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Tubagus Abdul Azis Nugraha[1]
Rudi Haryadi[2]
Yusrama Denny[3]

TECHNOLOGY APPLICATION MOBILE AUGMENTED REALITY IN EDUCATION (TAMARINE): IMPLEMENTATION OF APPLICATIONS IN IMPROVING UNDERSTANDING OF MECHANICAL WAVE CONCEPTS

Abstract
Android based learning applications are currently developing towards augmented reality (Expanded Reality or AR) innovation. In this research, researchers chose to use teaching materials through Augmented Reality applications to increase students' understanding of concepts through the use of augmented reality (AR) applications as teaching materials. Through an innovative work model utilizing the ADDIE model. Questionnaires were used for data collection. The population in this study were class XI students of SMA Negeri 3 Pandeglang, a sample of 30 students was taken. The assessment uses the Likert model for data analysis. The results of the media expert's judgment show that the TAMARinE application obtained an average score of 4.45 with a level of 89%, so it is included in the Very Eligible classification according to competency standards and the material expert's judgment obtained an average score of 3.71 with a level of 74%, which is included in the classification. Very suitable for competency standards or suitable for use. From the results of the initial and final trials given to students, the average pretest score was 59.3 and the posttest average score was 80.6. The increase in students' understanding of the learning media developed can be seen from the difference in pretest and posttest scores. The consequence of the sum test is 0.486 with the medium class indicating that the TAMARinE application is suitable for use.
Keywords: Augmented Reality; Understanding of Concepts, Mechanical Waves.

INTRODUCTION

In the world of education, various studies of students of all ages and levels of education, as well as in areas such as science, have shown that students have an inadequate or inaccurate understanding of many phenomena. Conceptual understanding has become a widely studied topic (Saricayir, H., Ay, S., Comek, A., Cansiz, G., & Uce, 2016). According to (Febriana Ramadhan, Sodikin, 2019), students are expected to understand what is being taught, understand what is being communicated, and be able to use the content. Students' actual ability to understand science concepts, principles and procedures after going through the learning process is known as conceptual understanding. Interpreting, giving examples, classifying, summarizing, guessing, comparing, and explaining are indicators of conceptual understanding. Affective, cognitive and psychomotor are Benjamin Bloom's three categories of learning outcomes.

Reasonable understanding is the second level in the mental realm which is the ability to repeat ideas or rules that have been learned and academic abilities. There are six levels in this cognitive domain, namely remembering, understanding, applying, analyzing, evaluating and creating. Of these six levels, a person must learn them slowly from easy to complex, if at the basic level a person cannot master them, he will have difficulty moving to a more complex mental level, namely applying, investigating, assessing and creating (Anderson, L.W., & Krathwol, 2010).

[1,2,3)] Physics Education, Faculty of Teacher Training and Education, Sultan Ageng Tirtayasa University, Indonesia
email: 2280200021@untirta.ac.id

The results of training cannot be separated from the teacher's task in managing the class, one of which is accuracy in using a learning technique so that it is successful in increasing students' conceptual understanding. According to Vygotsky, sociocultural constructivist learning theory can also interpret conceptual understanding. (Saricayir, H., Ay, S., Comek, A., Cansiz, G., & Uce, 2016) quoted Vygotsky as saying, "Learning builds various internal processes that can only run when children interact with people in their environment and by collaborating with their peers." According to Piaget's constructivist perspective (Hanne Søberg Finbråten a et al., 2022) on learning, information is constructed by people through what Piaget called osmosis and convenience. Because it involves changes to existing knowledge structures, the accommodation process can be considered a primary mechanism for conceptual change. It is important to probe students' prior knowledge and understanding to facilitate conceptual change.

Physics lessons in secondary schools are designed taking into account the characteristics of science, such as teaching students to observe, experiment, and think and act scientifically. This is based on the main goals of science and physics, namely observing, understanding, experiencing and interpreting natural phenomena related to energy and matter. Physics is a part of science that concentrates on the properties and characteristics found in inanimate objects (Ma'rifah, 2016). According to Minarty P (Nurdiansah et al., 2020), physics students study concrete and abstract natural phenomena as well as inanimate objects, with abstract concepts usually being more difficult to understand than concrete concepts.

