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The Effectiveness of Magnetism Recitation Program to Improving Students' Understanding Concepts on Topic Magnetism

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Abstract: Students often experience difficulties in mastering physics concepts, especially on the topic of magnetism due to inaccurate understanding and misconceptions. Limited learning time is also a factor that hinders in-depth understanding. To overcome this problem, a web-based recitation method was developed using the Moodle platform to help improve students' mastery of concepts. This research developed a recitation program called the Magnetism Recitation Program (MRP) and can be accessed using a smartphone or laptop with an internet network. MRP contains multiple choice questions with direct feedback that are tailored to various student thinking possibilities. This research aims to determine the effectiveness of MRP. To answer the objectives, this research used a one-group pretest-posttest design involving 25 Physics Education students at the State University of Malang who were taking the Basic Physics III course. The effectiveness of MRP is analyzed using the n-gain value. The research results show an n-gain value of 0.22, which means that MRP is effective in increasing students' mastery of concepts on the topic of magnetism, although there are several weaknesses that students still experience.

Kata Kunci:
Program Pengajian; Pendidikan Fisika; Pemahaman Konseptual

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Abstrak: *Siswa sering kali mengalami kesulitan dalam penguasaan konsep fisika khususnya pada topik kemagnetan akibat pemahaman yang kurang tepat dan miskonsepsi. Keterbatasan waktu belajar juga menjadi faktor penghambat pemahaman mendalam. Untuk mengatasi permasalahan tersebut, dikembangkan metode resitasi berbasis web dengan menggunakan platform Moodle untuk membantu meningkatkan penguasaan konsep siswa. Penelitian ini mengembangkan program pengajian yang diberi nama Magnetism Reitation Program (MRP) dan dapat diakses menggunakan smartphone atau laptop dengan jaringan internet. MRP berisi soal pilihan ganda dengan umpan balik langsung yang disesuaikan dengan berbagai kemungkinan berpikir siswa. Penelitian ini bertujuan untuk mengetahui efektivitas MRP. Untuk menjawab tujuan tersebut, penelitian ini menggunakan desain one-group pretest-posttest yang melibatkan 25 mahasiswa Pendidikan Fisika Universitas Negeri Malang yang sedang mengambil mata kuliah Fisika Dasar III. Efektivitas MRP dianalisis menggunakan nilai n-gain. Hasil penelitian menunjukkan nilai n-gain sebesar 0,22 yang berarti MRP efektif meningkatkan penguasaan konsep siswa pada topik kemagnetan, walaupun terdapat beberapa kelemahan yang masih dialami siswa.*

INTRODUCTION

Good mastery of concepts in physics is the main key that allows students to apply their knowledge to solve problems in everyday life (Docktor & Mestre, 2014; Reyza et al., 2017; Saifullah et al., 2017). Mastery of fundamental concepts is very important to help students overcome problems. Good mastery of fundamental concepts will support students in studying and solving more complex physics problems (Turányi & Tóth, 2013). Students are considered to have mastered the concept if they are able to understand and apply essential physics concepts in solving problems (Docktor et al., 2015; Kustusch, 2016), as well as explaining physical phenomena that occur both naturally and through human engineering (Lin & Singh, 2011). However, good concept mastery is often difficult to achieve because students have a tendency to build inaccurate concepts at previous levels and even experience misconceptions, namely a mismatch between the concept's students have and scientific knowledge. (Docktor et al., 2015).

