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Development of Interactive Physics E-Book to Reduce Student Misconception

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Abstract: This research develops an interactive physics e-book to provide innovation in physics learning at schools. The purpose of the study was to determine the feasibility of a physics e-book on simple harmonic motion material, to determine the reduction of student misunderstandings after learning using e-books, and to determine the practicality of the e-books developed. This research uses research and development (R&D) methods with the research subjects of class X students. Based on learning innovations that have been carried out, it was concluded that e-book learning media has been developed to reduce student misunderstandings. E-book has been validated by 3 experts and the result are very good so it is suitable for use in learning. There is a reduction in student misunderstandings in modeling and implementation classes. The largest decrease occurred in the implementation class which was 11.00% while the modeling class was 9.00%. The e-books used successfully improved students' understanding by 18.00% in classroom modeling and 48.00% in implementation classes. The effectiveness of e-books in reducing student misconceptions belongs to the medium criteria in all classes. The practicality of e-books in modeling and implementation classes belongs to very good criteria.

Keywords: E-book; Misconception; Physics; Reduce.

Introduction

Physics has encouraged humans, especially experts, to print products that can help human work (Young & Freedman, 2014). Therefore, physics needs to be taught to students so that technology can continue to develop. In learning physics, students are required to understand a concept regarding the occurrence of the concept, how to obtain it, and the relationship between concept (Purwanto & Winarti, 2020). However, not a few of them admit that they have difficulty in understanding the concepts of physics (Azizah et al., 2015).

Based on the education assessment center, the achievement of students' scores in physics lessons in Indonesia is still relatively low. Inadequate conceptual knowledge, difficulty in understanding abstract concepts, misconceptions, low skills in operating mathematics, and insufficient time allocated for lessons are the reasons (Aykutlu et al., 2015). The most common problem is misconception (Khazanov & Prado, 2010). Misconception is a student's misunderstanding of a particular event or concept that is experienced due to a discrepancy between the concepts that have been built with the scientific understanding of experts in that field (Hammer, 1996). The learning process that does not pay attention to misconceptions can result in low student achievement (Gumay, 2021).

Compared to other branches of science, namely chemistry and biology, physics is the subject that causes the most misconceptions in students (Soeharto et al., 2019). In physics, the material studied is abstract so that it allows the emergence of misconceptions in students (Entino et al., 2022). One of the physics materials that still has a high level of misconception is simple harmonic motion (Tumanggor et al., 2020). Students consider simple harmonic motion to be a relatively complex concept to understand (Iradat & Alatas, 2017). The misunderstanding that many students have is the

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relationship between frequency and amplitude (Somroob & Wattanakasiwich, 2017).

Misconceptions are related to differences in the level of understanding of students' concepts in capturing the material received (Purwanto & Winarti, 2020). This is because each student has different abilities and prior knowledge. The initial understanding may be wrong (misconception) or correct (preconception, conception). In the teaching process, misconceptions must be straightened out and replaced with conceptions that are in accordance with scientific knowledge. On the other hand, preconceptions really must be handled skillfully so as not to become misconceptions (Chrzanowski et al., 2015). If misconceptions have entered into students' cognitive structures, then these misconceptions will clearly hinder the process of accepting and assimilating new knowledge in students, so that it will hinder students' success in further learning processes (Klammer, 1998).

The difference in the interpretation of physics concepts by teachers and students has a negative impact on the quality of learning (Karagöz & Zeki, 2015). To avoid this, the teacher can introduce a new concept to students by explaining using things that are already known. Using analogies effectively makes it easier for teachers and students to communicate and understand abstract science concepts more concretely (Korganci et al., 2015). By giving time for students to discuss and apply concepts, it will make it easier for teachers to be able to find misconceptions that occur in students in class. In this way, misconceptions can be reduced immediately (Schuessler et al., 2016). A misconception is a false concept or conception that a person perceives as true and is used as a habit. One can recognize the error and correct it with a little warning (Ozkan & Ozkan, 2015).

