical Eco-gamification program.

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Author Contributions
Zuliande Zidan contributes to conceptualizing research idea, analyzing data, and writing articles. Kusnadi and Saefudin contributes for supervision in research methodology and review manuscript. Asyah Dwi Hastika and Zuliande Zidan contributes to investigation, developing resources, and project administration.

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Conflicts of Interest
The authors declare that there is no conflict of interest regarding the publication of this paper.

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