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Implementation of Android-Based Physics Learning Media in Increasing High School Students' Curiosity

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ABSTRACT
The 21st century skills are needed to create individuals who are able to compete in this century. One of the important attitudes of 21st century competence is curiosity. Curiosity can help someone solve the problems they face. In order to improve and foster students' curiosity, one aspect that can support learning is through the use of mobile technology. In this study, android physics learning media application in simple harmonic motion topic is implemented in learning using the pre-test-post-test control group experimental design. This study aims to determine the effect of Android-based physics learning media in increasing students' curiosity. The subject of this study involved students in three Senior High School in Banyumas Regency, Central Java. The results show that the use of Android-based physics learning media is proven to have a positive effect in increasing curiosity of students.

Keywords: *Physics learning media, Curiosity, Android, Mobile learning*

1. INTRODUCTION

Humans continue to evolve and change in thinking so as to encourage a change in all aspects of life. On the one hand, these changes must also be balanced by every individual in the world as a form of adaptation. One of them is the adjustment of skills and attitudes that must be mastered. The skills needed to create individuals who are able to compete in this century are contained in 21st century skills [1]. Efforts to achieve these targets, of course, need to be done seriously, one of which can be achieved through education. Ideally, education in schools is able to shape and prepare individuals to have reliable attitudes and skills according to the competencies needed in this century. One of the important attitudes of 21st century competence is curiosity. This attitude is important because curiosity is one of the attitudes that can help someone solve the problems they face [2]. Curiosity itself is a basic attitude that a person should have so that he can learn and continue to learn. Furthermore, the results of observations and interviews with teachers in 3 schools in Banyumas regency showed that the curiosity of students in learning physics was still varied, some were good but some were still lacking. However, there has been a tendency towards decreased curiosity in physics learning since online learning was introduced due to the COVID-19 pandemic. Thus, efforts to increase this attitude do not appear to be something that should stop, but must be continuously maintained and improved. In addition, globally, the creativity index of the Indonesian people cannot be said to be good because in The Global Creativity Index 2015, Indonesia still ranks 115 out of 129 countries with a score of 0.202 from a maximum of 1.00 [3]. In fact, creativity in a person will help him solve problems [4]. Furthermore, high creativity is also a reflection of a strong curiosity in a person [5], [6].

The national curriculum mandates curiosity as one of the attitudes that must be built. In addition, curiosity is included in the component of Cultural Education and National Character [7]. Moreover, science itself is a field that is closely associated with curiosity [8], [9]. Activities of discovering and inquiry in science can take place because of the desire to uncover something that has not been known before [8], [10], [11]. Curiosity is also needed so that students can have good scientific literacy [8]. Therefore, learning physics which is part of science should be an activity that

Table 1. Aspects and indicators of curiosity

	Aspects	Indicators
1	Exploration	Find out about foreign things.
		Not bored in studying.
		Discuss actively.
		Not satisfied quickly in finding out.
2	Attention	Noticing any explanation.
		Pay close attention to the details of processes.
		Focused and not easily distracted.
3	Question	Question everything that is not yet known.
		Ask in detail.

nurtures and fosters the curiosity of students. This attitude is needed in learning physics. As stated in Education and Culture ministerial regulation number 22 of 2016 regarding Educational Process Standards, learning activities should be carried out with student-centered activities, and use steps that stimulate the thinking of students to find out [12].

One aspect that can support learning in order to increase the curiosity of students is through the use of technology [13]–[15]. Technology can be served as an attractive learning medium so that it can foster students' interest and desire to learn [16], [17]. Furthermore, the national curriculum has also been mandated that learning activities should use the principles that take learning resources not only from teachers, but from a variety of sources [12]. In addition, the existence of technology in the midst of students' lives also has great potential [18]–[20]. Students own cell phones not only because they want to follow trends and without rational considerations, but because cell phones have become a necessity [21]. This can be controlled and utilized so that it can become activities that support their learning both in the school environment and outside the school. Teachers or schools no longer need to distribute new device, but just need to develop and utilize what is already owned by students in order to also be a source of learning. So, the potential use of technology for learning is one of several option that is very wide open.

