Development of Basic Biomedical Learning Model with STEAM (Science, Technology, Engineering, Art and Mathematics) Approach Based on Augmented Reality

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ABSTRACT

With a research design using the Research and Development method, the aim of this research is to develop a Basic Biomedical learning model using a STEAM (Science, Technology, Engineering, Art and Mathematics) approach based on Augmented Reality. In developing the Basic Biomedical Learning Model, researchers used the development model from Hannafin and Peck, while in designing augmented reality software that was integrated with a marker-based encyclopedia, researchers used the Waterfall model. After designing and developing, the model and media were evaluated using Tessmer formative evaluation with 4 stages, 1) Experts Reviews, 2) On-to-One, 3) Small Group and 4) Field Test. The research subjects were 2nd semester students, Health Study Program, FIKES, Ibn Khaldun University Bogor on Human Anatomy Physiology material. In collecting data, researchers used interview techniques, data, questionnaires, tests, observation sheets and documentation. The results of media tests based on learning model development must meet the requirements for feasibility, practicality and effectiveness. So it is hoped that the results of testing the development of a Basic Biomedical Learning Model using the Augmented Reality-based STEAM (Science, Technology, Engineering, Art and Mathematics) approach can improve students' 21st century skills in biomedical practicum activities and student learning outcomes.

Keyword: Biomedical Basics, STEAM, Augmented Reality, 4D Marker-Based encyclopedia.

INTRODUCTION

At this time, the world is entering a new civilization called the Information Era 4.0, where technological developments are increasingly rapid, resulting in global integration and the unification of information exchange from all corners of the world which includes products, thoughts, views and other cultural aspects. Based on research in 2014 by UNESCO and KOMINFO RI, as many as 30 million Indonesian children and teenagers are internet users and digital media is the main choice for access to communication. Humans are required to carry out activities as effectively as possible, so technology plays an important role as one of supporting the effectiveness of human activities, especially in the field of education. In accordance with technological developments in the Industrial Era 4.0, educational institutions are starting to intensively innovate learning activities. Learning activities in each educational unit are expected to be based on technology and digital (Gatot S. Dewa Broto, 2017).

The development of the Industrial Era 4.0 and the Independent Learning-Independent Campus Curriculum (MBKM) which has entered higher education requires lecturers to carry out learning by utilizing various learning methods and media. In accordance with the concept summarized in the Independent Learning Curriculum, intracurricular learning must be maximized, teaching staff can choose and determine learning methods and tools that are tailored to their needs, so that learning content can be delivered more optimally to students. Apart from that, students have time to deepen concepts, strengthen competencies and develop soft skills and character in accordance with 21st century skills and the profile of Pancasila students who are characterized by learning and innovation skills, the use of ICT as well as life and adaptability skills which are currently being

applied to students in various College.

It is very important for students to have 21st century skills in this digital era, including the ability to think critically and creatively, problem solving and decision making, as well as a person's ability to work in a global and digital world. Students must be able to master technology, be able to communicate and work together and collaborate, both in groups or communities and individually (Trilling and Fadel. 2007).

The results of the initial analysis through observation and distribution of questionnaires conducted by researchers at the Public Health Study Program, Faculty of Health Sciences (FIKES), Ibn Khaldun University, Bogor, found that: 1) Basic Biomedical courses have obstacles in practicum learning, due to the lack of practicum media facilities; 2) Data on student grades for the last 3 years has decreased in the Basic Biomedical Course, because lectures were held online during the pandemic; 3) Information on the Quality Control Group (GKM) for Basic Biomedical courses has not shown learning activities that are fun, innovative and have not adapted to current technological advances; 4) Teaching lecturers do not utilize varied learning methods in delivering material, resulting in a decrease in the learning outcomes of Public Health students in Basic Biomedical Courses; 5) Entering face-to-face learning, a product is needed in the form of appropriate learning media to be able to motivate students in the learning process, both demonstrations and practicums; 6) The existence of the MBKM (Free Learning-Free Campus) program which requires lecturers and teaching staff to be able to provide fun and varied learning in accordance with technological developments in the Industrial Era 4.0; 7) The need to improve the quality of learning in accordance with technological developments in the Industrial Era 4.0; 8) The need to improve the quality of learning in accordance with technological developments in the Industrial Era 4.0; 9) The need to improve the quality of learning in accordance with technological developments in the Industrial Era 4.0; 10) There is a need to improve the quality of learning in accordance with student needs. 0; 7) The need to improve 21st century skills in FIKES Public Health students so they can adapt to current technological developments.