One topic in physics where students have difficulty mastering the concept is the topic of magnetism. Several previous studies found that many students misinterpreted the concept of magnetic fields (Saarelainen et al., 2007). Lemmer et al., (2020) found that students thought the magnetic field lines in a bar magnet only appeared on the outside of the magnet. Then, when reasoning about the magnetic force on a conductor carrying an electric current, students have difficulty using the right-hand rule to determine the direction of the Lorentz force. (McColgan et al., 2017; Scaife & Heckler, 2010; Zabriskie & Stewart, 2019). Students also tend to think that the force generated by an electric field is the same as a magnetic field (McColgan et al., 2017). In addition, students use the Lorentz force qvB formulation without any particular physical meaning so they tend to ignore the angle formed between the magnetic field and the particle's moving speed. (Karim et al., 2018). These difficulties can occur because the material that students must master is not commensurate with the learning time. This time limitation causes students to lack practice questions and apply appropriate context association patterns (Ivanjek et al., 2022). As a result, students tend to use shallow understanding due to lack of time for deep reflection and processing.

Correcting wrong understanding requires a learning process that is able to accommodate thought remediation and convey correct physics concepts to students. When repetition of appropriate knowledge is developed over time in dealing with similar situations, there will be refinement of knowledge in students' memories so that a stable scientific concept is formed by experts. In order to convey broad concepts with limited time, a recitation method is needed (Yusmaridi et al., 2012). Recitation is an in-depth study carried out after lectures (Kohl et al., 2007), where the instructor provides a bit of information, asks a question, gets a student response, and then provides feedback by praising or correcting the student's mastery of a particular concept (Arends, 2012). Through recitations, time constraints can be overcome and allow students to continuously improve their understanding, as well as strengthen mastery of concepts.

Along with technological developments, computers have become an innovative solution to overcome time constraints in remediating incorrect concepts in the form of conceptual activities and problem solving accompanied by direct feedback. In this case, the recitation program can support students' self-regulation and time management skills to be actively involved in learning at each individual's pace (DeVore et al., 2017). The recitation program contains conceptual questions presented in many problem contexts and accompanied by feedback. The flexibility of the recitation program allows students to use concepts to solve similar problems repeatedly (Koenig et al., 2007), so that it can open new perceptions in students' thinking (Wood et al., 2014). On the other hand, providing feedback can help students correct mistakes (Diyana et al., 2020b) and supports the formation of robust knowledge structures (Simon, 1962).

Over the past decade, many recitation programs have been developed that can be used by students to improve their mastery of concepts, such as recitation programs on the topic of kinematics. (Febryanti & Taqwa, 2021) on the topic of static electricity (Hermawati & Hidayat, 2021) on the topic of fluid dynamics (Pebriana et al., 2018) on the topic of rotational dynamics (Pratama, 2020; Rahmawati & Sutopo, 2019a) on the topic of force and motion (Sutopo et al.,

2016) on the topic of static fluids (Amalina et al., 2021) and on the topic of fluid mechanics (Diyana et al., 2020c). Although the recitation program can improve students' mastery of concepts, there are still obstacles in its use. Some of the obstacles experienced by students include (1) students still don't know how to use the program, (2) students only read the questions and feedback briefly without understanding it properly. (Diyana, 2020), (3) Students can only solve questions in the same context as the context of the recitation program (Rahmawati & Sutopo, 2019a), (4) lack of variety of question contexts in the program (Rahmawati & Sutopo, 2019b). The obstacles experienced by students while using the recitation program will be input for researchers in developing this recitation program.

This research develops a web-based recitation program called the Magnetism Recitation Program (MRP) by taking into account findings about the advantages and disadvantages of previously developed recitation programs. The recitation program developed contains conceptual questions in multiple choice format which are presented in many problem contexts, with feedback for each answer option. Feedback is designed based on the student's possible conception of thinking and is given as soon as possible when the student answers. This aims to ensure that students immediately correct their mistakes. Feedback is also given to students who answer correctly in the form of discussion of problem solving to strengthen the students' correct concepts. Don't forget, the recitation program developed also includes instructions for use so that students understand the buttons to be used.

This research specifically explores aspects of the use of MRP that influence the effectiveness of the program in improving students' mastery of concepts. By looking at the correlation between student perceptions and increased mastery of concepts, researchers can determine the effectiveness of MRP and have the potential to provide insight into the most influential or need-to-be-improved aspects of the program for more effective development in the future.