A smart phone with an Android operating system is one that has great opportunities for learning. The data shows that Android is the most widely used operating system compared to other mobile operating systems [22]. The development of physics learning media applications based on the Android operating system has also been proven to be possible [23]–[25]. Furthermore, during the pandemic situation that occurred this year, the learning process had to be carried out remotely because schools had to be closed. This can also be facilitated by the presence of digital media on Android phones. In this case, the flexibility of an Android smartphone as a mobile device is very useful in supporting learning. This can be achieved because of the nature of mobile technology which is not limited to space and time [18], [26]. In this study, a physics learning application based on the Android operating system was used in physics learning, namely Interactive Physics Mobile Learning Media (IPMLM) in Simple Harmonic Motion subject. The application is developed using the Android Studio IDE with a target API level 28 and a minimum API level 21, which means the application can run on phones with android version 5.0 Lollipop or later. The application was equipped with features that support learning and encourage student curiosity. The media is equipped with material, discussion material, sample questions, practice questions, detailed answer of example problems, and evaluation questions. The use of technology that is close to students is expected to be able to stimulate them to study harder and want to know more. The attitude of curiosity in this study was measured using several indicators grouped into several aspects. The indicators are presented in Table 1, these indicators are the result of the synthesis of several sources [7], [27], [28]. Thus, this study aims to determine the effect of Android-based learning media on increasing students' curiosity.

2. METHOD

The research design used in study was the Pre-test-Post-test Control Group Design as shown in Table 2. Symbol O_1 is pre-test and O_2 is post-test for both classes, while X_1 is class using the android-based learning media and X_2 is class using standard material (ppt or pdf files).

Table 2. Pretest-posttest control group design

Class	Pre-test	Treatment	Post-test
Experiment	O_1	X_1	O_2
Control	O_1	X_2	O_2

2.1. Subject and Location

Research subjects for the experiment included students in 3 high schools in Banyumas district namely, SMA N 1 Purwokerto, SMA N 2 Purwokerto, and SMA N Sokaraja. This research was carried out in Banyumas Regency, Central Java Province.

2.2. Data Type

The type of data to be obtained is quantitative data. Data obtained from the assessment sheet of curiosity questionnaire and curiosity scores of students.

2.3. Instruments

Data collection instruments in this study consisted questionnaire. The questionnaire was used as an instrument validity sheet, and a questionnaire of curiosity. The validation questionnaire for curiosity measuring questionnaire was consisted of several indicators with Yes and No answer, those answers are then converted to a scale of 4 for further analysis. While the curiosity questionnaire was arranged using 4 scales consisted of Strongly Agree, Agree, Disagree, and Totally Disagree. The indicators used to create the curiosity questionnaire are presented in Table 1. Curiosity in this study is categorized into three aspects, namely exploration, attention, and questions.

The android-based physics learning media used in this study is a learning media on simple harmonic motion topic with the application name IPMLM. Applications are used during learning activities as the main learning resource with physics material as well as a discussion source with a discussion feature which contains material for discussion in the form of videos and simulations. The overall contents of the application are mainly listed in the material menu as displayed in Figure 2. When user selects on the sub menu of the material, they will then be directed to the layout as shown in Figure 1. The application also contains an evaluation system consisting of a formative test for each end of the meeting as well as a summative test for evaluation at the end of basic competency learning. The evaluation system is equipped with a detailed discussion of each item in it in order to help students easily understand problems that have not been resolved. Each evaluation also consists of two question packages, so that students can work on it again even though they have finished working on one of the question packages. Thus, students' learning opportunities become wider because there is an option to rework the questions that are similar to the ones that have been done, but by first studying and making corrections to the work that has been done before. And the main thing is, all of these activities are done digitally in the IPMLM application, which of course is not limited by time and space. Furthermore, this activity is also free from wasted paper use because all data is stored on the smartphones of each student and is also sent to the application developer's Google Sheets for much easier data collection.