Before the Covid-19 pandemic hit, FIKES KesMas always implemented a face-to-face (offline) learning system supported by a Wifi network and other learning media, however, when learning was carried out fully online because of the Covid-19 pandemic, it showed a decrease in student learning motivation which affected their grades and Their learning outcomes have decreased, which is shown in student learning outcomes data over the last 3 years.

Data on the average score of FIKES UIKA KesMas students in the Basic Biomedical course with Human Anatomy and Physiology material in the last 3 years is presented in table 1, as follows:

Table 1. Basic Biomedical Average Scores for the Last 3 Years

Value	Average rating		
	Year 2020 (38 people)	Year 2021 (27 persons)	Year 2022 (42 people)
UTS	75	69	67
Assignment	78	72	72
UAS	80	75	70

Table 1 explains the data that the average score of FIKES students in Basic Biomedical Courses in the last 3 years has been below 75, especially during online lectures. From the results of the initial analysis, namely interviews with lecturers, the decline in student grades in the Basic Biomedicine Course was caused by the use of learning models that were still conventional, in the sense that lecturers predominantly used the lecture method, and rarely used varied learning media, so that the acceptance of the material to students was somewhat limited. abstract and difficult to understand. Likewise, the results of interviews with several Public Health (Kesmas) students showed that practicum learning tends to be monotonous and reduces student learning motivation, which causes student learning outcomes to decrease.

Biomedicine will literally become abstract if you don't use visual media in practical activities, so interactive learning media is needed to provide meaningful understanding and skills to students. Apart from that, following the globalization of increasingly modern times, the application of technology in learning is deemed necessary to maintain its existence in the fields of science and technology. Seeing this gap, the focus of the problem is on Basic Biomedical learning with its practical learning system in the field of science. There needs to be special treatment by implementing a new learning model that is able to overcome student learning problems. The Biomedical field not only facilitates Mathematics and Natural Sciences learning but also improves students'

cognitive, affective and psychomotor knowledge. The role of the Biomedical field in the learning process has changed the way students adopt learning from curriculum, models to technology-based learning media (Makaramani, 2015).

Answering the problems above, this is what underlies researchers to develop a Basic Biomedical Learning Model with a STEAM approach based on Augmented Reality, which is suitable to answer gaps in Human Anatomy and Physiology material. The Basic Biomedical Learning Model in this case links 5 fields of knowledge, namely 1) Science in the field of learning studies, 2) Technology in the application of AR media software and hardware, 3) Engineering as the use of medical tools to analyze anatomy, 4) Art in visualization Anatomy and Physiology images, audio and animations, and 5) Mathematics in calculating the process of walking and forming anatomy.

Contextual learning using the STEAM approach invites students to understand phenomena that occur nearby, students will develop the nature of collaboration, cooperation and communication because the learning process using this approach is carried out in groups (Yakman in Tritiyatma, 2017: 5). There are five components contained in STEAM, the first is problem solving through innovation and design. Second, the relationship between assessment, plans and standards in learning. Third, the combination of more than one subject and its use in art. Fourth, process-based learning and collaborative learning. Fifth, focus on the things that happen in life. This educational model is considered an innovation and an access point to all subjects, not just the subjects themselves.

Based on a review of published literature, quite a lot of research has been found to develop learning media such as the Basic Biomedical Learning Model based on Augmented Reality, but in this case it is more widely used among early childhood and elementary school students in science subjects. This Basic Biomedical Learning Model which is integrated with AR technology aims to stimulate children's brain development in the fields of science, technology, mathematics, engineering and art. Augmented Reality is a metaverse-based technology that synthesizes real and virtual imagery (Atmajaya and Dedy, 2017: 228). AR itself has three characteristics, namely interactive, namely increasing user perception and interaction with the real world, in accordance with real time and 3D.

Wardani, S. 2018 Journal of Informatics Dynamics, creating a learning catalog by utilizing AR technology for Javanese script. AR technology can display Javanese script objects in a simple three-dimensional form that can be seen thoroughly and can be used effectively in learning. The marker creations in the catalog are more attractive compared to the black and white markers. Saputra. 2019 in the Journal of Computer Science and Informatics, creating an AR application at the Bandung Geological Museum. This application helps visitors to obtain information about existing fossils and also helps the museum in facilitating limited space for fossil replicas. The use of AR is also implemented in the Bali museum, Radya Pustaka museum and Zoology museum. At the Bali museum, AR is used to make it easier for tourists to get information regarding keris and the process of summoning a keris. Information is displayed in the form of a 3-dimensional object.