METHOD

This research aims to determine the effectiveness of MRP in increasing students' mastery of concepts on the topic of magnetism. Based on these objectives, this research uses a quantitative approach adapted from Creswell, (2015). Pretest data (O1) was collected before administering the intervention in the form of the Magnetism Recitation Program (MRP) (X), followed by measuring posttest results (O2). Overall, the research design is presented in detail in Figure 1.

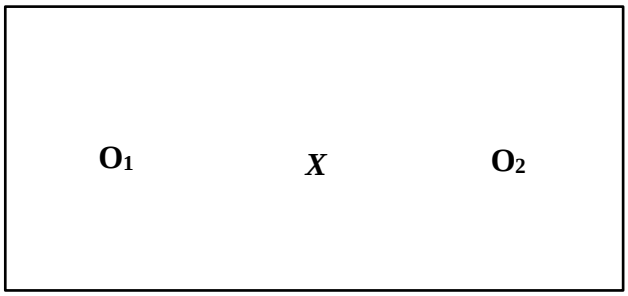

Figure 1. Quasi Experimental Design

The type of experiment used in this research is one group pretest-posttest design. This design was chosen because the adequacy of the data that had been obtained was in accordance with the problem formulation in the research. Quantitative data in this research is used to see the effectiveness of MRP. This research was carried out at the State University of Malang in the odd semester of the 2023/2024 academic year. The research subjects consisted of 25 students from the Physics Education Study Program, State University of Malang who were taking the Basic Physics III course.

Concept mastery test questions are used to determine students' mastery of concepts on the topic of magnetism. This concept mastery test question is given at the beginning before giving the recitation program (pretest) and also at the end after giving the recitation program (posttest). The questions used were adopted from questions that had been developed by (Li & Singh, 2017). The test questions contain 17 questions with the concepts listed in each question which explained in Table 1.

Table 1. Concepts Covered in the MCS Test

Concept	**Question No**
Magnetic force in bar magnet	1, 2
Distinguish between charges and magnetic poles	3
Direction of the magnetic field inside/outside the bar magnet	4,5
Motion is not always caused by forces	6, 8
Direction of motion or magnetic force on charged particles moving in a magnetic field	7, 10
Forces on charged particles in magnetic and electric fields	9, 11
Force on a current-carrying wire in a magnetic field	12, 14, 15
Distinguish between current-carrying wires leading in/out of field	13
The magnetic field produced by the current loop	16, 17

Quantitative data analysis was carried out on student concept mastery data to determine t he effectiveness of MRP in improving student concept mastery on the topic of magnetism. Data analysis involves comparing pretest and posttest scores using a difference test with a paired sam ple t-test to determine whether there is a difference in concept mastery scores before and after us ing the recitation program. Then an N-gain test was carried out to provide an overview of the inc rease in students' mastery of concepts after using MRP. Normalized N-gain can be calculated usi ng the following equation. Then an N-gain test is carried out to provide an overview of the incre ase in students' mastery of concepts after using MRP. The normalized n-gain can be calculated w ith the following equation (Coletta & Steinert, 2020) dan kriteria peningkatan n-gain (Sutopo & Waldrip, 2014) pada Tabel 2.

$$(g) = \frac{Skor_{posttest} - Skor_{pretest}}{Skor_{maks\ benar} - Skor_{pretest}}$$

Table 2. N-Gain Value Criteria

N-Gain Value	**N-Gain Criteria**
(g) <0,25	Low
0,25 ≤ (g) < 0,45	Lower Medium
0,45 ≥ (g) < 0,65	Upper Medium
(g) ≥ 0,65	Hight

(Sumber: Sutopo & Waldrip, (2014)

RESULTS AND DISCUSSION

Students' mastery of concepts is represented by a normalized increase from pretest to posttest scores. Previously it was necessary to ensure that the pretest and posttest scores were statistically different. The data obtained from the pretest and posttest were then analyzed quantitatively using descriptive statistical analysis and comparison of n-gain values. This analysis aims to determine the effectiveness of the Magnetism Recitation Program (MRP) in improving students' mastery of concepts. Complete descriptive statistical results are presented in Table 3.

