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Student Worksheet Development Using the PMRI Approach in the Classroom Context with an Orientation toward Students' Conceptual Understanding

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Abstrak

This research aimed to produce a valid and practical product in the form of a student worksheet using the Indonesian version of the Realistic Mathematics Education (PMRI) approach in the classroom context with an orientation toward students' conceptual understanding and to figure out the potential effect of the student worksheet developed. It is a piece of development research under the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model. Data collection was performed using documentation, a questionnaire, and a test. The object of this research was the development of a student worksheet using the PMRI approach within the classroom context with an orientation toward students' conceptual understanding. Meanwhile, the subjects of the research were students of grade X of SMAN 06 Banyuasin. The research results showed that the student worksheet produced was declared valid (with an average score of 90.83), practical (based on the students' questionnaire responses, with a score of 79.65), and potentially influential to a high degree (based on the students' test results, with a percentage of 84%). Therefore, the student worksheet that was developed using the PMRI approach within the classroom context with an orientation toward students' conceptual understanding was worth using in the learning process.

Keywords: Student Worksheet, PMRI, Classroom Context, Conceptual Understanding

Abstrak

Penelitian ini bertujuan untuk menghasilkan produk berupa LKPD menggunakan pendekatan PMRI dengan konteks ruang kelas berorientasi pada pemahaman konsep siswa yang valid, praktis dan untuk mengetahui efek potensial LKPD yang dikembangkan. Penelitian ini merupakan penelitian pengembangan dengan menggunakan model ADDIE (*Analysis, Design, Development, Implementation, and Evaluation*). Teknik pengumpulan data dalam penelitian ini adalah dokumentasi, angket dan tes. Objek penelitian ini adalah pengembangan LKPD menggunakan pendekatan PMRI dengan konteks ruang kelas berorientasi pada pemahaman konsep siswa. Subjek penelitian ini yaitu siswa kelas X SMAN 06 Banyuasin. Hasil penelitian menunjukan LKPD yang dikembangkan dinyatakan sangat valid, dengan skor rata-rata 90,83. LKPD dinyatakan praktis berdasarkan penilaian dari angket respon siswa dengan skor 79,65. Dinyatakan memiliki efek potensial dengan kriteria sangat tinggi berdasarkan hasil tes belajar siswa dengan persentase sebesar 84%. Jadi LKPD yang dikembangkan menggunakan pendekatan PMRI dengan konteks ruang kelas berorientasi pada pemahaman konsep siswa layak digunakan dalam proses pembelajaran.

Kata Kunci: LKPD, PMRI, Konteks Ruang Kelas, Pemahaman Konsep

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INTRODUCTION

Mathematics education plays an important role in education, given that virtually all daily life contexts are associated with mathamatics (Wati & Murtiyasa, 2016). The success of a mathamatics teacher in providing an instruction can be seen from the students' success in understanding, implementing, and developing the learning materials the teacher has taught, both in mathematics and in other subject learning (Kadir & La, 2016).

However, students often find it difficult to solve mathematical problems related to conceptual understanding, which in turn results in their low mathematical achievements (Wati & Murtiyasa, 2016). This is as indicated by the results of the Program for International Student Assessment (PISA) study conducted by the Organization for Economic Cooperation and Development (OECD), which was aimed to figure out students' mathematical literacy levels, in 2018, according to which Indonesia ranked 74th of 79 countries (OECD, 2019). As posited by Wati & Murtiyasa (2016), these low student achievements were influenced by the way learning processes were undertaken in schools: the teacher only instructed students to solve a number of problems following the examples that were previously given without explaining what it might contribute to daily life. In addition, students had yet to understand and solve problems in realistic contexts.

The low mathematics achievements of the students reflected that the students' conceptual understanding was still low. This was as reported by Hendrayanain (2017) that students' ability to understand conceptual concepts was short of expectations. Conceptual understanding itself refers to an ability that is demonstrated by students to interpret concepts or materials within the cognitive domain as opposed to just memorize (Rosliana, 2019). The indicators of conceptual understanding, according to Shadiq (Edriati, Handayani, & Sari, 2017), are as follows: 1) classifying objects by certain properties (in accordance with the concept in question); 2) providing some examples and non-examples for the concept; 3) delivering the concept in various forms of mathematical representations; 4) developing necessary and sufficient conditions of the concept; 5) implementing, utilizing, and selecting a certain procedure or operation; and 6) applying the concept or problem-solving algorithms.