2.4. Data Analysis Technique

2.4.1. Questionnaire Data of Curiosity Questionnaire Validation

Data validation results of the curiosity measuring instrument were analysed using Aikens' V validity. The content validity coefficient based on several judgment of rater can represent the measured item construct. Data were obtained from 5 assessors with a maximum scale of 4 and a minimum of 1 for each statement item in the curiosity questionnaire. This value is then analysed for each item and then compared with the minimum V value in the Aiken's V table. The minimum value of V for an instrument with a rating scale of 4 and the number of raters of 5 is 0.93 [29]. This value is a minimum number with an error rate of <0.01.

2.4.2. Empirical Data of Curiosity Questionnaire

Evidence of content validity was empirically obtained through the items' response analysis of test results in the form of polytomous data from curiosity measuring questionnaire. Polytomous data were analysed using Item Response Theory (IRT) using the QUEST program.

2.4.3. Improvement of Curiosity

The effectiveness of the android-based learning media is discovered by looking at differences in curiosity scores of experimental and control class students. The data is converted first into an interval scale from the previous ordinal scale so that it can be analysed. The analysis was carried out on the data obtained before and after learning using the Paired Sample t Test and the difference of data between

experimental and control group is analysed using One Way ANOVA. The data analysis process was carried out using the help of the SPSS program.

Figure 1 The display of physics content sub material Introduction

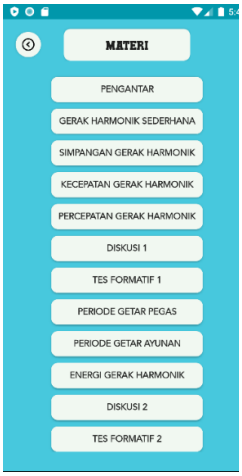

Figure 2 Material menu of the application containing sub material of simple harmonic motion, discussion material, and formative test.

3. RESULT AND DISCUSSION

Before being used in the data collection process, the curiosity questionnaire was validated first using the curiosity questionnaire validation sheet. Besides the content validity, testing of the questionnaire was also conducted empirically, for further analysis using the item response theory. Measurement activities are carried out after the questionnaire is declared good and feasible to measure the curiosity of students, both theoretically and empirically. Learning activities in research first began with a pretest which aims to determine the initial curiosity of students before participating in learning. Furthermore, in the experimental class it was continued with learning activities where the main learning resource was using the IPMLM android based application, while in the control or comparison class, learning activities were carried out using media that were commonly used previously, namely pdf, ppt, and books. After going through the learning process according to the syllabus and learning process plan, along with the final evaluation, a posttest is carried out to determine the curiosity of students after participating in learning activities using the IPMLM application. The description of the results of the analysis of the data obtained in the assessment in detail is explained in the points below.

3.1. Validation of Curiosity Questionnaire

The validity of the contents of the curiosity questionnaire instrument was measured using the assessments of several raters consisting of experts and physics education practitioners. The assessment of 5 raters is then analysed using the Aiken equation to obtain the Aiken V index. The rater's assessment questionnaire has a maximum scale of 4 and a minimum of 1. The results of the V index calculation show that the statement items in the developed curiosity questionnaire have an index value range of 0.93 to 1.00. Then, from the Aiken's V table, it is found that the minimum V index limit for items with a rating scale of 4 and the number of raters of 5 at an error rate <0.01 is 0.93 [29]. Therefore, it can be concluded that all items made are declared theoretically valid because they meet the criteria for the minimum V index.

3.2. Empirical Validity of Curiosity Questionnaire

Testing the validity of the curiosity questionnaire used in this study was also conducted empirically. Empirical testing involved 316 students who were randomly selected as respondents. The results of the data collection were then analyzed using a computer program based on Item Response Theory (IRT), namely QUEST. The results of program analysis in the form of fit and reliability items are used as a reference to determine the quality of the developed curiosity questionnaire.