One of the physics materials that is difficult for students to understand is waves. Waves are one of the class XI high school physics materials that are important to master and understand well. However, according to(Anik Istyowati, Sentot Kusairi, 2017), as many as 28% of students think that studying traveling waves and stationary waves is difficult, 26.67% think that studying thermodynamics is difficult, 21.11% think that studying mechanical waves is difficult, and 16.67% thought that studying sound and light waves was difficult. In (La Jumadin, Arif Hidayat, 2017), Serway & Jewett also argue that wave material is abstract. According to (Pablo Barniol & Genaro Zavala, 2017), students' conceptual understanding of mechanical wave material is very important. Therefore, a strategy is needed that can make it easier for educators to convey basic and clear wave material that is directly related to real problems in everyday life. With the aim that students can easily understand the concept of theoretical waves. One approach that can be taken is to incorporate wave material into teaching materials that can present an abstract object in three-dimensional visual form.

A good understanding of concepts will improve the quality of education. However, there are several other factors that influence learning in schools, such as teachers, students, the school environment, and the type of media used in the learning process. Learning media includes various real devices used to convey learning material, such as books, recording devices, cassettes, camcorders, video recorders, films, slides, photos, pictures, illustrations, TV and computers. Ultimately, learning media is one of the tools used by educators in delivering learning material(Pujiastuti, H., & Haryadi, R., Arifin, 2020).

Based on the results of the meeting with the 11th grade science subject educators, it was found that the learning experience in the classroom had used books, whiteboards, PDF modules and the use of Force Point media as media used to deliver learning materials. This can be seen from the learning outcomes obtained over the past few years in 11th grade science which showed that 47.0% of students in the mechanical wave material with the sub-material of the relationship between frequency, propagation speed, and frequency on rope waves did not understand well. Based on the results of interviews with students of class XI IPA SMAN 3 Pandeglang, the learning outcomes of mechanical wave material of class XI IPA students are relatively low. It is suspected that class XI students made conceptual errors when doing homework given by the teacher, which led to low learning outcomes. Differences in students' absorption and retention abilities are the root cause of low learning outcomes.

Augmented reality (AR) technology is currently being developed for Android-based learning applications. Expanded Reality is an application that combines current reality with the virtual world, either in two-layer or three-layer form, and simultaneously brings it into a shared habitat. Real-time content integration, where images from videos and information from computers are displayed simultaneously, is made possible by this combination of technologies.

The progress of Expanded Reality innovation has currently been applied in the fields of education and clinical considerations. The results show that with Expanded Reality innovation, professionals can be helped in carrying out their tasks (Pujiastuti & Haryadi, 2023).

According to (Pujiastuti & Haryadi, 2023), the advancement of Augmented Reality technology has resulted in the creation of a new environment where real and virtual objects are integrated at various levels. According to research by Alvarez-Marin and Velazquez-Iturbide, the use of Augmented Reality (AR) innovation can support a growing experience. The use of augmented reality in engineering education is demonstrated by the example of Alvarez-Marin and Velazquez-Iturbide. In the main model, AR is used to show special images.

Through augmented reality, students can see cross-sectional and 3D representations of the objects they have to draw. In the second illustration, augmented reality is used in an electronics lab. On a real circuit board, an augmented reality system is used to display virtual wires and components. AR also allows for the display of repair steps and analysis of electronic devices. Research by Alvarez-Marin and Velazquez-Iturbide shows that the use of augmented reality (AR) can increase students' interest and motivation by increasing their active participation in learning (Lyrath, F., Stechert, C., & Ahmed, 2023). The importance of learning resources based on the previous explanation. The use of the Expanded Reality (AR) application as a teaching material is carried out with the aim of further developing students' calculation understanding, in this study the researcher decided to use teaching materials through the Expanded Reality application. The selection of the Expanded Reality (AR) application is expected to further develop students' calculation understanding related to mechanical wave material.

METHOD

In this study, the Research and development research (Innovative work) was used, the innovative work strategy or in English Innovative work is an exploration technique used to create certain items, and test the feasibility of the item. On this occasion, only examples of innovative work strategies are given that can be used for social exploration, especially training(Sugiyono, 2013). Meanwhile, according to (Creswell, 2019) the meaning of development research is understood that "innovative work is a powerful methodology for further developing practice. This is the interaction used to create and approve instructive items.