Students' poor understanding might be driven by a number of factors, for example, the unavailability of appropriate teaching materials and non-application of suitable learning approaches to improve students' conceptual understanding. Meanwhile, the factor that could lead to students' low conceptual understanding according to Ardilla & Hartanto (2017) was the learning being teacher-centered, in which case the teacher only provided formulas and some example problems along with some solutions without explaining how they could come up with such formulas. Therefore, to deal with such a problem and to improve students' conceptual understanding, a fitting learning approach is thus required.

Some of the suiting learning approaches available is the PMRI approach. This approach is one that can help students connect abstract mathematical concepts to real-world problems (Saputri & Zulkardi, 2020). As defined by Istarani (2014), the PMRI approach requires that theoretical concepts and real life must be equal or balanced. According to Warni et al. (2022), this approach refers to the implementation of school mathematics with students' realities and experiences being positioned as a starting point in mathematics learning so the students rediscovery mathematical concepts to solve their everyday problems. This approach is based on three principles namely guided reinvention and progressive mathematization, didactical phenomenology, and self-developed models (Afriansyah, 2016). According to Gravemeijer, the PMRI approach is characterized by the following: 1) using a contextual problem; 2) using a model or a bridge; 3) using students' contributions; 4) involving interactivity; and 5) being integrated with other learning topics (Gustiningsi & Utari, 2020). Learning in the PMRI is likened to an iceberg; Frans Moerland states that the visualization of the methematicization process in learning using this approach is alike tothe iceberg formation process (Haji, 2013). Retta (2016) states that there are 4 levels of the iceberg model described in learning with the PMRI: 1) situational; 2) referential (model of); 3) general (model for); and 4) formal. The iceberg model use is intended to illustrate students' understanding process that moves from a real state (real life) toward an understanding of abstract mathematical symbols.

The PMRI approach is considered suitable to enhance students' conceptual understanding as it involves students directly in the learning process. Based on the research by Jeheman, Gunur, & Jelatu (2019), students taught with the PMRI approach had a better understanding than students taught with conventional approaches.

To enhance students' conceptual understanding, it will require not only a learning approach but also student worksheets. Mu'tashimah, Putri, & Ramury (2020) define that student worksheets are sheets containing tasks or activities students must perform that serve as a means for achieving learning objectives. According to Muliastrini et al. (2021), student worksheets are a learning aid, be it a learning medium or a learning source, which contains guides or learning materials that students can use independently to improve their understanding, skills, and attitudes.

Student worksheets should be used in contexts of real world. According to Dey, a context is a condition that informs characterization of the situation of an entity, in which case the entity can refer to a humanbeing, an object, a place, or an event, depending on the needs of the user (Engel, Angela, & Hutagalung, 2016). Adha & Refianti (2019), meanwhile, define it as a perspective of a mathematical problem in relation to students' daily life. The use of contexts can not only be positively influential to students' activities in learning but also train students to think critically and creatively in solving mathematical problems (Kadir & La, 2016). There is a large range of contexts used in the matrix material. Among them are the Islamic context investigated by Maqruf and Ulpah (2020) in a study entitled development of student worksheets (LKS) based on Islamic context to improve student's mathematics understanding in class XI matrix material and the local context of Banten investigated by

Safitri, Pujiastuti, and Sudiana (2020) entitled development of educational games with the context of local wisdom of Banten on matrix material. One of the real-world contexts that can be implemented in learning and that is in a close proximity to students is the classroom context. Classroom as context means the use of objects in the classroom as supports for the successful achievement of learning objectives.

Among the mathematics materials to which conceptual understanding is paramount is the matrix material. According to Ruminta (2014) a matrix is a collection of numbers that are specifically arranged in rows and columns, hence forming rectangles or squares written between parentheses or square brackets. As stated by Naila, Tasya, Rahayu, and Hidayat (2018), matrix is one of the materials in mathematics considered difficult by students as the students often make calculation errors in matrix operations as a result of their poor conceptual understanding. This was also the experience of the author, in which case the errors made in solving matrix problems were also due to low conceptual understanding. The aim of this research was to produce a worksheet with the PMRI approach within the classroom context with an orientation toward students' conceptual understanding that is valid, practical, and potentially influential to students' conceptual understanding. What makes this research different from previous LKPD development research lies in the context used. In this research, the context used is the classroom context.