Various ways can be done to reduce students' misconceptions, one of which is by using the right media (Pratiwi & Meilani, 2018). Learning using a representative module based on e-learning has been proven to reduce students' misconceptions (Halim et al., 2020). During observations, it was found that students had learning media in the form of printed books. However, the printed book is not used in the online learning process at all. Online learning requires students to learn independently. To increase students' interest in independent learning, interactive learning media are needed.

Currently there are various learning media. One of the interactive learning media is an e-book (Hidayat et al., 2017). With existing technological facilities, now learning materials can be studied by accessing e-books via smartphones. E-books have recently gained more support due to the proliferation of digital publishing and e-book readers (Lee et al., 2019). The chief advantage of e-books that they are compact and easily portable so that e-books can be used anytime and anywhere (Jin, 2014). Mobile technology brings about important changes in the learning process, both the way teachers teach and the way students learn (González et al., 2015).

E-books also can help students independently learn the material (Rafli & Adri, 2019). The use of e-books can help students understand abstract learning so that it becomes clear (Lestari et al., 2018). The material designed must be adapted to the basic concepts so that there are no misconceptions for students. Misconceptions can be caused by inaccurate writing of mathematical formulas in various literatures. So it takes literature with proper writing in order to reduce students' misconceptions (Tiandho, 2018).

E-books can be designed as attractive as possible to foster student interest in learning. Students who study using interactive e-books also review lessons that have been implemented in schools with the aim of increasing understanding, or are interested in seeing animated concepts displayed through multimedia (Kusumastuti, 2021). Students who use interactive electronic books obtain higher learning outcomes compared to printed books (Suyatna et al., 2018). This is because e-books can be facilitated with questions that can stimulate student curiosity. A question has a big influence on student curiosity (Salmon & Barrera, 2021).

Based on the explanation of the problems above, an e-book learning media is needed in the online learning process. E-books need to be developed based on applicable concepts and curriculum so as not to cause students to experience misconceptions. This study aims to provide learning innovations in schools by developing interactive physics e-books that can reduce students' misconceptions on simple harmonic motion material.

Method

This study uses the research and development (R&D) method with a 4D model (define, design, develop, and distribute). The research begins with the definition stage, namely student analysis, curriculum analysis, and analysis of conceptual material to be used in research. Furthermore, at the design stage, the selection of learning media, lesson plans design based on the syllabus, e-diagnostic test design, and e-book design were carried out. At the develop stage, the book is made and then assessed according to the experts. After the e-book is valid, it can be used for the next stage, namely product testing in learning activities at school. In the final stage, the results of this research will be disseminated.

The research was carried out at one of senior high school in Purwokerto. The study was conducted in April 2021. In this study, the learning device was tested on students in 2 stages. The first stage is a modeling activity

with the researcher as a teacher and the second stage is an implementation activity with a physics subject teacher as a teacher. The subjects used in this study were 2 classes. Modeling activities are carried out using class X Science 1 and for implementation activities using class X Science 2. This study collects data using instruments in the form of expert validation sheets, student response sheets, and diagnostic test sheets to determine the effectiveness of e-books in reducing students' misconceptions.

To find out whether the developed e-book is suitable for use in the learning process or still needs to be revised, an analysis is carried out. The feasibility of the e-book was analyzed using the Equation 1.

$$\overline{X} = \frac{\sum X}{n} \quad (1)$$

Where $\overline{X}$ is the average score, ΣX is the number of scores, and n is the number of people who rate. This equation is also used to determine the practicality of e-books based on the response of learners. Furthermore, the average score is compared based on the feasibility assessment criteria in Table 1.

Table 1. Feasibility Assessment Criteria

Scale Range	Criteria
$\overline{X} \geq Xi + 1.8\ SBi$	Very Good
$Xi + 0.6\ SBi < \overline{X} \leq Xi + 1.8\ SBi$	Good
$Xi - 0.6\ SBi < \overline{X} \leq Xi + 0.6\ SBi$	Enough
$1.6 < \overline{X} \leq Xi - 0.6\ SBi$	Less
$\overline{X} \leq Xi - 1.8\ SBi$	Very Less

E-diagnostic tests are used as pretests and posttests using the Certainty of Response Index (CRI). By using CRI, the level of confidence of students in answering each question can be known. So that CRI can detect between students who experience misconceptions and don't know the concept (Muna, 2016). CRI criteria can be seen in Table 2.