Research Design and Procedures

Educational applications are developed using this type of research. The developed application is intended for and tested on grade XI IPA students because it is educational and effective for mechanical wave material. through a research and development model that uses the original ADDIE model by Robert Marible Branch. The exploration system is enhanced into 5 phases, namely Investigation, Planning, Improvement, Execution, Assessment (Al-Bulushi, A. H., & Ismail, 2017). The process of making learning media is depicted in the flowchart in the following figure:

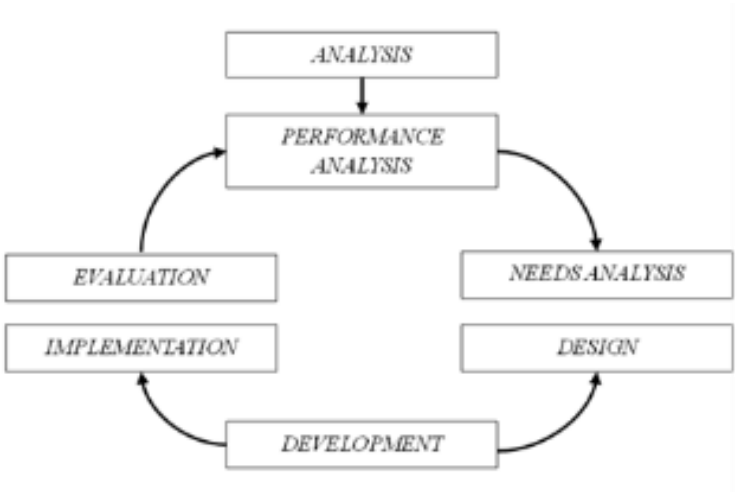

Figure 1. ADDIE Model Design Development of the ADDIE learning model

The use of the ADDIE model is a rule in building successful, robust preparation program tools and frameworks, and supports the implementation of the preparation itself (Sari, 2018).

1. Analysis
   Testing in the ADDIE model is the initial step of configuring the ADDIE learning framework model. According to Sari (2018), Peterson's statement, learning targets are the designer's main concern during this phase.
2. Design
   Configuration is the second step of the ADDIE learning framework configuration model. Configuration is done based on what has been planned at the exam stage. Syllabus creation is comparable to the design stage. (Ali, 2012).
3. Development
   The stages required to realize the product design are included in the development in the ADDIE model. At the planning stage, a calculation system has been prepared to run other learning models/techniques. The framework that is still conceptual is realized into a product that is ready to be used at the development stage. (Arifin, 2009).
4. Implementation
   The designs and approaches that have been created are then applied in real situations, especially in the classroom. The main objectives of the implementation stage are as follows:
   a. Directing students to achieve learning targets
   b. Ensure critical thinking or answers to address student gaps.
   c. Produce competency outputs in the form of knowledge, skills, and attitudes needed by students. After the strategy is implemented, an initial assessment is completed to provide criticism of the implementation of the next model/technique (Sari, 2018).
5. Evaluation
   Assessment is the final step of the ADDIE learning framework configuration model. Assessment is a cycle that is completed to provide benefits for improving the presentation of material in learning (Cahyadi, 2019).

Population and Sample

The population in this study were students of class XI IPA of SMA Negeri 3 Pandeglang who had studied mechanical waves. The researcher took two classes of XI IPA and several classes of XI IPA to be used as exam questions. This study used a purposive research procedure. This study used a questionnaire with ten questions given directly to students to collect data. The sample was 30 students.

Data Collection and Instrument

Data collection in this study used a questionnaire instrument in the form of questions consisting of several mechanical wave materials, as well as student and teacher response questionnaires to determine satisfaction with the use of learning media.

Data Analysis

Data testing with a Likert model assessment with the highest score given a value and the lowest score given a value of 1, with the help of the SPSS program version 26 for windows.

RESULT AND DISCUSSION

The The type of Exploration directed is Innovative Work (Exploration and Development), namely to obtain information related to the validity of the development of Augmented Reality-based learning media made by experts, as well as work to obtain information related to the level of applied understanding skills of class XI students of SMAN 3 Pandeglang towards the learning media created.