METHODS

This research is a research and development (R & D) study that was conducted under the ADDIE development model. As stated by Mulyatiningsih (2014), the ADDIE model can be applied to a variety of product developments, such as the development of a model, a learning strategy, a learning method, a learning medium, or a learning material. The object of this research was the development of a student worksheet using the PMRI approach within the classroom context with an orientation toward students' conceptual understanding. The research subjects were 26 students of grade X of SMAN 06 Banyuasin. In a small-group tryout, the student worksheet was used in a trial involving 6 students, whereas in a large-group tryout, it was used in a trial involving 20 students. The research was conducted in the even semester of academic year 2020/2021 for the matrix material.

This research consisted of five stages: Analysis, Design, Development, Implementation, and Evaluation (Mulyatiningsih, 2014). In the Analysis stage, an analysis was conducted on students who were involved as research subjects and who belonged to the class in which the student worksheet developed was tried. In the Design stage, the design and the structure of the student worksheet were developed. Here, the research and expert validation instruments were also created. The Development stage was where the student worksheet was created and written. After expert validation, the student worksheet was revised. In the Implementation stage, a try-out of the student worksheet developed was conducted involving some students if it was declared valid and feasible to use by the validators. Lastly,

the Evaluation stage is a stage of assessment of the development performed in the aspects of feasibility, construct, and language.

Data collection in this research was carried out using documentation, an expert validation sheet, a student questionnaire, and a test. Meanwhile, data analysis was conducted using the techniques of document analysis, expert validation sheet analysis, student questionnaire response analysis, and learning test results analysis. The expert validation sheet was used to gather the validity data of the student worksheet developed. Hamzah (2019) states that validity is the extent of accuracy and precision of a measuring instrument in performing its function. The student questionnaire was used to gather data on the student worksheet practicality. According to Purwanto (2009), practicality is the quality of the general possibility of performing an assessment technique based on cost, time, ease of use, scoring, and results interpretation. Meanwhile, the test was aimed at figuring out the potential effect on students' mathematical conceptual understanding in the classroom context. Haviz (2013) holds that the effectiveness of a teaching material can be reviewed from its potential effects on learning outcome quality and students' attitude and motivation. In this research, the expert validation sheet consisted of 16 assessment items, the student questionnaire consisted of 21 questions, and the test consisted of 5 essay problems.

RESULTS AND DISCUSSION

After the ongoing problem was identified, a set of analyses consisting of needs analysis, curriculum analysis, and media analysis was conducted. In the next stage, the Design stage, preliminary planning of the student worksheet to be developed was carried out. In the Development stage, the student worksheet developed was subjected to validity testing by experts for its validity and reliability. The experts' suggestions and commentaries were used to revise the student worksheet developed. All in all, the validators suggested improving the clarity of the pictures, fixing mistakes in writing, and fixing the student worksheet steps to comply with the PMRI approach better.

In this stage, the student worksheet that was developed and declared valid was tried out by a small group of students to figure out its practicality. The small-group tryout was intended to find out how practical the student worksheet developed was prior to a tryout in a larger group. In the Implementation stage, the student worksheet developed was tried out by the small group of students. After partaking in the product tryout, the students were given some test questions to figure out the potential effect of the student worksheet developed. In the last stage, the Evaluation stage, an overall evaluation was performed on the student worksheet developed. In this stage, the product validity, the product practicality, and students' test results were analyzed.

Student Worksheet Validity Analysis

This analysis was aimed at looking into the validity of the student worksheet developed following the expert validation sheet. Product validation test was carried out by three validators, namely two mathematics lecturers and one mathematics teacher. The results of the validity data analysis are presented in Table 1.

Table 1. Student worksheet validity data analysis results of matrix

Validator	Description	Score	Criterion
Validator 1	Math lecturer	97.5	Highly valid
Validator 2	Math lecturer	78.75	Valid
Validator 3	Math teacher	96.25	Highly valid
Total		90.83	Highly Valid

From the student worksheet validity data analysis an average score of 90.83 in the highly valid category was obtained. It means that the student worksheet developed was worth trying out by students.