Table 2. CRI Criteria

CRI	Criteria
5	Certain
4	Almost Certain
3	Sure
2	Not Sure
1	Almost Guess
0	Totally Guessed Answer

Based on student answers and CRI criteria, the student's conception profile can be analyzed using Table 3.

Table 3. Conception Profile Based on CRI and Student Answers

Conception Profile	Student Answers	CRI
Understand	Right	>2
Don't Understand	Right/False	<3
Misconception	False	>2

The effectiveness of e-books can be analyzed using N-gain with Equations 2.

$$\langle g \rangle = \frac{\text{Posttest Score} - \text{Pretest Score}}{\text{Ideal Score} - \text{Pretest Score}} \quad (2)$$

Where <g> is the decrease in students' misconceptions. Furthemore, the N-gain value is used to determine the effectiveness criteria of the e-book, which is shown in the Table 4.

Table 4. N-Gain Criteria

Interval	Criteria
$\langle g \rangle > 0.7$	High
$0{,}3 \leq \langle g \rangle \leq 0.7$	Medium
$\langle g \rangle < 0.3$	Low

Result and Discussion

The development of e-books is carried out with the aim of reducing misconceptions that occur in students. The material used in this research is simple harmonic motion. Simple harmonic motion material explains concepts that are often found in everyday life. So that the e-book can be developed by providing examples of simple harmonic motion concepts that are easy to find in daily activities. The e-book also invites students to actively demonstrate with simple materials as can be seen in Figure 1.

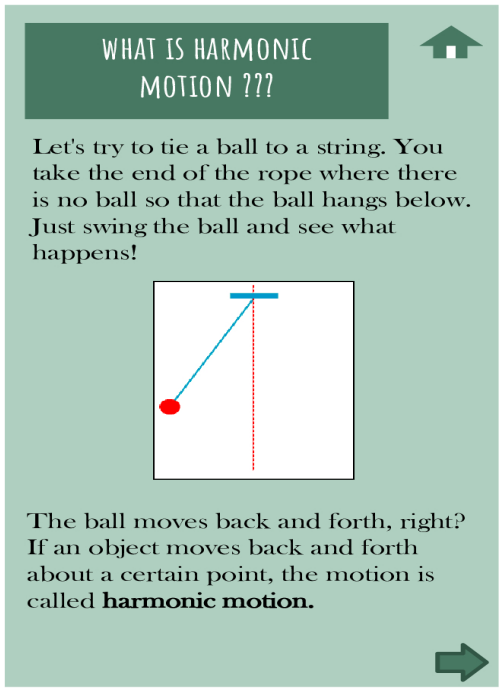

Figure 1. Interactive Physics E-Book on Simple Harmonic Motion Material

Providing examples of the application of the concept of simple harmonic motion in the e-book is

expected to make it easier for students to understand the concept of simple harmonic motion. Using analogies effectively makes it easier for students to understand abstract concepts better (Korganci et al., 2015). In addition, the e-book is also equipped with moving animations It aims to attract the interest of students to take part in learning using e-books. The image in Figure. 1 is an example of moving animation presented in this e-book.

Validation by experts needs to be done on e-book that has been designed so the contents that appear in the e-book are in accordance with the theory and do not cause misconceptions. The evaluation of the feasibility of the e-book is carried out based on the media format and material in the e-book. E-book validated by 3 experts. The results of the e-book feasibility assessment can be seen in Table 5.

Table 5. Validation Analysis Results

Aspect	Score	Criteria
Media	3.67	Very Good
Material	3.83	Very Good
Mean	3.75	Very Good

The results obtained from 3 experts indicate that the learning media in the form of e-books that have been developed are classified as very good so that e-books are feasible to be used as a source of learning physics on simple harmonic motion material. Revision of e-book is done first based on comments and inputs provided by experts before the e-book is used for research.

E-books are tested to determine the effectiveness and practicality in their use. The e-book trial was conducted 2 times in 2 different classes. The first class is modelling classes conducted with the teacher is a researcher. The second class is the implementation class is done with the teacher is a physics teacher who does teach in the class.