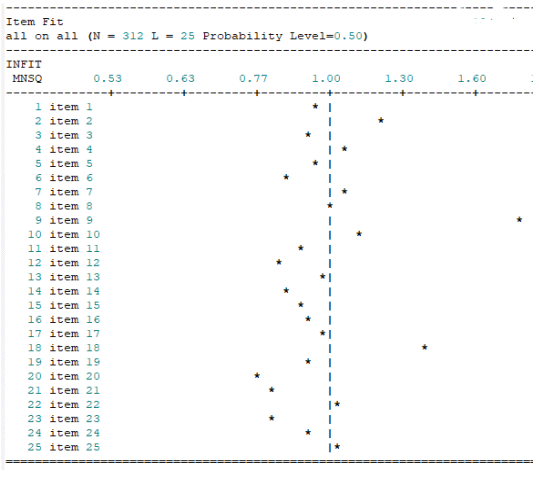

Figure 3 Item fit analysis of QUEST IRT program.

The results of the fit item indicate that of the 25 statement items in the questionnaire, there are two

statements that are not fit for the IRT model. The fit criteria for the model itself are based on the MNSQ infit value at the program output which is in the range 0.77 to 1.30 [30]. Items that have an MNSQ infit value outside this range are declared not fit to the model and invalid. Thus, two items that were outside the acceptance limits of fit were not included in the primary data analysis, namely experimental data from the control class and the experimental class. So, the curiosity questionnaire, which initially consisted of 25 items, after going through the empirical test process turned out to be composed of only 23 items. The display of QUEST output in the form of item fit is shown in Figure 3.

Furthermore, from the results of the same analysis, an estimate of the reliability index was also obtained from the curiosity questionnaire. The QUEST program is able to present two types of reliability estimates, namely estimates based on case or respondent, and estimates based on items. The two estimation results are presented in Table 3. The estimation of the questionnaire score reliability index on empirical testing shows that the numbers on the criteria are quite good [31].

Table 3. Reliability estimates of empirical test of curiosity questionnaire

Estimation Type	Estimated Reliability Index
Reliability of item estimates	0,67
Reliability of case estimates	0,81

3.3. Effectivity of Media in terms of Curiosity Improvement

The effectiveness of using the IPMLM android application in increasing the curiosity of students in learning was tested by comparing the curiosity score in the experimental class and the control class. The analysis was carried out using the One-Way ANOVA method in the SPSS program. The data obtained using a questionnaire is data with an ordinal scale, while non-parametric analysis requires interval or ratio scale data. So, before the experimental data is analysed statistically, the ordinal scale of the data is converted into an interval scale using the Successive Interval method. Changing the scale is done using the Ms. program. Excel that has installed the Analysis Method of Successive Interval (MSI) add-ins. After the scale was changed, before entering into further analysis, the prerequisite test for ANOVA was first carried out, namely the normality test and the homogeneity test. The test results on data normality are presented in Table 4.

Table 4. Normality test of data

Tests of Normality			
	Shapiro-Wilk		
	Statistic	df	Sig.
Experiment	0.969379	58	0.149699
Control	0.984077	61	0.611389

The normality test shows that with a significance level of 5% the experimental data on the curiosity of students in both the experimental and control groups is normally distributed. After the prerequisites in testing are met, the post-test data for the experimental class and the control class are tested whether there is a significant difference in the mean between the two. The ANOVA analysis results show that at the 5% significance level there is a significant difference in the curiosity of students in the control class and the experimental class because of the Sig. <0.05. Thus, it can be seen that the use of Android-based learning media in physics learning activities has a significant effect on the curiosity of students. The results of ANOVA analysis using the SPSS program are shown in Table 5.

Table 5. ANOVA Analysis

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	747.654	1	747.654	7.775	0.006
Within Groups	11251.185	117	96.164		
Total	11998.839	118			

Furthermore, the analysis was carried out to find out how different the increase in curiosity was in the control class and the experimental class. The analysis was carried out using the Paired Sample t Test method on SPSS, as presented in Table 6. The results of the pre-test-post-test analysis of the experimental class showed that at the 5% significance level there was a significant difference in the curiosity of students between before and after participating in learning using based learning media. android. While the results of the control class pre-test-post-test analysis showed that at the 5% significance level there was no significant difference in the curiosity of students

before and after learning using conventional methods, namely media in the form of pdf, ppt, and books. Judging from the mean increase, the experimental class experienced an increase in the mean curiosity score at different pre-test and post-test by 6.66, while the control class experienced an increase in curiosity scores on different pre-test and post-test by 1.00. The mean difference figures and other information in the more detailed pre-test post-test analysis are shown in Table 6. These results indicate that the implementation of unique learning media, one of which is in the form of an android application, is proven to be able to make a difference to the curiosity of students in the form of statistically significant improvements.