Student Worksheet Practicality Analysis

This analysis was intended to find out the practicality of the student worksheet developed based on the student response questionnaire scores. This assessment involved six X graders of SMAN 6 Banyuasin and was aimed to gather data on the student worksheet's practicality. The results are presented in Table 2.

Table 2. Student worksheet practicality analysis results of matrix

No	Name	Score	Feasibility Score	Criterion
1	Respondent 1	81	77.14	Practical
2	Respondent 2	102	97.14	Highly practical
3	Respondent 3	71	67.61	Practical
4	Respondent 4	88	83.80	Highly practical
5	Respondent 5	84	80	Practical
6	Respondent 6	74	70.47	Practical
Total Feasibility Score		500	79.36	Practical

Based on Table 2, the product gained an average score of 79.36 from the small-group tryout, which was categorized as practical. As stated by Haviz (2013), a product is said practical if the practitioners state in theoretical terms that it can be used in the field, provided that it is good in its application.

Conceptual Understanding Test Results Analysis

The data of the students' conceptual understanding test results were analyzed based on the Minimum Passing Criterion ≥ 75. Of the 26 students who took the test, 22 passed the test and 4 failed. The students' average score in the conceptual understanding test was 84%, which was categorized as a

very high passing rate. Such a category marked that the students' conceptual understanding in solving matrix problems was very high. The indicators used to assess conceptual understanding in this research were as follows: 1) grouping objects based on certain properties (according to the concept in question); 2) providing some examples and non-examples of the concept; 3) delivering the concept in various forms of mathematical representations; 4) developing the necessary and sufficient conditions of the concept; 5) implementing, utilizing, and selecting a certain procedure or operation; and 6) applying the concept or problem-solving algorithms.

In the tryout stage several findings were collected, some of which concerned differences in the students' answers to a problem contained in the student worksheet. This problem is shown in Figure 1.

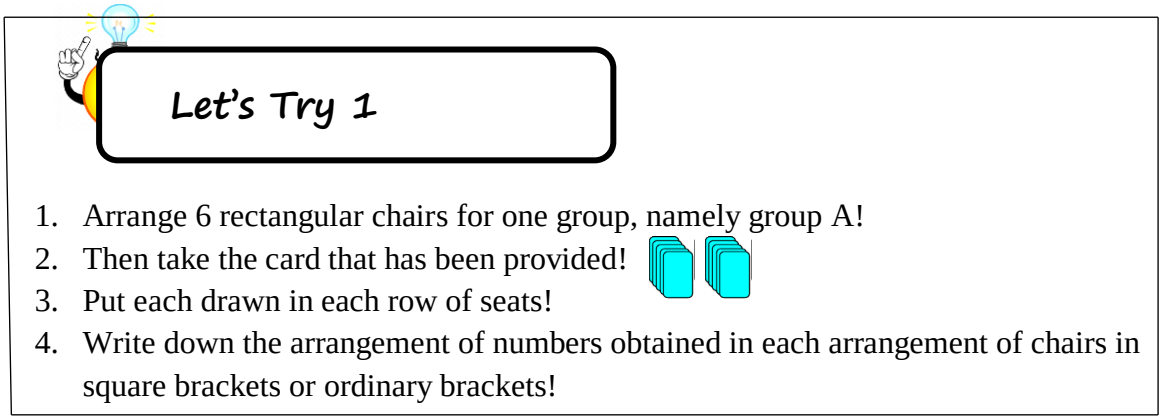

Figure 1. The problem the students had to solve in the student worksheet

As shown in Figure 1, the students were asked to arrange some rectangular benches, numbering six for each group. Some of the answers of the students for the problem in Figure 1 are provided in Figure 2 and Figure 3.