Table 3. Descriptive Statistics of Pretest-Posttest Scores

	Pretest	*Posttest*	*N-gain*
Min	0	18	-0,08

Max	41	59	0,53
Mean	20,56	38,44	0,22
SD	9,618	10,087	-

Test scores are on a scale of 1-100

Table 3 shows that there was an increase in the average score from pretest to posttest reaching 17.88. At the pretest, the average score was 20.58 (SD=9.618) which then increased at posttest with an average of 38.44 (SD=10.087). To strengthen this claim, a statistical difference test was carried out regarding the average score of students' concept mastery before and after the intervention. There are two different possible tests that can be used, namely parametric and non-parametric, therefore, the data is first seen for normality using Shapiro-Wilk. The results of the normality test show that the pretest and posttest data are both normally distributed, which is indicated by a significance value of 0.055 for the pretest and 0.258 for the posttest. Thus, the difference test can be carried out with a parametric test using a paired sample t-test. The results of the paired sample t-test show a significance value of $0.000 < \alpha = 0.05$, so it is concluded that there is a significant difference between the average pretest and posttest scores. Then, to find out how effective MRP is in increasing students' mastery of concepts, n-gain calculations were carried out.

The resulting n-gain score is 0.22, included in the low category. A similar thing was also found by (Diyana et al., 2020b), who stated that low n-gain indicated that students had difficulty mastering concepts, so further evaluation of the program was needed. Further evaluation was carried out through a questionnaire which included student perceptions regarding the application of MRP. The results of this evaluation are discussed in detail in Section 4.4. Furthermore, the distribution shows that the majority of students are in the low n-gain and lower medium categories, while only a small portion reach the upper medium category. Even though the n-gain calculation results are relatively low, there is still an increase in the number of students who answered correctly from pretest to posttest. Based on the results of the data analysis above, it shows that MRP makes a positive contribution to increasing students' mastery of concepts. These results are supported by a number of previous studies which show that the use of a recitation program can significantly increase students' mastery of concepts, because it contains conceptual questions in many problem contexts accompanied by direct feedback on each choice (Cahyaningrum, 2018; Diyana et al., 2020a, 2020b; Jayanti et al., 2016; Rahmawati & Sutopo, 2019b; Sutopo et al., 2017).

Even though the effectiveness of MRP increases students' mastery of concepts in the low category, there is a development in students' understanding of concepts towards better concepts. The distribution of students' correct answers for each question item during the pretest and posttest is presented in Figure 2.

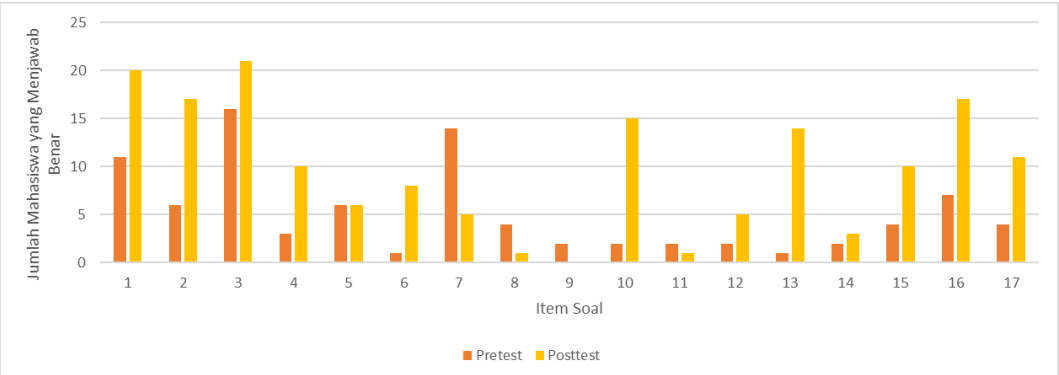

Figure 2. Comparison of the number of students who answered each item correctly in the pretest and posttest