Modelling activities are carried out online through google meet. During the learning activities, the model teacher has followed the learning steps sequentially by adjusting the lesson plans prepared by the researchers before the learning activities. At the beginning of the activity, students were asked to fill out an e-diagnostic test via the link provided. Students are also asked to download an e-book application. Furthermore, the model teacher explains the simple harmonic motion material to students with the help of the e-book that has been provided. At the end of the lesson, students are asked to fill in the e-diagnostic on a different link. The results of the analysis of diagnostic tests based on the mapping of misconceptions, misunderstandings, and understandings of students in the modelling class can be seen in Figure 2.

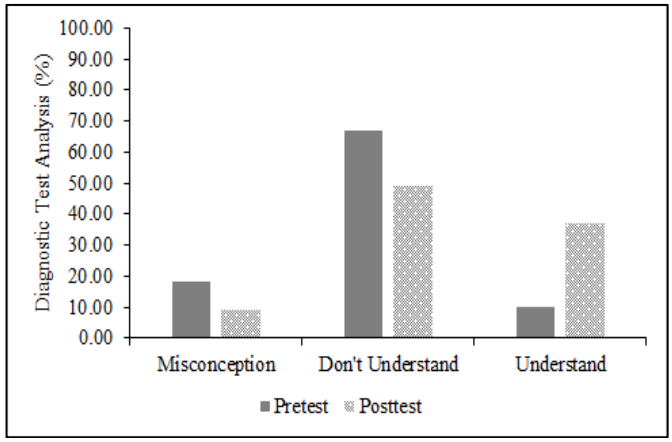

Figure 2. Results of the Diagnostic Test Analysis of Modeling Class Students

Diagnostic test show that the percentage of students who had misconceptions and did not understand decreases after the implementation of learning innovations in the modelling class. The number of students with misconceptions decreased by a percentage of 9.00% and the number of students who did not understand decreased by a percentage of 18.00%. Meanwhile, the number of students who understand increased by a percentage of 27.00%.

The average score obtained by students also increased after learning was carried out, it can be seen in Figure 3. The average score obtained by students before learning was 1.90. While the average score obtained by students after the implementation of learning is 5.43.

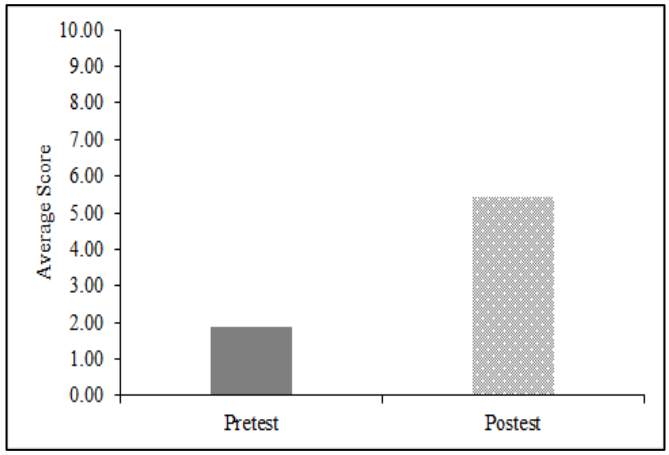

Figure 3. The Average Score of Students in the Modeling Class

Implementation activities are carried out after modelling activities. The learning steps taken in the implementation of implementation activities are the same as the implementation of modelling activities. The results of the analysis of students' diagnostic tests in the implementation class can be seen in Figure 4.

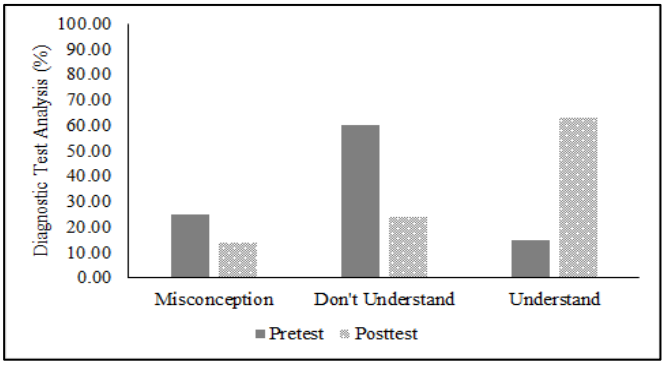

Figure 4. Results of the Diagnostic Test Analysis Implementation Class Students

The results of the diagnostic test analysis showed that the percentage of students who had misconceptions and students who did not understand decreased after learning was carried out in the implementation class. The percentage of students with misconceptions decreased by 11.00%. The percentage of students who do not understand also decreased by 36.00%. Meanwhile, the number of students who understand has increased by a percentage of 48.00%.

