

Development of Sciencepreneurship Modules on Environmental Pollution with PjBL Model to Improve Collaboration Skills and Creative Thinking Skills in Grade VII Students

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ABSTRACT

The sciencepreneurship modules on environmental pollution was developed to empower students' collaboration and creative thinking skills through the Project-Based Learning (PjBL) model. This study aimed to produce a module that is valid, practical, and effective in enhancing collaboration skills and creative thinking skills. The research employed a Research and Development (R&D) design based on the ADDIE model. Validity data were obtained from expert validation by subject matter experts, instructional material experts, learning design experts, and field practitioners. Practicality data were collected from practicality tests, student response questionnaires, teacher response questionnaires, and observations of the learning syntax implementation. Effectiveness data were obtained from test scores, student and teacher activities, and student response questionnaires. Questionnaire and observation data were analyzed descriptively using percentages, while collaboration and creative thinking test data were analyzed using ANCOVA with IBM SPSS Statistics 26. The results indicated that: (1) the module was valid in terms of content, instructional materials, and learning tools; (2) the module was practical for student use; and (3) the module was effective, as evidenced by significant differences in collaboration and creative thinking scores, excellent levels of student and teacher activity in implementation (100 %), and highly positive student responses of modules (90.2%).

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1. INTRODUCTION

Quality education is a key foundation for achieving the goals of the Sustainable Development Goals (SDGs) in Indonesia by emphasizing 21st-century skills. One essential 21st-century skill required by students is collaboration. Collaboration skills are necessary for students to enhance teamwork with individuals from diverse backgrounds in facing the challenges of the 21st century [1]. [2] identified common barriers to effective collaboration, including students' limited collaborative abilities, low participation in group contributions, unequal competency levels among students, and a lack of task focus during group work.

The needs analysis conducted in ten junior high schools in Pasuruan City revealed that 60% of science instruction hasn't been directed towards enhancing students' collaboration skills. In addition, questionnaire and interview results indicated that 90% of teachers have not developed instruments to assess students' collaboration skills, resulting in unmeasured and underdeveloped collaboration abilities. Teachers tend to emphasize cognitive learning outcomes rather than collaboration skills, thus contributing to the low level of collaboration among students. Therefore, the integration of collaboration indicators in each learning activity are necessary.

Collaboration skills in the learning process can support the achievement of SDG goals in sustainable quality education. The implementation of SDG-based learning in junior high schools can promote students' social awareness in global issues and creating sustainable solutions. This approach requires experiential learning to

establish meaningful understanding and develop future competencies. One such competency is entrepreneurship, which contributes to SDGs by reducing poverty and increasing economic growth ([3]; [4]). This entrepreneurship oriented learning can be integrated into science subjects to provide students with holistic, meaningful, active, and authentic learning experiences known as sciencepreneurship.

Sciencepreneurship learning can be applied in environmental pollution topics to allow students process waste materials as a form of meaningful learning [5]. [6] stated that sciencepreneurship learning guides students in using scientific knowledge to create creative, innovative, and beneficial products while enhancing their life skills. This approach was effective when applied using a Project-Based Learning (PjBL) model. Sciencepreneurship learning using the PjBL model encourages students to actively seek solutions to environmental problems. According to [7], PjBL emphasizes students' ability to identify real-life problems and determine appropriate solutions. This model can also enhance creative thinking skills by training students to develop various problem-solving strategies, either independently or collaboratively ([8]; [9]; [10]). Therefore, collaboration skills are necessary in the production of creative outcomes, while creative thinking skills support the innovation process in sciencepreneurship learning.

Creative thinking skills enable students to generate added value from available resources. These skills also promote divergent thinking, argument formulation, open-mindedness, and the development of multiple ideas ([11];[12]). However, [13] found that constraints such as limited instructional time and convergence-oriented tasks hinder the development of creative thinking. These obstacles can be overcome through process-oriented instruction and intensive teacher monitoring during task completion. The needs analysis in ten junior high schools in Pasuruan City revealed that 53% of science learning is rarely directed toward enhancing creative thinking skills. Furthermore, all teachers reported that they had never developed instruments to assess students' creative thinking, resulting in unmeasured and underdeveloped skills. Consequently, sciencepreneurship learning is believed to strengthen both collaboration and creative thinking skills while fostering entrepreneurial opportunity recognition among students.