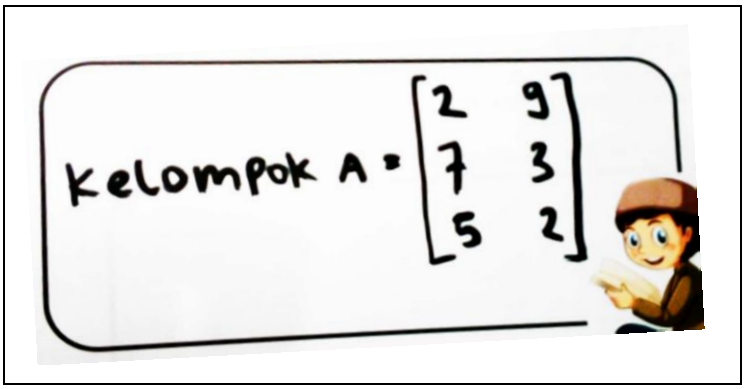

Figure 2. The answer of Student 1 for the first problem about compiling a matrix

Student 1 arranged the six rectangular benches in three rows and two columns. Thus, they made a matrix in the order 3×2. From Figure 2 we can see that the student was able to understand the problem and solve it by describing it in a mathematical representation. This is as defined by Rosliana (2019) that conceptual understanding is an ability that is demonstrated by students to interpret concepts or materials within the cognitive domain as opposed to only memorize. A different answer was given by Student 2, which is provided in Figure 3.

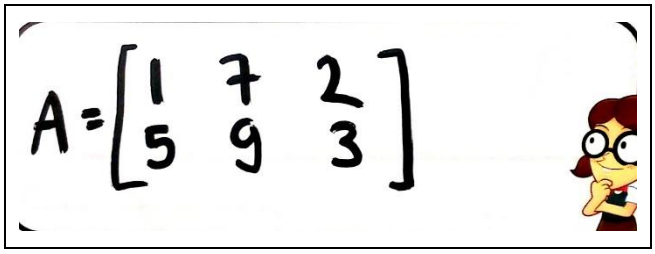

Figure 3. The answer of Student 2 for the first problem about compiling a matrix

Student 2 arranged the six rectangular benches in two rows and three columns. Thus, they made a matrix in the order 2×3. As can be seen in Figure 2 and Figure 3, the two students offered two different answers to the same problem. This difference stemmed from the student' ability to deliver a concept in various forms of mathematical representations. It also indicated that the students were able to implement, utilize, and select a certain procedure or operation in solving the problem. From Figure 2 and Figure 3 it was concluded that the students were able to apply their own concepts or problem-solving algorithms.

This was in line with Ulia's (2016) definition of conceptual understanding as an extent of students' learning outcome to which they are able to describe or explain a learning material in their own sentences. From Figure 2 and Figure 3 it can be said that the students had a good conceptual understanding as they were able to solve the problem in accordance with the conceptual understanding indicators.

From Figure 2 and Figure 3 it can also be seen that the student worksheet developed agreed with the three principles of the PMRI, namely guided reinvention, didactical phenomenology, and self-developed models (Afriansyah, 2016). Other than variance in answers, the researchers also identified some errors that the students made in solving the provided test problems. One of the errors aforementioned can be seen in Figure 4.

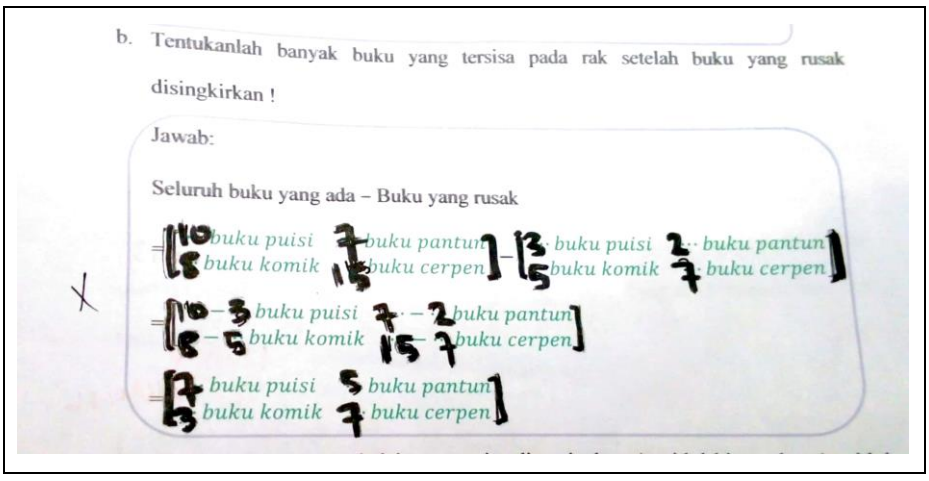

Figure 4. A student's error in solving a matrix subtraction operation problem

As shown in Figure 4, the error that the student made in solving the problem above was inaccuracy, in which case the error was only found in the calculation process. The student wrote the operation of reducing 10 by 3 incorrectly. In spite of such an error, the student was already able to solve

the problem according to some conceptual understanding indicators: they were able to classify the objects in the problem, solve the problem with mathematical representations, and apply concepts in the problem-solving process. However, this inaccuracy in solving the problem indicated that the student had yet to be able to meet the conceptual indicator of implementing, utilizing, and selecting a certain procedure or operation. Another mistake made by one of the students is presented in Figure 5.