Table 6. Paired sample t test analysis

Paired Differences					
	Mean	Std. Dev	t	df	Sig. (2-tailed)
Experiment	-6.66	6.81	-7.448	57	0.000
Control	-1.00	6.38	-1.229	60	0.224

After it is known that the implementation of an Android-based learning media application can be used to increase students' curiosity, further analysis is carried out on the observed aspects of curiosity, including exploration, attention, and questions. The results of the analysis of these three aspects are presented in detail in the form of a bar graph in Figure 4. The analysis of each aspect in curiosity is written as a percentage. On the graph, it is clear that the bar in the experimental class has increased significantly for each aspect of the curiosity. Meanwhile, in the control class, the increase in each aspect is relatively small, although the three aspects have increased, but it is not significant.

The data shows that the largest increase occurred in the question aspect, with a value of 5.75%. This shows that the implementation of the android-based media used most influences the feeling of wanting to ask students. Students are encouraged to ask things they don't understand, or things that sound foreign to them. During the learning process, there is a tendency for students to ask for terms in simple harmonic motion topic that have not been explained in detail in the material or there is already an explanation but they have not fully understood them. This fact is in line with the results of data analysis which show that this aspect has the highest increase. Furthermore, students who use smartphones as tools for learning are generally connected directly to the internet in it. So, even when they have questions, they can easily try to find answers via the internet or ask friends or teachers through social media or chat services. The second aspect is attention, up by 5.17%. In the learning process, this aspect is mainly encouraged using the discussion sheets by stimulating attention to the materials in it. The smallest increase in the experimental group was in the exploration aspect, with value 4.38%. The exploratory attitude of students did not increase as much as other aspects possibly due to the lack of teaching materials in the application, as well as offline applications. So, what students can explore is still limited to what has been presented in the IPMLM application only.

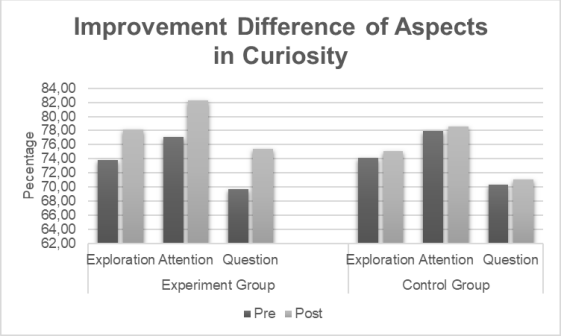

Figure 4 Detailed improvements of curiosity aspects

Basically, the exploration and attention aspects can be increased because of the discussion material features on the IPMLM application and supported by discussion sheets. In the discussion, there are materials in the form of videos and simulations that are embedded in the application. Students are invited to explore and build an understanding of the subject matter in discussions with the stimulus. In the process, the questions and problems in the discussion sheet also invite students to find for themselves what they want to look for, and write down what they find with answers in the form of opinions. Students are trained to explore and pay attention to the details of the materials in it independently in groups. With this feature, students' curiosity can be stimulated and learning activities become more meaningful because students find out and build their own understanding. Moreover, students were encouraged to be more interested and curious about experimental activities in the discussion [13]. The implementation of the IPMLM android application has also been in line with the learning principles of the curriculum, namely active students and creating student-centered learning activities. Curiosity itself can be seen as an attempt to know because there is pleasure in knowing, or vice

versa, because there is a feeling of torment because of not knowing, therefore, the type of person who wants to know can vary [2]. In this study, it could not be done a more in-depth analysis of the type of curiosity of students. Thus, the motivation of students to become curious because they enjoy finding out, in order to solve problems, or to avoid feeling stressed by not knowing, cannot be detected.