The concept of sciencepreneurship learning is based on the integration of science literacy, 21st-century skills, and entrepreneurship to enable students to solve problems collaboratively and creatively. This concept is in line with the Sustainable Development Goals, particularly the goals of quality education and poverty eradication [3]. In the context of science education at the junior high school level, sciencepreneurship combines scientific concepts with the design of useful products through Project-Based Learning (PjBL) models, enabling students to understand concepts and produce innovative solutions that have economic and social added value. Theoretically, this approach requires measurable indicators for collaboration skills and creative thinking skills. However, its implementation faces various obstacles, including the dominance of cognitive-oriented learning and final results, low collaborative skills among students due to unequal contributions within groups, limited learning time, the unavailability of authentic assessment instruments to measure process skills, and a learning culture that still emphasizes convergent answers, thereby limiting the exploration of ideas ([2]; [12]). The limitations indicate that the development of sciencepreneurship modules requires not only the integration of content and entrepreneurial projects, but also the systematic design of assessment systems, monitoring strategies, and time management and group dynamics so that the objectives of empowering collaboration and creative thinking skills can be achieved effectively.

The existence of this module as teaching material was needed to help students in conducting independent science entrepreneurship learning activities with the guidance of teachers. The module has several advantages, namely training students' independence in learning, being presented in a communicative manner, and emphasizing learning activities with clear and measurable objectives. The use of modules has been proven effective in facilitating students to improve their competencies ([14]; [15]). Based on the results of a needs analysis conducted in 10 junior high schools in Pasuruan City, junior high school teachers still do not have teaching materials in the form of modules on waste management that contain entrepreneurship content that guides learning by empowering collaboration skills and creative thinking skills. This will have an impact on students' collaboration skills and creative thinking skills, which are still not optimal. The existence of sciencepreneurship modules is urgently needed in Pasuruan City to foster an entrepreneurial spirit by empowering students' collaboration and creative thinking skills in facing future career challenges. This aligns with the research by [16], which states that the implementation of sciencepreneurship can build independence and creativity in students at SD Muhammadiyah Banjarnegara. The purpose of this study is to produce a valid, practical, and effective module that empowers collaboration skills and creative thinking skills.

2. RESEARCH METHOD

This study used a Research and Development (R&D) approach based on the ADDIE model proposed by [17], which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. The product developed in this study was a sciencepreneurship module on environmental pollution designed to enhance students' collaboration and creative thinking skills.

The analysis stage revealed that science instruction in Pasuruan City rarely focuses on collaboration and creative thinking, and teachers lack entrepreneurship-based instructional modules. Therefore, the development of a sciencepreneurship module integrated with collaboration and creative thinking was required. The design stage involved the development of a storyboard based on student learning sources and the selection of appropriate development software. During the development stage, the module was constructed according to the storyboard and validated by four experts: a subject matter expert, an instructional material expert, a learning design expert, and a field practitioner. The product was then tested for practicality through (1) one to one trial test, (2) small group trial test, and (3) field trial test. The implementation stage was conducted at SMPN 2 Pasuruan to evaluate the effectiveness of the module in improving collaboration and creative thinking skills. The effectiveness test was conducted using a quasi-experimental design of the nonequivalent pretest-posttest control group type in the experimental class and the control class. The experimental class used the developed sciencepreneurship module with the PjBL model, while the control class used the PjBL model without the module.

