A Hands-On Classroom Activity to Understand Organic Waste Handling With Conventional Biotechnology: Handout Nata De Orange

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Abstract
The application of handling organic waste that applies conventional biotechnology concepts to students in high schools is still very low. Moreover, the concept of biotechnology innovation is one of the difficult subjects for students. The contextuality of developing learning resources for biotechnology innovation must be improved through students' understanding of science and hands-on activities. The aim of developing the "Nata De Orange" handout is to improve students' psychomotor skills in biotechnology concepts. This type of research is Research and Development (R & D) using the Plomp development model with stages a) preliminary research, b) prototyping phase, and c) assessment phase. This handout contains practical activities for making nata from orange juice using *Acetobacter xylinum* and opportunities for other materials, including household organic waste. The results show that this handout is valid, practical, and effective for improving students' psychomotor skills. The students' response to the use of this handout was very positive, which is a measure of the success of implementing the Nata de Orange handout. Apart from that, this handout can be a reference for science teachers to carry out biotechnology innovation practicums in making nata.

Keywords: Classroom Activity, Biotechnology, Science Education

Introduction

Currently, countries around the world are reforming curricula and education to prepare students for the future (Li & Wang, 2024; So et al., 2024). Indonesia, since 2022, has started implementing the Merdeka curriculum at various educational levels. This curriculum change impacts the learning process, including biology teaching and learning. Moreover, the concept of biotechnology innovation is one of the most difficult subjects for students. Teaching and learning biology with the topic "biotechnology innovation" in the Merdeka curriculum indeed requires instructional media that help students understand concepts and apply them in daily life. The development of quality teaching materials that are aligned with curriculum standards can guide teachers and students to apply instructions and help students learn (Aris et al., 2025; Gleason et al., 2011).

The application of handling organic waste that applies conventional biotechnology concepts to students in high schools with hands-on activities and teaching material is still very low. Hands-on activities are an educational approach that involves students actively engaging in the learning process through practical experiences (Monegro et al., 2024; Schwichow et al., 2016). This method is particularly effective in biology education as it allows students to apply theoretical concepts of science in the real world, which can enhance their understanding and skills (Gericke et al., 2023). Hands-on activities equipped with learning materials are very helpful in the learning process (Idris et al., 2022). Learning materials in the form of handouts are needed for hands-on activities. Therefore, learning material in the form of handouts is needed that can guide students during the learning process of “biotechnology innovation.”

A handout is written instructional material containing important concepts of a learning material concisely. Handouts are considered effective teaching materials because they focus on one topic and are presented in a simple format, making it easy for students to understand (Sidik et al., 2024). The content of handouts should ideally include contextual issues related to students' environments to make learning more engaging and comprehensible. Teachers can also develop materials based on research findings (Khotimah et al., 2021). One effective teaching material is handouts, as they provide specific and concise information to students. Teachers can design lessons centered around real-world problems related to biotechnology innovation, such as issues of environmental sustainability, public health, or food security. Students can then be encouraged to identify, analyze, and seek solutions to these problems using biotechnology concepts, particularly conventional biotechnology. Practical sessions specifically designed to introduce concepts of conventional biotechnology can be integral to this learning approach. With engaging, relevant learning experiences focused on developing students' skills in the field of biotechnology, they become better prepared to face future challenges and opportunities. This is because they not only grasp biotechnology concepts theoretically but also gain practical experience in applying them in real-life contexts.

According to Ferris (2010), the psychomotor domain is the domain associated with aspects of skills involving the functions of the neuromuscular system and psychological functions. This domain consists of (a) readiness: which involves the preparedness of an individual to perform a certain skill or activity; (b) imitation: which involves the ability to observe and replicate actions or behaviors demonstrated by others; (c) habituation: refers to the process of acquiring skills through repeated practice until they become automatic or habitual. It involves refining movements and developing muscle memory. (d) Adaptation: involves the ability to modify or adjust movements or behaviors in response to changing circumstances or

environmental conditions. It requires flexibility, problem-solving skills, and the ability to make quick adjustments. These components of the psychomotor domain are essential for the development and mastery of various physical and practical skills, ranging from simple tasks to complex activities requiring precision and coordination (Meilani & Aiman, 2020). This research aimed to examine the usefulness of a handout Nata de Orange as teaching material to improve students' psychomotor skills on biotechnology concepts through hands-on classroom activity.

Method

Research Design

This type of research uses the Plomp development model with stages: a) preliminary research (need assessment teacher and student), b) prototyping phase (design product): an experiment was conducted at the microbiology laboratory FMIPA Universitas Negeri Malang, c) assessment phase was tried out to three groups of students, namely experimental, control positive and control negative. The research design is explained in Table 1.