IPMLM applications are mobile, so that their use is not limited to space and time. Therefore, the process of finding out students can happen anywhere. When students have the opportunity to open applications, they can learn immediately, in accordance with the nature of flexible mobile learning [26]. When compared with the media used in the control class, namely conventional media such as pdf, ppt, and books, the Android-based media is clearly superior. Apart from the fact that pdf and ppt files can also be opened via an android smartphone, the packaging of pdf and ppt teaching materials is not fairly convenient. For example, if the material is delivered using pdf or ppt facilities, if there is a video, the video file will be separate from the pdf or ppt file itself. Whereas in the Android application, videos can be directly embedded in it, becoming a complete compact application. Therefore, this is clearly one of the advantages of an Android application that makes it easier for students to access their learning material.

Curiosity can be in the form of a desire to know new information and experiences that can lead to a series of events where a person will find a resolution of his curiosity that can be either satisfying or unsatisfactory. [32]. When a person finds a solution to his curiosity that feels satisfying to him, it will trigger another curiosity [13]. IPMLM learning media have been designed and implemented to encourage the curiosity of students to continue to increase. This has been proven by a significant increase in the curiosity of students. Technology in learning is able to have a positive influence on the attitudes of students [13]. The implementation of EPUB technology has also been proven to have a positive effect on the curiosity of students [33]. Even though when compared directly, the flexibility of the android application is much better than EPUB, because EPUB itself also can be opened using android devices. Thus, the development opportunities and the increase in the positive effects of using Android technology can be even better and wider. However, it needs to be admitted that the magnitude of the increase in curiosity after carrying out learning activities using IPMLM cannot be used as a benchmark because there is no other technology-based learning treatment that is directly compared.

4. CONCLUSION

Based on the results obtained, it can be concluded that the implementation of android based physics mobile learning media named IPMLM on simple harmonic motion topic can significantly increase the curiosity of students. The aspect that increases the best is the Question aspect, even though the IPMLM media is not specifically designed for students to easily ask questions. Further research can be carried out to determine the motivation of students' curiosity in finding out. Because in several research studies have been carried out on multi-dimensional curiosity.

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REFERENCES

[1] J. Voogt, N.P. Roblin, A Comparative Analysis of International Frameworks for 21st Century Competences: Implications for National Curriculum Policies, Journal of Curriculum Studies 44(3) (2012) 299–321. DOI: https://doi.org/10.1080/00220272.2012.668938

[2] T.B. Kashdan, M.C. Stiksma, D.D. Disabato, P.E. McKnight, J. Bekier, J. Kaji, R. Lazarus, The Five-Dimensional Curiosity Scale: Capturing The Bandwidth of Curiosity and Identifying Four Unique Subgroups of Curious People, Journal of Research in Personality 73 (2018) 130–149. DOI: https://doi.org/10.1016/j.jrp.2017.11.011

[3] Martin Prosperity Institute, *The Global Creativity Index 2015*, Rotman, Toronto, 2015. Accessed on: Oct 2020. [Online]. Available: http://www-2.rotman.utoronto.ca/mpi/wpcontent/uploads/2015/07/Global-Creativity-Index-2015.pdf

[4] E. Rofiah, N.S. Aminah, E.Y. Ekawati, Penyusunan Instrumen Tes Kemampuan Berpikir Tingkat Tinggi Fisika pada Siswa SMP, Jurnal Pendidikan Fisika 1(2) (2013) 17–22.

[5] B. Silaban, Hubungan antara Penguasaan Konsep Fisika dan Kreativitas dengan Kemampuan Memecahkan Masalah pada Materi Pokok Listrik Statis, Jurnal Penelitian Bidang Pendidikan 20(1) (2014) 65–75. DOI:

https://doi.org/10.24114/jpbp.v20i1.3072

[6] P. Armandita, E. Wijayanto, L. Rofiatus, A. Susanti, Analisis Kemampuan Berpikir Kreatif Pembelajaran Fisika di Kelas XI MIA 3 SMA Negeri 11 Kota Jambi, Jurnal Penelitian Ilmu Pendidikan 10(2) (2017) 129-135. DOI: https://doi.org/10.21831/jpipfip.v10i2.17906

[7] S.H. Hasan, *Development of Cultural Education and National Character*, Balitbang Kemendikbud RI, 2010.