The population consisted of 7th grade students at SMPN 2 Pasuruan. The reason of 7th grade students were chosen as research subjects is that 7th grade grade students are marked by the development of early formal thinking skills. Therefore, it is more effective to instill collaboration and creative thinking skills from the beginning of middle school so that they can develop it continuously. In addition, the environmental pollution material is the context for the development of the sciencepreneurship module and taught in the early phase in 7th grade. The 7th grade students students were tested for equivalence using their elementary school graduation exam equivalence. The sample was selected using purposive sampling based on requirements and was considered representative of the equivalence test results. The research sample consisted of two 7th grade students classes. The experimental class was taught using the sciencepreneurship modules, while the control class was taught without using the developed modules. Class VII E served as the experimental group, and Class VII F as the control group. Data were both quantitative and qualitative. Quantitative data included validation sheets, implementation observation sheets, teacher and student activity observations, student and teacher response questionnaires, self-assessment, peer assessment, and tests. Qualitative data consisted of expert and practitioner suggestions.

The instruments used in this study aim to measure the validity, practicality, and effectiveness of the sciencepreneurship module on environmental pollution to empower students' collaboration and creative thinking skills. The module validity instrument uses an expert validation sheet. The module practicality instrument uses a practicality sheet, a learning syntax implementation sheet, a student response questionnaire, and a teacher response questionnaire. The module effectiveness instrument uses a student response questionnaire, a teacher and student activity sheet, an observation sheet, a self-assessment questionnaire, a peer assessment questionnaire, and a test.

The data analysis technique used in this development study employs quantitative data analysis and descriptive qualitative data analysis. Quantitative analysis is used to analyze data from the validation results of the science entrepreneurship module, practicality test results, student response questionnaire results, teacher response questionnaire results, learning syntax implementation results, test results, teacher and student activity sheets, self-assessment questionnaire results, peer assessment questionnaire results, and observation sheets. Qualitative analysis was used to analyze comments, and suggestions from validators, practitioners, respondents, and observer assessment results.

The validity data of the module was obtained from the results of the validation of the modules by subject matter experts, teaching material experts, learning tool experts, and field practitioners. The practicality data of the module was obtained from the results of practicality tests, student response questionnaires, teacher response questionnaires, and learning syntax implementation results. The validity and practicality data of the module were analyzed using the following formula.

$$P = \frac{\sum x}{\sum xi} \times 100\%$$

- P = percentage
- ΣX = total score each item
- ΣXi = maximum total score each item

Table 1 Criteria for the Validity and Practicality of Modules

Percentage (%)	Criteria
100	Highly valid/Highly practical, or the product can be used without modification.
85,00 ≤ X ≤ 99,99	Highly valid/Highly practical, or the product can be used with minor modifications.
70,00 ≤ X < 85,00	Valid/Practical, or the product can be used with moderate modifications..
55, 00 ≤ X < 70,00	Less valid/Less practical, or the product can be used with major modifications.
40, 00 ≤ X < 55,00	Not valid/Not practical, or the product cannot be used..
X < 40,00	Highly invalid/Highly impractical, or the product cannot be used.

Source: Sulisetijono (2018)

Table 2. Criteria for Student Response Questionnaires and Teacher Response Questionnaires

Percentage (%)	Criteria
$85,00 \leq X \leq 99,99$	Very positive
$70,00 \leq X < 85,00$	Positive
$55,00 \leq X < 70,00$	Fairly positive
$40,00 \leq X < 55,00$	Less positive
$X < 40,00$	Not positive

Source: Sulisetijono (2018)

The effectiveness data obtained from the results of student and teacher activities and student response questionnaires were analyzed using the following formula.

$$P = \frac{\sum x}{\sum xi} \times 100\%$$

- P = percentage
 $\sum X$ = total score each item
 $\sum Xi$ = maximum total score each item

Table 3 Criteria for Teacher and Student Activities

No.	Percentage (%)	Criteria
1.	91-100	Very good
2.	81-90	Good
3.	71-80	Fair
4.	61-70	Poor
5.	0-60	Very poor

Source: Sudjana (2012)

Collaboration skills and creative thinking skills data were tested for prerequisites first. The prerequisite tests conducted were the Kolmogorov-Smirnov test and homogeneity with Levene's Test at a significance level of 5% (Sugiyono, 2017). The criteria for the prerequisite tests were as follows.