Table 1. Research Design

Intevention	Posttest
X1	O1
X2	O2
X3	O3

Adapted from (Cohen et al., 2018)

Explanation

X1: Experiment
X2: Control Positive
X3: Conventional
O1: Psychomotor skill score with handout nata de orange
O2: Psychomotor skill score with control positive class
O3: Psychomotor skill score with control negative class

Data Analysis

The research samples are second-semester tenth-grade students in the biology class of the year 2023 at SMA Negeri 3 Makassar, South Sulawesi, Indonesia. These students were divided into three groups, namely the experiment, which had 36 students, the control positive which had 36 students and the control negative group, which had 35 students. The experimental group learned using the handout nata de orange that had been developed based on the results of prior laboratory experiments. Experimental groups received treatment in the form of PINISI learning model. Control positive groups received treatment in the form of the Problem-Based Learning model and control negative groups received conventional learning. Three groups will be observed using psychomotor ability observation sheets during the learning process. The outcomes of the psychomotor skills observation sheet were then compared between the three groups and used Kruskal-Wallis to analyze the data.

Result and Discussion

The results of the experimental phase are divided into three steps: (1) preliminary research, (2) prototyping phase design product, (3) assessment phase:

Preliminary Research

The results of preliminary research in November-December 2022, show that the percentage of biology teachers at Makassar City High Schools who understand the characteristics of interdisciplinary problem-based learning is only 5.9%, while those who do not understand it amount to 94.1%. This is due to their constraints in designing instructional materials: innovation biotechnology. The analysis of students' biology learning outcomes also indicates that they are still relatively low. Surprisingly, 75% of the students are facing difficulties in understanding the material, particularly in grasping the concepts of technological innovations in biology.

Prototyping Phase Design Product

The prototyping phase design product is activities for the preparation of handout nata de orange based on nata de orange research conducted at the Microbiology Laboratory of FMIPA, University Negeri Malang. The handout nata de orange is designed using Canva Pro, while the content is created using Microsoft Word 365. Arial is the font used in this handout, with the required size and 1.5 spaces. This handout is illustrated with images of research results printed on A4 format paper weighing 120 grams. This handout is divided into three parts: the front (cover, introduction, and table of contents), the contents (introduction, material, practicum instructions, evaluation questions, and structured assignments), and the closing part (reference list, and the author's curriculum vitae). The nata de orange handout was developed as a learning tool for students in biology learning in Class X on biotechnology innovation presented in Figure 1.

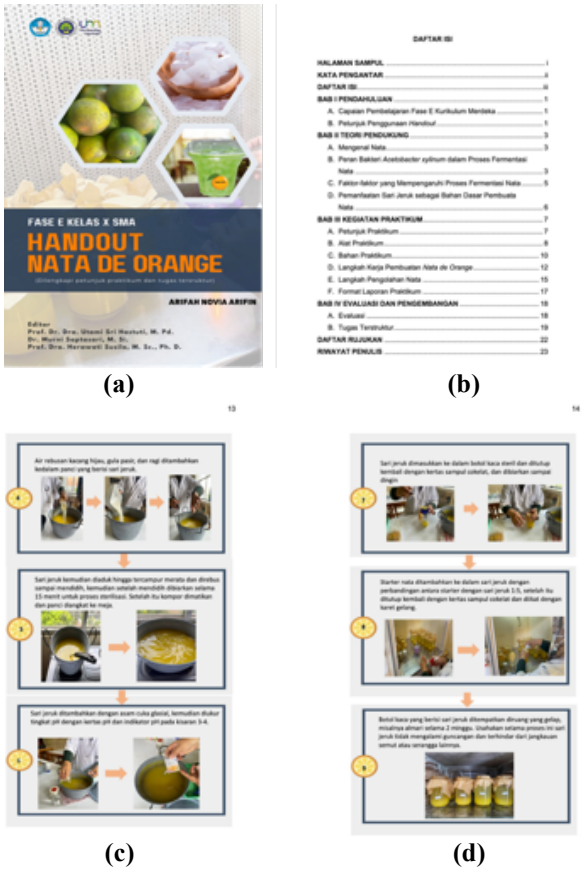

Figure 1: Handout Nata De Orange
Remark: (a) cover, (b) list of content, (c) (d) instruction for hands on activity

The development phase produced the handout nata de orange content based on laboratory study findings. At this phase, the handout prototype that had been designed during the design phase was developed as needed. Furthermore, expert validation was done to determine the validity and reliability of the handout**.**

Table 2. Validation and Reliability Scores of the Nata De Orange Handout by Microbiology Expert

No	Assessment Aspect	Validity Score	Reability Score
1	Content Validity	98,33	88,89
2	Presentation Validity	96,67	88,89
3	Contextual	100	100
	Mean	98,33	92,59

Table 2 shows that the validity score of the Handout Nata De Orange obtained from the expert validator in microbiology is 98.33%, indicating that the developed Nata De Orange handout falls into the valid category. Additionally, the reliability score falls within the range of 92.59%, which is above the required percentage for inter-observer agreement of 70%. These results indicate that the developed handout nata de orange is both valid and reliable.