The TAMARinE application, which stands for Technology Application Mobile Augmented Reality Augmented Reality in Education, is the final result of the researcher's work. This application can be used on Android mobile phones to help grade XI students understand mechanical wave material. The learning media developed contains scanned images that produce three-dimensional images of various mechanical waves, both longitudinal and transverse waves. The media created uses the Expanded Reality method so that students can more easily learn

wave material and can find material in 3D and more real than 2D images. To encourage students to be able to recall the material that has been learned and apply it in the form of questions, both questions that are solved by analyzing formulas and cause and effect questions, the learning media developed has included example questions. This allows students to think indirectly and find the answers.

The following is an explanation of the findings of this study for each stage of development. Preliminary research has been conducted at SMAN 3 Pandeglang on learning media. Because this school still uses PPT and books as learning media, it is necessary to develop appropriate learning media to support learning and review previous research on the development of augmented reality applications. The design stage of TAMARinE: Mobile Augmented Reality Technology Application in Education which includes the introduction, content, and conclusion of the application began in November 2023. The Expanded Reality learning media base plan that was created is shown in table 1.

Table 1. TAMARinE Design: Technology Application Mobile Augmented Reality in Education as an Effort to Improve Students' Understanding of Concepts

Desain	**Keterangan**
Spesification product	The application size is 260 MB consisting of 5 menus, namely AR scan, materials, questions, application info, about the application. The application can be used offline without requiring the internet to connect to a smartphone.
Material	Mechanical Wave
Languange	Indonesia
Content	There are 5 menus in the learning media, AR scan, learning materials, questions, application info, about the application.

In general, the explanation of the description of the basic parts of Augmented Reality learning media is as follows:

1. TAMARinE Application Main Menu

Figure 2. Main Menu of TAMARinE Application

2. Instructions for Using Learning Media

Figure 3. Instructions for Use

This section contains a guide to using learning media that is made simple so that it is easy for students to understand.

3. Learning objectives

Figure 4. Learning Objectives

A description of the learning process and outcomes that students are expected to achieve.

4. AR scan

Figure 5. AR scan of TAMARinE

This section contains a scanner that can scan mechanical wave image objects, thus producing 3D images.

5. Material

Figure 6. TAMARinE Application Material

This section contains an explanation of the material regarding mechanical waves that can be studied by students.

6. Questions

Figure 7. TAMARinE Application Questions

This section contains questions that function as a stimulus for students' conceptual understanding of the material being studied.

Activities at the development stage are:

Media expert test

The introduction of the item is carried out with the aim of seeing whether an item is feasible to use or not before conducting exploration on students. In addition, the introduction of the item also sees the extent to which the goals and objectives can be achieved by the item created. The introduction of the item is directed by the media specialist and material specialist, specifically as follows:

Table 2. Summary of Media Expert Validation Results

Media Expert Lecturer	**Assesment Aspect**	**Indicator**	**Value**	∑	**Average**	**%**
Nofita Fajariyanti, M.Pd	Quality Aspects of Application Design	1	4	43	4,3	86%
		2	5			
		3	5			
		4	5			
		5	4			
		6	4			
		7	4			
		8	4			
		9	4			
		10	4			
	Aspect of visual communication	1	5	46	4,6	92%
		2	5			
		3	5			
		4	4			
		5	5			
		6	5			
		7	5			
		8	4			
		9	4			
		10	4			
∑ Overall			89			
Overall Average			4,45			
% Eligibelity			89%			
Categori			Very Worthy			

The assessment data as seen in Table 2 shows that the TAMARinE application obtained an average score of 4.45 or 89 percent. This places the results in the "very feasible" category based on the material expert validation criteria used to assess the level of validity of the presentation of the material in the TAMARinE application. The TAMARinE application was developed using an assessment instrument sheet consisting of three aspects, namely the aspect of content feasibility, the aspect of presentation feasibility, and the aspect of content feasibility. The data from the validation results of the material expert from the TAMARinE application for mechanical wave material are shown in Table 3.

Table 3. Summary of Expert Material Validation Results

Material Expert Lecturer	Assesment Aspect	Indicator	Value	∑	Average	%
Mustika, M.Pd	Aspect of content suitability	1	4	10	0,66	66%
		2	3			
		3	3			
	Aspect of content suitability persentation	1	4	27	0,77	77%
		2	4			
		3	3			
		4	4			
		5	4			
		6	4			
		7	4			
	Aspect of suitability persentation	1	5	15	0,75	75%
		2	3			
		3	4			
		4	3			
∑ Overall			52			
Overall Average			3,71			
% Eligibelity			74%			
Categori			Worthy			

After going through calculations and expert material test results, an average value of 3.71 and a success rate of 74% were obtained, so the results are included in the category of Eligible and meet the criteria for being quite valid.