[8] S.N. Muhammad, L. Listiani, A. Adhani, Hubungan antara Literasi Sains dan Rasa Ingin Tahu Siswa pada Materi Ekosistem, Natural: Jurnal Ilmiah Pendidikan IPA 5(2) (2018) 112-116. DOI: https://doi.org/10.30738/natural.v5i2.2935

[9] R. Diani, H. Khotimah, U. Khasanah, M.R. Syarlisjiswan, Pengaruh Pendekatan Saintifik Berbantukan LKS terhadap Hasil Belajar Fisika Peserta Didik Kelas XI SMA Perintis 1 Bandar Lampung, Jurnal Ilmiah Pendidikan Fisika Al-Biruni 5(1) (2016) 310-319. DOI: https://doi.org/10.24042/jpifalbiruni.v5i1.108

[10] D. Nuvitalia, S. Patonah, E. S, Khumaedi, A. Rusilawati, Dimensi Rasa Ingin Tahu Siswa Melalui Pendekatan Saintifik Berbantuan Alat Perga Penjernihan Air, Phenomenon: Jurnal Pendidikan MIPA 6(2) (2016) 10-17. DOI: https://doi.org/10.21580/phen.2016.6.2.1077

[11] Emhadelima, The Use of Virtual Media Laboratory to Increase Students' Motivation on Direct Current Circuits Materials at Class X of MAN I Pekanbaru, Al-Ta'lim Journal 22(3) (2015) 254–265. DOI: https://doi.org/10.15548/jt.v22i3.147

[12] Ministry of Education and Culture RI, Regulation of The Minister Education and Culture No 22 of 2016 about Basic and Secondary Education Process Standards, Jakarta, 2016.

[13] K. Hochberg, J. Kuhn, A. Müller, Using Smartphones as Experimental Tools—Effects on Interest, Curiosity, and Learning in Physics Education, Journal of Science Education and Technology 27(5) (2018) 385–403. DOI: https://doi.org/10.1007/s10956-018-9731-7

[14] E. Wahyuni, Pengaruh Pemanfaatan Multimedia dalam Pembelajaran Fisika terhadap Pemerolehan Belajar, Jurnal Visi Ilmu Pendidikan 7(1) (2012) 694–710. DOI: https://doi.org/10.26418/jvip.v7i1.338

[15] M.Á. González, M.E. Martín, C. Llamas, O. Martínez, J. Vegas, M. Herguedas, C. Hernández, Teaching and Learning Physics with Smartphones, Journal of Cases on Information Technology 17(1) (2015) 31–50. DOI: https://doi.org/10.4018/JCIT.2015010103

[16] M. Taufik, A. Kristanto, Pengembangan Mobile Learning Berbasis Aplikasi Android Mata Pelajaran Fisika Materi Listrik Arus Searah Kelas XI SMK Negeri 2 Kediri, Jurnal Mahasiswa Teknologi Pendidikan 9(2) (2018) 1–8.

[17] C.D. Mayangsari, B.H. Iswanto, D. Susanti, Handout Berbasis Android untuk Pembelajaran Usaha dan Energi di SMA dengan Model Problem Based Learning, in: M.A. Marpaung, Prosiding Seminar Nasional Fisika, vol. 7, Universitas Negeri Negera Jakarta, Jakarta, 2018, pp. 70–77. DOI: https://doi.org/10.21009/03.SNF2018.01.PE.09

[18] R.R. Permana, Supriyadi, A.H. Permana, G.A. Ishak, Widyanirmala, N. Azizah, A. Nugraha, Pengembangan Aplikasi Android Untuk Pembelajaran Mobile Learning Pada Pokok Bahasan Alat-Alat Optik, in: Prosiding Seminar Nasional Fisika, vol. 3, Universitas Negeri Negera Jakarta, Jakarta, 2014, pp. 108–114.