Table 3. Validation and Reliability Scores of the Nata De Orange Handout by Instructional Media Expert

No	Assessment Aspect	Validity Score	Reability Score
1	Graphic Desain	97,14	88,89
2	Language Appropriateness	100	100
	Mean	98,57	94,45

Table 3 indicates that the validity score of the Handout Nata De Orange obtained from the instructional media expert validator is 98.57%, showing that the developed Nata De Orange handout falls into the valid category. Furthermore, the reliability score falls within the range of 94.45%, which is above the required percentage for inter-observer agreement of 70%. These results indicate that the developed handout nata de orange is both valid and reliable.

Assessment Phase

The handout nata de orange with hands-on classroom activity was used and evaluated on grade X students in the odd semester of SMA Negeri 3 Makassar, South Sulawesi, Indonesia. The use of this handout was carried out during the practicum learning activity with the sub-theme of biotechnology innovation. The experimental group used this nata de orange handout with the PINISI learning model. The positive control class used the Problem-Based Learning (PBL) model without using the handout nata de orange. The negative control class uses conventional learning without using the handout nata de orange. Practicum activities are carried out in the school laboratory and nata de orange observation is carried out every week for 2 weeks. Assessment of students' psychomotor abilities is carried out during the learning process. The effectiveness of the handout nata de orange implementation in learning was measured by the difference between the scores of the psychomotor skills students (Figure 2).

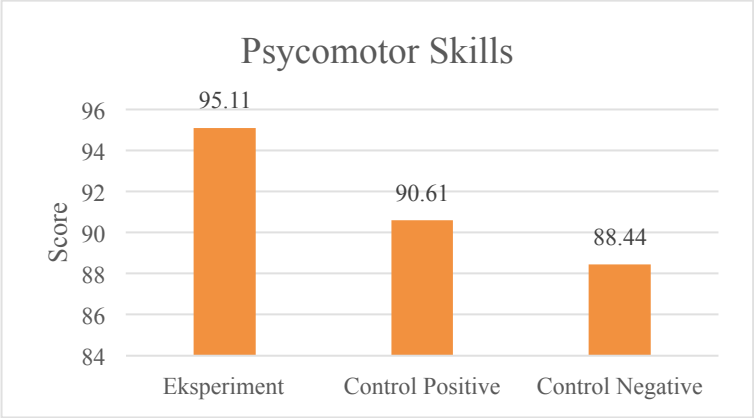

Figure 2: Score of Psychomotor Skills Students

Figure 2 the above shows that the average psychomotor skills score of students for the positive control class (PBL) is 90.61 and the negative control class (conventional) is 88.44 in the medium category. The average psychomotor skills of students in the experimental class (using nata de orange handout, hands-on classroom activity and PINISI learning model) was 95.11 which was included in the high category. This shows that the nata de orange handout is effective in improving students' psychomotor skills.

Table 4. Results of Descriptive Statistic with Kruskal Wallis
Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Psychomotor Posttest	107	81.7532	12.10532	61.90	100.00
Group Learning Model	107	1.9907	.81837	1.00	3.00

Table 5. Results of Mean Rank with Kruskal Wallis
Ranks

	Group Learning Model	N	Mean Rank
Psychomotor Posttest	Eksperiment	36	89.31
	Control Positif	36	53.61
	Control Negative	35	18.09
	Total	107	

Table 6. Results of Hypothesis Test with Kruskal Wallis
Test Statistics[a,b]

	Psychomotor Posttest
Kruskal-Wallis H	94.945
df	2
Asymp. Sig.	.000

a. Kruskal Wallis Test

b. Grouping Variable: Group Learning Model

Based on the summary of the Kruskal Wallis test results table 4 (Descriptive Statistic), table 5 (mean ranks) and table 6 (test statistics for hypothesis test), it is evident that the p-value is 0.000, which is less than the significance level (α) of 0.05. Therefore, Hypothesis H1, which states that there is an influence of the nata de orange handout on students' psychomotor biology learning outcomes, is accepted.