- If the $p\text{-value} < \alpha$ (0.05), then it is not normal and homogeneous.
- If the $p\text{-value} \geq \alpha$ (0.05), then it is normal and homogeneous.

Hypothesis testing was performed using the One-way Analysis of Covariance (Ancova) test after conducting prerequisite tests with the following significance levels:

- If the $p\text{-value} \leq \alpha$ (0.05), then it is significant.
- If the $p\text{-value} > (0.05)$, then it is not significant.

3. RESULT AND DISCUSSION

1. Modules Validation Result

The module validation results were obtained from subject matter experts, teaching material experts, learning tool experts, and field practitioners. Revisions to the developed module were made based on the assessments and comments/suggestions from the experts before it was used in the implementation stage. The module validation results showed that the average module validation score was 99.35%, which is categorized as highly valid, meaning that the module is ready to be used in learning. The module validation results are presented in Table 4.

Table 4. Modules Validation Result

No.	Validator	Result (%)	Criteria
1	Subject matter expert	100	Highly valid
2	Teaching materials expert	99,63	Highly valid
3	Learning tools expert	99,44	Highly valid
4	Field practitioner	98,33	Highly valid
Average Total		99,35	Highly valid

2. Modules Practical Result

The practicality of the module can be determined by conducting a preliminary test before implementation. The preliminary test was conducted on seventh grade students, which is equivalent to the grade level for implementation. The preliminary test results showed that the average practicality score of the module was 91.06%, which is categorized as highly practical. The preliminary test results are presented in Table 5.

Table 5. Module Trial Result

No.	Test Subject	Result (%)	Criteria
1	One to one trial test	93,33	Highly practical
2	Small group trial test	90	Highly practical
3	Field trial test.	89,86	Highly practical
Average Total		91,06	Highly practical

The practicality test results were also conducted by giving student response questionnaires and teacher response questionnaires in the field trial and PjBL syntax implementation sheets when the module was implemented in class. The results of the response questionnaire on the module showed that students responded very positive with a score of 86.6% and teachers responded very positive with a score of 90%. In addition, the results of the PjBL learning model syntax implementation showed that the learning syntax could be carried out very good at 93.61% during the implementation of the module developed in classroom learning. The practicality test results are presented in Table 6.

Table 6. Modules Practical Result

No.	Subject	Result (%)	Criteria
1	Module trial result	91,06	Highly practical
2	Student response results	86,6	Very positive
3	Teacher response results	90	Very positive
4	Learning syntax implementation results	93,61	Very good

3. Modules Effectiveness Result

The effectiveness of modules can be seen from student learning outcomes, student learning activities, and student responses. Data on students' collaborative skills and creative thinking skills were obtained from pretest and posttest scores conducted during the PjBL learning process in the experimental and control classes. The prerequisite test results on learning outcomes showed that the pretest and posttest data on collaborative skills were normally distributed and homogeneous. The pretest and posttest data for creative thinking skills were also normally distributed and homogeneous. The results of the prerequisite test are presented in Table 7.

Table 7. Prerequisite Test Result

Variabel	N	Kolmogorov-Smirnov	sig.	Decision	Levene Statistic	Sig.	Decision
Pretest Collaboration Skills	62	.092	.200	Normal	.246	.622	Homogen
Pretest Creative Thinking Skills	62	.067	.200	Normal	.121	.729	Homogen
Posttest Collaboration Skills	62	.107	.077	Normal	.007	.931	Homogen
Posttest Creative Thinking Skills	62	.099	.200	Normal	2.857	.096	Homogen

The results of the ANCOVA test for collaboration skills showed a difference between the experimental class taught using the developed module and the control class without using the module. The significance value obtained was .000 ($\alpha < 0.05$), indicating that the use of the module had an effect on the collaboration skills of seventh-grade students. The results of the ANCOVA test for collaboration skills are presented in Table 8.