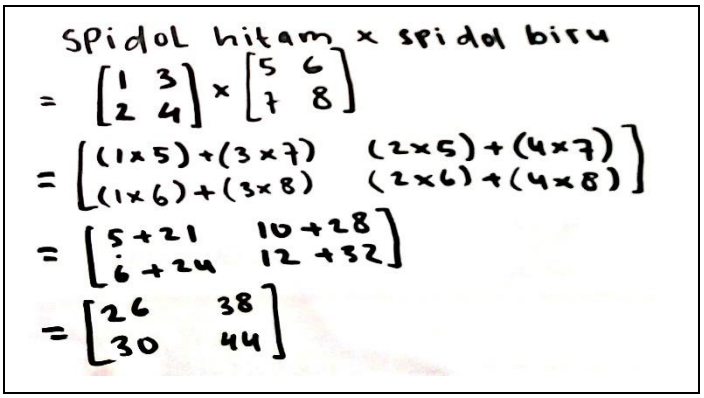

Figure 5. An error made by a student in completing a matrix multiplied operation

The error made by the student as shown in Figure 5 indicated that the student's conceptual understanding was still poor. This was in line with Hendrayana's (2017) report of students' low conceptual understanding. However, when it is seen from the Minimum Passing Criterion, 22 of the 26 test-taking students passed the test. A passing rate of 84% was obtained, signifying a very high category. Based on this result, it can be concluded that the student worksheet that was developed using the PMRI approach within the classroom context with an orientation toward students' conceptual understanding did have a potential effect on the students' conceptual understanding test results. This means that the students' conceptual understanding of the matrix material was excellent. It was so because, in the test, 22 students were able to solve the problems well and correctly. This was in parallel with the research by Sari (2017), which states that students' conceptual understanding was better when the students were taught using the PMRI approach.

The students' success in understanding the concept was also inextricably linked to the context involved in the learning process. It was as stated by Kadir & La (2016) that context use had a positive effect on students' activities in learning and could train the students to think critically and creatively in solving mathematical problems. In this research, context was found to have a strong positive effect on students' conceptual understanding for the matrix material, as shown by a passing rate of 84%. Such a very high passing rate suggested that nearly all the students were able to solve problems related to the matrix material. In addition, with an average validity score of 90.83%, which fell to the highly valid category, it can be said that the student worksheet on the matrix material developed was very good. As stated by Hamzah (2019), validity is an instrument's extent of accuracy and precision in performing its function. The findings in this research demonstrated that the student worksheet developed using the PMRI approach for the matrix material was able to help the students understand the concept of matrix.

This was shown by the students' success in solving problems on matrix according to the conceptual understanding indicators and by the high passing rate of the students for those problems.

From the description abive, it was thus concluded that the student worksheet that was developed using the PMRI approach within the classroom context with an orientation toward students' conceptual understanding was valid, practical, and potentially influential to students' conceptual understanding. It thus also means that the student worksheet is worth using in the learning and teaching process in the classroom.

CONCLUSION

Based on the results of this R&D study where a student worksheet was developed using the PMRI approach within the classroom context with an orientation toward students' conceptual understanding, it can be concluded that the student worksheet developed was valid, practical, and potentially influential to students' conceptual understanding. The validity was reflected in the validators' judgment in content, construct, and language aspects, in which case the product was declared highly valid with an average score of 90.83. Meanwhile, the practicality was reflected in the results of the small-group product tryout, in which case the product was declared practical with an average score of 79.65. The potential effect, on the other hand, was reflected in the results of the students' conceptual understanding test, with a passing percentage of 84%. Therefore, the student worksheet that was developed using the PMRI approach within the classroom context with an orientation toward students' conceptual understanding was worth using in the learning process.

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