Based on Figure 2, it can be seen that there was an increase in the number of students who answered correctly on question items number 1, 2, 3, 4, 6, 10, 12, 13, 14, 15, 16, and 17 from pretest to posttest. The effectiveness of MRP in improving students' mastery of concepts can also be seen in the n-gain score for each question, as shown in Table 4. Questions with high n-gain indicate the effectiveness of MRP, while low and negative n-gain indicate its ineffectiveness.

Table 4. N-Gain Value for Each Question

No. Question	*N-gain*	No. Question	*N-gain*	No. Question	*N-gain*	No. Question	*N-gain*
1	0,64*	6	0,29	11	-0,04**	16	0,56*
2	0,58*	7	-0,82**	12	0,13**	17	0,33
3	0,56*	8	-0,14**	13	0,54*		
4	0,32	9	-0,09**	14	0,04**		
5	0,00**	10	0,57*	15	0,29		

*) Questions in the upper medium (highest) n-gain category
**) Questions in the low n-gain category (lowest)

Based on Table 4.3, the questions with the highest n-gain in the upper medium category ($0.45 \geq (g) < 0.65$) include questions number 1 and 2 (magnetic force on a bar magnet); number 3 (distinguish between charge and magnetic pole field direction); number 13 (distinguishes between live wires leading into/out of the field); and number 16 (magnetic field produced by a current-carrying loop). Questions number 1, 2, and 3 cover the basics of magnetism, while questions number 13 and 16 cover the topics of magnetic forces in conductors carrying electric current and induced magnetic fields. These five questions illustrate the effectiveness of MRP in increasing students' mastery of concepts in magnetism material on related topics.

Meanwhile, there are 7 questions with low n-gain, including question number 5 (direction of the magnetic field inside / outside the bar magnet); 7 (direction of motion or magnetic force on charged particles moving in a magnetic field); 8 (motion does not always mean force); 9 and 11 (forces on charged particles in magnetic and other fields); 12 and 14 (force on a current-carrying wire in a magnetic field). Questions number 5 and 7 cover the basics of magnetism, questions number 8, 9 and 11 cover the topic of the motion of charged particles in magnetic fields and electric fields. Meanwhile, questions number 12 and 14 cover the topic of magnetic force on conductors carrying electric current and induced magnetic fields. Even though some of these questions involve the basic topics of magnetism and magnetic forces in conductors carrying electric current and induced magnetic fields, they have different concepts and problem contexts.

Based on these seven questions, it appears that MRP is less effective in improving students' mastery of concepts on the three topics of magnetism, especially on the concept of magnetic field direction inside/outside a bar magnet, direction of motion or magnetic force on charged particles moving in a magnetic field, motion is not always means force, the force on charged particles in a magnetic field and other fields, as well as the force on a current-carrying wire in a magnetic field.

CONCLUSION

The MRP that has been developed has proven to be effective in increasing students' mastery of concepts on the topic of magnetism. The effectiveness of this program can be seen from the results of the paired sample t-test statistical test which shows that there is a significant difference between the average pretest and posttest scores, namely increasing from 20.56 to 38.44. Apart from that, the n-gain score of 0.22 also shows an increase in students' mastery of concepts before and after using MRP, although the increase is in the low category. Based on research findings regarding the weaknesses of MRP, future researchers are expected to develop variations

of questions in many problem contexts to achieve learning objectives. Then, it is important to include clear and easy to understand discussion so that students do not experience difficulties. Researchers can also add videos to feedback to help students understand concepts through visuals and audio, providing a more concrete picture of difficult concepts.

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