Table 8. Ancova Test for Collaboration Skills Result

Source	df	Mean Square	F	Sig.
Corrected Model	2	468.811	7.531	.001
Intercept	1	5260.886	84.506	.000
Pretest	1	35.619	.572	.452
Module	1	869.301	13.964	.000
Error	59	62.255		

The results of the ANCOVA test of collaboration skills between the two classes show that the experimental class experienced a greater improvement than the control class in collaboration skills. The results show that the

mean score for the experimental class was 81,674 and the mean score for the control class was 74,159. The results of the ANCOVA test of collaboration skills between classes are presented in Table 9.

Table 9. Ancova Test Comparison of Collaboration Skills in 2 Classes Result

Class	Mean	Std. Error	Lower Bound	UpperBound
Control	74.159	1.397	71.364	76.954
Experiment	81.674	1.443	78.787	84.561

The results of the creative thinking ANCOVA test show that there is a difference between the experimental class taught using the developed module and the control class without using the module. The significance value obtained is .000 ($\alpha < 0.05$), indicating that the use of the module has an effect on the creative thinking skills of seventh-grade students. A summary of the creative thinking skills ANCOVA test results is presented in Table 10.

Table 10 Ancova Test for Creative Thinking Skills Result

Source	df	Mean Square	F	Sig.
Corrected Model	2	561.538	23.610	.000
Intercept	1	2336.546	98.239	.000
Pretes	1	32.343	1.360	.248
Module	1	1078.280	45.336	.000
Error	59	23.784		

The results of the ANCOVA test of creative thinking skills between the two classes show that the experimental class experienced a greater improvement than the control class in creative thinking skills. The results show that the mean score for the experimental class was 78.671 and the mean score for the control class was 70.322. The results of the ANCOVA test of creative thinking skills between classes are presented in Table 11.

Table 11 Ancova Test Comparison of Creative Thinking Skills in 2 Classes Result

Class	Mean	Std. Error	Lower Bound	UpperBound
Control	70.322	.862	68.597	72.048
Experiment	78.671	.891	76.889	80.453

The learning process was conducted in five meetings, focusing on mastering the material to produce products from waste processing. The results of student and teacher activity in the experimental class showed that the average student and teacher activity was 100 %. These results were categorized as excellent in using the sciencepreneurship module on environmental pollution in PjBL learning in grade VII. In addition, the results of student and teacher activity in the control class showed that the average result of student and teacher activity was 89.86% and was categorized as good. These results indicate that students and teachers were active in participating in PjBL learning on environmental pollution material in the experimental and control classes.

The results of student responses to the use of the module were obtained from assessments by 7th grade E students as the experimental class that used the module in learning through filling out student response questionnaires. These student responses were collected with the aim of obtaining an objective assessment of the module content developed during the learning process. The results of the student response questionnaire showed that students gave a very positive response to the application of the developed module product, with a score of 90.2%.

4. Discussion

The validation conducted by the subject matter expert indicated that the sciencepreneurship module on environmental pollution was feasible and ready to be used in the learning process, with a validity percentage of 100%. Revisions to the content aspects of the module were made based on the expert's suggestions to ensure that all components achieved a "very valid" category. According to [18], effective instructional materials should facilitate students' understanding in processing concepts and applying them in everyday life. Therefore, the depth of the material must be contextual and aligned with students' developmental stages.

The validation by the instructional material expert revealed that the sciencepreneurship module on environmental pollution was categorized as very valid, with a validity percentage of 99.63% after revisions were made based on the expert's feedback. These results indicate that the module meets the validity criteria and possesses appropriate characteristics for use in the learning process. Essential characteristics of a good module include being self-instructional, self-contained, stand-alone, adaptive, and user-friendly [19].

The validity assessment of the learning tools focused on two components: the Learning Objective Flow (Alur Tujuan Pembelajaran/ATP) and the teaching module. The ATP was declared very valid, with a validity percentage of 99.44% after revisions were implemented according to expert suggestions. These results indicate that the ATP meets the validity requirements and is appropriate for use in learning activities. According to the Ministry of Education [20], a well-developed ATP provides a comprehensive overview for both teachers and students regarding the stages and sequences necessary to achieve the expected learning outcomes (Capaian Pembelajaran/CP). The validation of the teaching module also yielded a very valid category with a percentage score of 99.43%, indicating that it is suitable for classroom use. [21] state that an effective teaching module should

emphasize essential concepts through learning experiences, stimulate student interest and active involvement, remain relevant and contextual to prior experiences, and ensure continuity according to students' learning levels.