An increase also occurred in the average score obtained by students after learning was carried out, it can be seen in Fig. 5. The average score obtained by students before the implementation of learning is 3.00. While the average score of students after learning is 7.50.

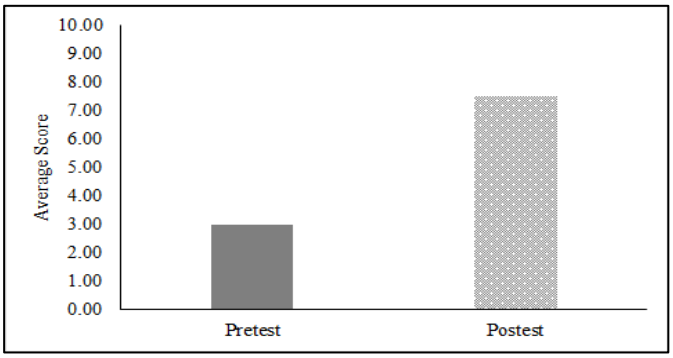

Figure 5. The Average Score of Students in the Implementation Class

Based on the average pretest and posttest scores of the modeling class and the implementation class, the N-Gain value can be analyzed to determine the increase in student scores before and before being given learning treatment using e-books. The results of the N-gain calculation show that e-books can increase student scores in the medium criteria, which can be seen in Table 6.

Table 6. N-gain Analysis Results

Class	Pretest Score	Posttest Score	N-Gain	Criteria
Modelling	1.90	5.43	0.44	Medium
Implementation	3.00	7.50	0.64	Medium

Students were asked to provide their responses regarding the e-book to find out the practicality of e-books that had been developed. The results of the student response analysis can be seen in Table 7. Based on the analysis of learners' responses both on modeling and implementation classes show that interactive physics e-books are very good used for learning.

Table 7. Results of Student Response Analysis

Aspect	Modelling Class		Implementation Class	
	Score	Criteria	Score	Criteria
Media	3.63	Very Good	3.56	Very Good
Material	3.74	Very Good	3.52	Very Good
Mean	3.68	Very Good	3.54	Very Good

Conclusion

Based on the results of research in the form of learning innovations, it can be concluded that: (1) Learning media in the form of e-books have been developed to reduce student misconceptions. The e-book has been validated by 3 experts and obtained very good results so that the e-book is suitable for use in learning activities. (2) There is a reduction in students' misconceptions in the modeling and implementation class. The biggest reduction occurred in the implementation class, which was 11.00%, while in the modeling class it was 9.00%. The e-book used succeeded in increasing students' understanding by 18.00% in the modeling class and 48.00% in the implementation class. The effectiveness of e-books in increase student scores belongs to the medium criteria in all classes. The results of this study show that e-books can reduce students' misconceptions. (3) The practicality of e-books in both modeling and implementation classes is very good.

References

Aykutlu, I., Bezen, S., & Bayrak, C. (2015). Teacher Opinions about the Conceptual Challenges Experienced in Teaching Physics Curriculum Topics. *Procedia - Social and Behavioral Sciences*, *174*, 390–405. https://doi.org/10.1016/j.sbspro.2015.01.681

Azizah, R., Yuliati, L., & Latifah, E. (2015). Kesulitan Pemecahan Masalah Fisika pada Siswa SMA. *Jurnal Penelitian Fisika Dan Aplikasinya*, *5*(2), 44–50. https://doi.org/10.26740/jpfa.v5n2.p44-50

Chrzanowski, M. M., Cieszyńska, A., & Ostrowska, B. (2015). Communication during Science Classes. *Procedia - Social and Behavioral Sciences*, *174*, 496–502. https://doi.org/10.1016/j.sbspro.2015.01.694