1) Questionnaire test of class XII student responses

The data shows that TAMARinE-based learning media is very good for use in learning applications because more than 50% of respondents gave a very good response to Augmented Reality-based learning media based on the trial results of thirty class XII IPA 7 SMAN 3 Pandeglang students. Activities at the implementation stage are:

2) Pre-test Post-test Results

Students were given pre-test questions to determine their abilities before learning the TAMARinE Expanded Reality application. After being given Expanded Reality-based learning media, students were given post-test questions to determine their abilities after learning. Table 4 shows the average pre-test and post-test scores of students who received Augmented Reality-based learning materials.

Table 4. Average Results of Pretest and Posttest Scores

No.	Type of questions	Average value	KKM	Number of students who completed	Number of students who have not yet completed
1.	Pretest	59,3	78	9	21
2.	Posttest	80,6	78	19	11

3) Analysis of Student Understanding Improvement Test N-Gain

The gain formula is used to determine the student understanding improvement test. The addition test aims to determine the improvement that occurs during the test questions. The improvement in student understanding of the developed learning media is determined by the difference in pretest and posttest scores. The improvement test results obtained were 0.486 with a moderate classification. The final results of the addition test examination can be seen in table 5 below:

Table 5. Test N-Gain

	N	Minimum	Maximum	Mean	Std. Deviation
Ngain_Score	30	-0.50	1.00	0.4867	0.39208
Ngain_Percen	30	-50.00	100.00	48.6667	39.20767
Valid N (listwise)	30				

The activity in the Evaluation stage has a result of 0.48 with a moderate category based on the results of the gain test, which is also known as the test of increasing the ability to understand concepts. This shows that the TAMARinE application—Augmented Reality Mobile Application Technology Augmented Reality in Education—can improve the ability to understand concepts of students in grades XI and XII.

CONCLUSION

Based on the research and development that has been done, it can be concluded as follows:

1. The quality of the TAMARinE application: Technology Application Mobile Augmented Reality Augmented Reality in Education to provide an increase in students' conceptual understanding based on media expert validation obtained a feasibility percentage of 89% with an overall average score of 4.45 or included in the Very feasible category. While based on the validation of material experts, the feasibility percentage was 74% with an overall average score of 3.71 or included in the very feasible category.
2. Teacher responses to the use of Augmented Reality-based learning media on mechanical wave material to provide an increase in students' conceptual understanding abilities are in the very good category with an average result obtained of 4.43.
3. Student responses to the use of the TAMARinE application on mechanical wave material to provide an increase in students' conceptual understanding abilities are in the very good category with an average result obtained of 4.3.
4. The TAMARinE application can improve students' conceptual understanding abilities, as evidenced by the results of the gains test of 0.48, which is categorized as a moderate improvement.

SUGGESTION

The development of the TAMARinE application is still simple due to limited facilities or menus that can be accessed and the resulting 3D images are global or less detailed, so that the resulting learning media is still simple. There needs to be an increase in augmented reality-based learning media in various physics materials, so that it is not only limited to mechanical wave material. In addition, the TAMARinE application needs to be evaluated in various schools to determine its level of effectiveness in various educational environments.

REFERENCES

Al-Bulushi, A. H., & Ismail, S. S. (2017). Developing An Online Pre-Service Student Teaching System Using ADDIE Approach In A Middle Eastern University. Theory And Practice In Language Studies, 7(2), 96. https://Doi.Org/Http://Dx.Doi.Org/10.17507/Tpls.0702.02

Ali, S. Dan K. (2012). Evaluasi Pembelajaran. Universitas Negeri Makassar.

Anderson, L.W., & Krathwol, D. (2010). Kerangka Landasan Untuk Pembelajaran, Pengajaran, Dan Asesmen. Pustaka Belajar.

Anik Istyowati, Sentot Kusairi, S. K. H. (2017). ANALISIS PEMBELAJARAN DAN KESULITAN SISWA SMA KELAS XI TERHADAP PENGUASAAN KONSEP FISIKA. PROSIDING SEMINAR NASIONAL III TAHUN 2017, April, 237–243. http://Research-Report.Umm.Ac.Id/Index.Php/

Arifin, Z. (2009). Evaluasi Pembelajaran (Vol. 8). Bandung: Remaja Rosdakarya.