[19] A.E. Damayanti, H. Komikesari, I. Syafei, R. Rahayu, Kelayakan Media Pembelajaran Fisika Berupa Buku Saku Berbasis Android pada Materi Fluida Statis, Indonesia Journal of Science and Mathematics Education 1(1) (2018) 63–70. DOI: https://doi.org/10.24042/ijsme.v1i1.2476

[20] I.A.D. Astuti, R.A. Sumarni, D.L. Saraswati, Pengembangan Media Pembelajaran Fisika Mobile Learning Berbasis Android, Jurnal Penelitian & Pengembangan Pendidikan Fisika 3(1) (2017) 57–62. DOI: https://doi.org/10.21009/1.03108

[21] J.A. Nasution, N. Neviyarni, A. Alizamar, Motif Siswa memiliki Smartphone dan Penggunaannya, Jurnal Penelitian Pendidikan Indonesia 3(2) (2017) 15–29. DOI: https://doi.org/10.29210/02017114

[22] M.Z. Zahid, Aplikasi Berbasis Android untuk Pembelajaran: Potensi dan Metode Pengembangan, in: I. Rosyida (Eds.), Prosiding Seminar Nasional Matematika, vol. 1, FMIPA Universitas Negeri Semarang, Semarang, 2018, pp. 910–918.

[23] S.H. Aji, Jumadi, A.T. Saputra, R.N. Tuada, Development of physics mobile learning media in optical instruments for senior high school

student using android studio, in: The 5th International Seminar on Science Education, vol. 1440, IOP Publishing, Bristol, 2020, pp. 1-9. DOI: https://doi.org/ 10.1088/1742-6596/1440/1/012032

[24] M. Husna, H. Kuswanto, Development of Physics Mobile Learning Based On Local Wisdom to Improve Vector and Diagram Representation Abilities, International Journal of Interactive Mobile Technologies 12(6) (2018) 85–100. DOI: https://doi.org/10.3991/ijim.v12i6.8746

[25] O.A. Nanda, I. Wilujeng, The Effectiveness of Android-assisted Optical Devices Learning to Improve Students' Conceptual Understanding, Jurnal Penelitian dan Pembelajaran IPA 4(2) (2018) 105–115. DOI: https://doi.org/10.30870/jppi.v4i2.4038

[26] K.T. Martono, O.D. Nurhayati, Implementation of Android-Based Mobile Learning Application as A Flexible Learning Media, International Journal of Computer Science Issues,11(3) (2014) 168–174.

[27] A.T. Collete, E.L. Chiappetta, Science Instruction in The Middle and Secondary Schools, Macmillan Publshing, 1994.

[28] W. Harlen, Teaching, Learning and Assessing Science 5-12, Paul Chapman, 2001.

[29] L.R. Aiken, Three Coefficients for Analyzing The Reliability and Validity of Ratings, Educational and Psychological Measurement 45(1) (1985) 131–142. DOI: https://doi.org/10.1177/0013164485451012

[30] R.K. Hambleton, H. Swaminathan, H.J. Rogers, Fundamentals of Item Response Theory Library, Sage Publication, 1991.

[31] N.D.L. Dewi, Z.K. Prasetyo, Pengembangan Instrumen Penilaian IPA untuk Memetakan Critical Thinking dan Practical Skill Peserta Didik SMP, Jurnal Inovasi Pendidikan IPA 2(2) (2016) 213–222. DOI: https://doi.org/10.21831/jipi.v2i2.11963

[32] M.P. Arnone, R.V. Small, S.A. Chauncey, H.P. McKenna, Curiosity, Interest and Engagement in Technology-Pervasive Learning Environments: A New Research Agenda, Educational Technology Research and Development 59(2) (2011) 181–198. DOI: https://doi.org/10.1007/s11423-011-9190-9

[33] N. Haryanti, I. Wilujeng, S. Sundari, Problem based learning instruction assisted by e-book to improve mathematical representation ability and curiosity attitudes on optical devices, in: The 5th International Seminar on Science Education, Journal of Physics: Conference Series, vol. 1440, IOP Publishing Bristol, 2020. DOI: https://doi.-org/10.1088/17426596/1440/1/012045