Entino, R., Hariyono, E., & Lestari, N. A. (2022). Analisis Miskonsepsi Peserta Didik Sekolah Menengah Atas Pada Materi Fisika. *PENDIPA Journal of Science Education*, *6*(1), 177–182.

https://doi.org/10.33369/pendipa.6.1.177-182

González, M., González, M., Martín, M. E., Llamas, C., Martínez, Ó., Vegas, J., Herguedas, M., & Hernández, C. (2015). Teaching and learning physics with smartphones. *Journal of Cases on Information Technology*, *17*(1), 31–50. https://doi.org/10.4018/JCIT.2015010103

Gumay, O. P. U. (2021). Analisis Miskonsepsi Siswa Kelas X Pada Materi Gerak. *Silampari Jurnal Pendidikan Ilmu Fisika*, *3*(1). https://doi.org/10.31540/sjpif.v3i1.1239

Halim, Soewarno, Elmi, Zainuddin, Huda, & Irwandi. (2020). The Impact of the E-Learning Module on Remediation of Misconceptions in Modern Physics Courses. *JPPPF (Jurnal Penelitian DanvPengembangan Pendidikan Fisika)*, *6*(2), 203–216. https://doi.org/10.21009/1.06207

Hammer, D. (1996). More than misconceptions: Multiple perspectives on student knowledge and reasoning, and an appropriate role for education research. *American Journal of Physics*, *64*(10), 1316–1325. https://doi.org/10.1119/1.18376

Hidayat, A., Suyatna, A., & Suana, W. (2017). Pengembangan Buku Elektronik Interaktif Pada Materi Fisika Kuantum Kelas XII SMA. *Jurnal Pendidikan Fisika*, *5*(2), 87–101. Retrieved from https://ojs.fkip.ummetro.ac.id/index.php/fisika/article/view/854/746

Iradat, R. D., & Alatas, F. (2017). The Implementation of Problem-Solving Based Laboratory Activities to Teach the Concept of Simple Harmonic Motion in Senior High School. *Journal of Physics: Conference Series*, *895*(1). https://doi.org/10.1088/1742-6596/895/1/012014

Jin, C. H. (2014). Adoption of e-book among college students: The perspective of an integrated TAM. *Computers in Human Behavior*, *41*, 471–477. https://doi.org/10.1016/j.chb.2014.09.056

Karagöz, Ö., & Zeki, A. (2015). Development Of Teacher Guidance Materials Based On 7E Learning Method In Virtual Laboratory Environment. *Procedia - Social and Behavioral Sciences*, *191*, 810–827. https://doi.org/10.1016/j.sbspro.2015.04.524

Khazanov, L., & Prado, L. (2010). Correcting Students ' Misconceptions about Probability in an Introductory College Statistics Course. *ALM International Journal*, *5*, 23–35. Retrieved from https://files.eric.ed.gov/fulltext/EJ1068215.pdf

Klammer, J. (1998). An Overview of Techniques for Identifying , Acknowledging and Overcoming Alternate Conceptions in Physics Education. *Klingenstein Project Report, Teachers College-Columbia University*, 40. Retrieved from https://files.eric.ed.gov/fulltext/ED423121.pdf

Korganci, N., Miron, C., Dafinei, A., & Antohe, S. (2015). The Importance of Inquiry-Based Learning on Electric Circuit Models for Conceptual Understanding. *Procedia - Social and Behavioral Sciences*, *191*, 2463–2468. https://doi.org/10.1016/j.sbspro.2015.04.530

Kusumastuti, F. A. (2021). Pengaruh Integrasi E-Book Interaktif Pada Kegiatan Belajar Mengajar Sains. *JURNAL BECOSS (Business Economic, Communication, and Social Sciences)*, *2*(1), 83–88. https://doi.org/10.21512/becossjournal.v2i1.6063

Lee, B., Fenoff, R., & Paek, S. Y. (2019). Correlates of participation in e-book piracy on campus. *Journal of Academic Librarianship*, *45*(3), 299–304. https://doi.org/10.1016/j.acalib.2019.04.002