Discussion

Hands-on classroom activity with handout nata de orange in the experimental group showed that students' psychomotor skills were higher and significantly different compared to other groups. The hands-on classroom activity is an effective classroom method not only to explain many biological processes but also to encourage student curiosity about learning by doing (Idris et al., 2022). Students who are directly involved in learning can develop their science knowledge and skills (Deehan et al., 2024). In the experimental group, students carried out practical activities using handout nata de orange which were equipped with practical instruction and structured questions related to problems in their environment. Students in the positive control group only used the PBL learning model with student worksheets without using the nata de orange as did the students in the negative control group, who only studied conventionally. The use of nata de orange handouts can improve students' psychomotor skills, which has an impact on improving student learning outcomes.

Biotechnology innovation learning in high school biology requires teachers to be able to develop and apply student knowledge through direct, hands-on activities. Scientific concepts with hands-on activities can help students solve their daily problems (Ramnarain, 2015). Science is very important as the foundation of human thinking (Itzek-Greulich & Vollmer, 2017), which has an impact on psychomotor ability (Nazia & Gani, 2024). One of the efforts to improve psychomotor skills and learning performance is to carry out practical activities using learning resources.

Several studies have shown that hands-on classroom activity can improve student learning performance (Chen et al., 2020; Fakaruddin et al., 2024). Student hands-on activities should be used more in learning special materials (Maričić et al., 2019), such as biotechnology innovation in biology class. Learning can be said to be successful if the implementation of learning has a positive impact on students (Sahronih et al., 2019). This impact is a direct result of an increase in student learning outcomes, including attitudes, knowledge, and skills in science. Hands-on classroom activity is an effort that can provide a real experience to students in applying the mastery of concepts and theories in science directly.

Based on the results of the study, there are differences between the experimental class and the positive and negative control classes. The experimental class obtained higher science and psychomotor ability scores compared to the two control classes. This is based on students' understanding of science by using handout nata de orange as a learning resource. With handouts in hand, students can at any time relearn the material and instructions for the stages of practicum activities to create effective learning conditions (Avval et al., 2013). The psychomotor abilities that students develop in this training can be used to solve problems in real-life situations (Maspul, 2024), which are integrated with science education. This is supported by handouts developed from the results of laboratory research and student needs (Nerita et al., 2017). Handouts could give the student a general overview of the educational material.

The difference between the experimental class and the control class. The experimental class experienced a better improvement in science process skills compared to the control class. Improving students' skills reflects mastery of the material. The skills that students develop in science education are science process skills, which are skills that can be used to solve problems in real-life situations (Thompson et al., 2024), which are integrated with science education, including biotechnology. This condition can be achieved by using teaching

materials that can help improve students' science skills (Bulut Ates & Aktamis, 2024). The handout nata de orange was a handout that is prepared because of laboratory research, that is prepared based on relevant materials, and is equipped with practicum instructions, including the process of making nata de orange, as well as pictures of tools, materials, and the manufacturing process. In addition, this handout is also equipped with practice questions and structured tasks. The structured assignment developed in this handout has the goal that students can design research on making nata from various kinds of fruits besides sweet oranges that are not used up during the harvest to increase students' creativity and students' psychomotor skills.

Secondary educational levels, in which the students have a significant need to develop the elements of psychomotor skills (Begam & Tholappan, 2018; Nicholls et al., 2016) . Students' psychomotor skills can be improved by psychomotor ability indicators, namely students' learning. Psychomotor abilities can be improved by psychomotor indicators namely, (1) readiness, students who use the handout nata de orange, can understand and prepare learning and the implementation of hands-on activities well. (2) Imitation in this indicator, students can show the ability to observe and follow the stages of implementing hands-on activities to make nata. (3) Habituation in this indicator, students with repeated exercises will improve their movements and develop their muscle memory so that they understand better for the next practicum activities. (4) Adaptation in this indicator, students can adjust to the stages that will be carried out in hands-on activities.

The handout nata de orange applied with hands-on activities contains factual problems that can be found by students around their environment (Maspul, 2024). This handout is presented as the result of laboratory research that contains environmental problems around students and how to overcome them with conventional biotechnology. The learning process using handouts can reduce students' boredom in learning and increase motivation in learning so that it can improve students' psychomotor skills. The work steps in the practicum instructions are complemented by photos of the researcher and the results of the research obtained by the researcher. This is evident from the results of research conducted by researchers in the experimental class, students who use the handout nata de orange have the highest average score compared to other classes. The results show that this handout is valid, practical, and effective for improving students' psychomotor skills. The students' response to the use of this handout was very positive, which is a measure of the success of implementing the handout nata de orange. Apart from that, this handout can be a reference for science teachers to carry out biotechnology innovation practicums in making nata.

Conclusion

The results show that this handout is valid, practical, and effective for improving students' psychomotor skills. The student’s response to the use of this handout was very positive, which is a measure of the success of implementing the handout nata de orange. Apart from that, this handout can be a reference for science teachers to carry out biotechnology innovation practicums in making nata.

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