Cahyadi, R. A. H. (2019). Pengembangan Bahan Ajar Berbasis ADDIE Model. Halaqa: Islamic Education Journal, 3(1), 35–43 https://Doi.Org/Https://Doi.Org/10.21070/Halaqa.V3i1.2124

Creswell, J. W. (2019). Research Design Pendekatan Metode Kualitatif, Kuantitatif Dan Campuran. Pustaka Pelajar.

Febriana Ramadhan, Sodikin, U. F. (2019). Hubungan Kompetensi Pedagogik Dengan Kreativitas Guru. SOSIO DIDAKTIKA: Social Science Education Journal, 6(2), 126–133.

Hanne Søberg Finbråten A, B, H. K. G., A, K. S. P., C, C. F., & A, Ø. G. (2022). Nursing Students' Experiences With Concept Cartoons As An Active Learning Strategy For Developing Conceptual Understanding In Anatomy And Physiology: A Mixed-Method Study. Nurse Education In Practice, 65, 1–11. https://Doi.Org/Https://Doi.Org/10.1016/J.Nepr.2022.103493

La Jumadin, Arif Hidayat, S. (2017). PERLUNYA PEMBELAJARAN MODELLING INSTRUCTION PADA MATERI GELOMBANG. Jurnal Pendidikan: Teori, Penelitian Dan Pengembangan, 2(3), 325–330 http://Journal.Um.Ac.Id/Index.Php/Jptpp/

Lyrath, F., Stechert, C., & Ahmed, S. I. U. (2023). Application Of Augmented Reality (AR) In The Laboratory For Experimental Physics. Procedia CIRP, 119, 170–175 https://Doi.Org/Https://Doi.Org/10.1016/J.Procir.2023.03.089

Ma'rifah, M. S. (2016). Pengaruh Penerapan Media Power Point Dalam Pembelajaran Fisika Terhadap Prestasi Belajar Fisika Pokok Bahasan Listrik Dinamis. Jurnal Ilmiah Pendidikan Fisika-COMPTON, 3(1), 96–103. https://Jurnal.Ustjogja.Ac.Id/Index.Php/COMPTON/Article/View/677/1029

Nurdiansah, I., Islami, F. H., & Nana. (2020). PENERAPAN MODEL POE2WE TERHADAP PEMAHAMAN KONSEP FISIKA MATERI GELOMBANG BERJALAN DAN GELOMBANG STASIONER. Edufisika: Jurnal Pendidikan Fisika, 5(1) https://online-journal.unja.ac.id/EDP/article/view/9027

Pablo Barniol & Genaro Zavala. (2017). The Mechanical Waves Conceptual Survey: An Analysis Of University Students' Performance, And Recommendations For Instruction. EURASIA Journal Of Mathematics Science And Technology Education, 13(3), 929–952. https://Doi.Org/10.12973/Eurasia.2017.00651a

Pujiastuti, H., & Haryadi, R., Arifin, A. . (2020). The Development Of Augmented Reality - Based Learning Media To Improve Students' Ability To Understand Mathematics Concept. Unnes Journal Of Mathematics Education, 9(2), 92–101. https://Doi.Org/Https://Doi.Org/10.15294/Ujme.V9i2.39340

Pujiastuti, H., & Haryadi, R. (2023). Enhancing Mathematical Literacy Ability Through Guided Inquiry Learning With Augmented Reality. Journal Of Education And E-Learning Research, 10(1), 43–50. https://Doi.Org/10.20448/Jeelr.V10i1.4338

Sari, B. K. (2018). Desain Pembelajaran Model Addie Dan Implementasinya Dengan Teknik Jigsaw. Prosiding Seminar Nasional Pendidikan, 87–102 http://Eprints.Umsida.Ac.Id/432/

Saricayir, H., Ay, S., Comek, A., Cansiz, G., & Uce, M. (2016). Determining Students ' Conceptual Understanding Level Of Thermodynamics. Journal Of Education And Training Studies, 4(6), 69–79. https://Doi.Org/Https://Doi.Org/10.11114/Jets.V4i6.1421

Sugiyono. (2013). Metode Penelitian Kuantitatif, Kualitatif Dan R & D. Alfabeta.