Lestari, R. T., Adi, E. P., & Soepriyanto, Y. (2018). E-Book Interaktif. *Jurnal Kajian Teknologi Pendidikan JKTP*, *1*(1), 71–76. Retrieved from http://journal2.um.ac.id/index.php/jktp/article/view/3529

Muna, I. A. (2016). Identifikasi Miskonsepsi Mahasiswa Pgmi Pada Konsep Hukum Newton Menggunakan Certainty of Response Index (Cri). *Cendekia: Journal of Education and Society*, *13*(2), 309. https://doi.org/10.21154/cendekia.v13i2.251

Ozkan, A., & Ozkan, E. M. (2015). Misconceptions on the Summation Symbol Subject and Solution Proposals. *Procedia - Social and Behavioral Sciences*, *186*, 670–673. https://doi.org/10.1016/j.sbspro.2015.04.018

Pratiwi, I. T. M., & Meilani, R. I. (2018). Peran Media Pembelajaran dalam Meningkatkan Prestasi Belajar Siswa. *Jurnal Pendidikan Manajemen Perkantoran*, *3*(2), 173–181. https://doi.org/10.17509/jpm.v3i2.11762

Purwanto, E., & Winarti. (2020). Representasi Miskonsepsi Peserta Didik Pada Materi Suhu dan Kalor. *Papua Journal of Physics Education (PJPE)*, *1*(1), 28–35. https://doi.org/10.31957/pjpe.v1i1.1279

Rafli, Y., & Adri, M. (2019). Pengembangan Modul Berbasis E-Book Interaktif Pada Mata Pelajaran Dasar Desain Grafis. *VOTEKNIKA Jurnal Vokasional T Eknik Elektronik a Dan Informatika*, *7*(1). https://doi.org/10.24036/voteteknika.v7i1.103787

Salmon, A. K., & Barrera, M. X. (2021). Intentional questioning to promote thinking and learning. *Thinking Skills and Creativity*, *40*, 100822. https://doi.org/10.1016/j.tsc.2021.100822

Schuessler, H., Kolomenski, A., Bunker, P., & Perkins, C. (2016). Improving Effectiveness of Teaching Large Introductory Physics Courses with Modern Information Technology. *Procedia - Social and Behavioral Sciences*, *228*, 249–256. https://doi.org/10.1016/j.sbspro.2016.07.037

Soeharto, S., Csapo, B., Sarimanah, E., Dewi, F. I., & Sabri, T. (2019). A Review of Students' Common Misconceptions in Science and Their Diagnostic Assessment Tools. *Jurnal Pendidikan IPA Indonesia*, *8*(2), 247–266.

https://doi.org/10.15294/jpii.v8i2.18649
Somroob, S., & Wattanakasiwich, P. (2017). Investigating student understanding of simple harmonic motion. *Journal of Physics: Conference Series*, *901*(1). https://doi.org/10.1088/1742-6596/901/1/012123
Suyatna, A., Maulina, H., Rakhmawati, I., & Khasanah, R. A. N. (2018). Electronic versus printed book: A comparison study on the effectivity of senior high school physics book. *Jurnal Pendidikan IPA Indonesia*, *7*(4), 391–398. https://doi.org/10.15294/jpii.v7i4.14437
Tiandho, Y. (2018). Miskonsepsi Gaya Gesek Pada Mahasiswa. *Jurnal Pendidikan Fisika Dan Keilmuan (JPFK)*, *4*(1), 1–9. https://doi.org/10.2572/jpfk.v4i1.1814
Tumanggor, A. M. R., Supahar, S., Ringo, E. S., & Harliadi, M. D. (2020). Detecting Students' Misconception in Simple Harmonic Motion Concepts Using Four-Tier Diagnostic Test Instruments. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, *9*(1), 21–31. https://doi.org/10.24042/jipfalbiruni.v9i1.4571
Young, H. D., & Freedman, R. A. (2014). *University Physics with Modern Technology*. Pearson Education. Retrieved from https://physica.cloud/ajab/uploads/2018/10/Hugh-D.-Young-Roger-A.-Freedman-A.-Lewis-Ford-University-Physics-with-Modern-Physics-with-MasteringPhysics%C2%AE-13th-Edition-Addison-Wesley-2011.pdf