The validation conducted by field practitioners in science education indicated that the sciencepreneurship module on environmental pollution was classified as very valid, with a validity percentage of 98.33%. These results were obtained after revisions were made following the practitioners' recommendations. This finding confirms that the module meets validity criteria and is appropriate for use in learning, as it is aligned with the characteristics and environment of students in Pasuruan City. According to [22], module development should be tailored to student characteristics in order to foster productive, creative, and innovative dispositions. Therefore, the developed module must reflect the students' environment and future life contexts.

Overall practicality was evaluated based on student practicality assessment sheets, student response questionnaires, teacher response questionnaires, and observation of the implementation of learning syntax. The overall results indicated that the sciencepreneurship module on environmental pollution is categorized as very practical. When instructional materials are considered very practical, revision is no longer necessary and they can be directly implemented in the learning process [23]. The practicality of instructional materials demonstrates their ability to facilitate students in discovering, associating, and integrating learning experiences in a representative manner, thereby actively engaging students in solving problems innovatively and creatively [24].

The effectiveness of instructional materials must be tested to determine improvements in students' performance in achieving targeted competencies through the learning process [25]. Effectiveness can be evaluated through student learning outcomes, learning activities, and responses from both students and teachers ([26] ; [27]). The ANCOVA results revealed that the use of the sciencepreneurship module on environmental pollution significantly affected the collaboration skills of Grade VII students. The average posttest scores for collaboration skills in the class that used the developed module were higher than those in the class that did not use the module. Therefore, it can be concluded that the sciencepreneurship module effectively improves students' collaboration skills.

Creative thinking is an essential skill that must be developed in students to enable them to generate new ideas, create alternative solutions, and express themselves in diverse ways [28]. Through creative thinking, students gain the ability to analyze information and develop innovative ideas based on available data [29]. The ANCOVA analysis also indicated that the use of the sciencepreneurship module on environmental pollution had a significant impact on students' creative thinking skills. The average posttest scores for creative thinking in the experimental class were higher than those in the control class. These findings confirm that the sciencepreneurship module effectively enhances students' creative thinking skills.

The development of instructional materials should support classroom learning activities to facilitate the achievement of learning objectives [30]. Instructional materials that actively engage students in learning can significantly improve learning outcomes [31]. Observation results showed that student and teacher activities were categorized as very good in the experimental class and good in the control class. Moreover, the level of activeness in the experimental class was higher than in the control class.

The effectiveness of instructional materials can also be reflected in students' responses, indicating the ease of use and the meaningfulness of the developed materials [32]. Student responses collected from the experimental class revealed a very positive perception of the module, with a percentage score of 90.2%. This highly positive response indicates that the module was well accepted by students and is effective in improving collaboration and creative thinking skills. Instructional materials that are well received by students can enhance learning outcomes and assist learners in understanding abstract concepts more effectively [33].

5. CONCLUSION

The sciencepreneurship module on environmental pollution meets the criteria of validity, practicality, and effectiveness. The sciencepreneurship modules on environmental pollution has met the criteria for material validity, teaching materials, and learning tools for use in learning by subject matter experts, teaching material experts, learning tool experts, and field practitioners. The sciencepreneurship module on environmental pollution has met the practicality criteria for use by students based on the results of student practicality assessment sheets, student response questionnaires, teacher response questionnaires, and learning syntax implementation sheets. The environmental pollution sciencepreneurship module is effective in empowering collaboration skills and creative thinking skills based on the difference in collaboration skills and creative thinking skills before and after using the module, the activity level of students and teachers is very good, and student response to the use of the module is very positive. Therefore, the module is appropriate for continuous implementation in junior high school science learning environments.

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