Prasetya. 2018 National Symposium on Applied Technology, using AR to display information on collections of historical objects in 3-dimensional form for visitors to the Radya Pustaka Museum. Gonydjajal, R., 2021 at the National Scientific Seminar on Computer Systems and Intelligence, the use of the AR application at the Zoology museum in an interactive and interesting way conveys information related to collections and animal fossils in the museum so that application users are interested in visiting and studying animals in Indonesia through the museum. Based on several studies, information can be obtained regarding the use of AR as a medium to introduce an object globally to the public through various approaches and learning methods.

The Basic Biomedical Learning Model which is integrated into AR, can increase students' creativity and 21st century skills in carrying out practicums, because students have many intense opportunities to hear, see, feel, and collaborate with other colleagues and make it easier to learn and visually analyze real images virtually. That way, the stimulus process for students' visual development does not develop in one direction only and the learning method is not monotonous and students become motivated to find out more (Saputro, R.E. 2015).

The reasons for choosing the research title "Development of a Basic Biomedical Learning Model using a STEAM approach based on Augmented Reality" are: a) The use of AR media is one of the Basic Biomedical learning solutions for human Anatomy and Physiology material which in recent years has used learning models that are less innovative so that the learning value students decreased; b) Development of a Basic Biomedical Learning Model as integration into a Marker-Based AR Encyclopedia, as an effort to solve learning problems; c) AR technology that can be manipulated, students can further explore the objects displayed without needing to

carry large concrete learning media; d) The existence of a Basic Biomedical Learning Model will improve students' 21st century skills in practical learning; e) With the increase in 21st century skills in students, it is hoped that learning outcomes can improve which in the last 3 years have decreased. Visualization and interaction needs can be optimized by integrating Augmented Reality technology, which is closely related to the fields of Science and Education, one of which is Basic Biomedicine, so its use is very effective in the learning process.

THEORETICAL STUDIES

The mindset and elements included in the learning system strategy are illustrated through models discussed in the form of flow diagrams or designs. Learning models often outline the actions or processes required to develop productive, efficient and engaging learning experiences. This learning model, according to Morisson, Ross, and Kemp (2001), will help those who develop programs or learning activities to understand the theoretical framework better and use the theory to produce more useful and efficient learning activities. Learning models act as conceptual, management and communication tools to analyze, design, create and evaluate learning programs and training programs. In general, each learning system design has its own characteristics and variations in the processes and methods used. Variations are often seen in the terminology used. However, all design models have the same basic idea of trying to create high-quality learning programs.

Fausner (2006) is of the view that a learning program designer cannot create an effective learning program if he only knows one design model. Learning program designers must be able to choose the right design that suits the specific learning situation or setting. This requires good knowledge and understanding of learning models and how to implement them.

The Hannafin and Peck model is a direct learning framework that outlines the important stages in designing a learning system, so that it is easy to learn and effective for product development. The Hanafin and Peck model is one of several product-focused instructional design models.

As stated by Hanafin and Peck (1988:60), the stages involved in developing a multimedia virtual chemistry laboratory include three main phases: needs assessment phase, design phase and development and implementation phase. The waterfall method was developed by Winston W. In 1970, Royce used This term describes the process of creating a software product. The waterfall model, commonly known as the traditional life cycle, is a software development approach that highlights a methodical and sequential series of stages. It begins with identifying customer requirements and continues through planning, modeling, construction, and deployment, ultimately leading to ongoing support for the finished software. The waterfall model consists of five stages: analysis, design, implementation, testing, and maintenance.

STEAM (science, technology, engineering, arts and mathematics) is an interdisciplinary approach to education. Initially, there was only a STEM approach introduced by the United States National Science Foundation (NSF) in the 1990s. However, in its development and seeing current needs, the STEM approach developed into STEAM by adding artistic aspects to it. The definition of STEAM according to the Merriam-Webster Dictionary stated by Siantajani (2020) is that science is knowledge or learning about nature based on facts discovered through observation and experimentation. Technology is the application of science in the engineering sector and other fields to find practical solutions to various problems. Engineering is the process of applying scientific methods to the design and development of new goods or systems. Expressive arts include drawing, painting, sculpture, architecture, music, theater and dance are forms of expressive arts. Art enriches life by elevating our emotions and ideas above the routine things that occur in it. Science is the science of numbers, their operations, relationships, combinations, generalizations, measurements and transformations is known as mathematics.

To improve educational standards in the current Industrial Era 4.0, the education sector must continue to adapt to technological advances, especially in the field of application of information and communication technology. Metaverse Augmented Reality technology is one of the tools used in the learning process. The term "augmented reality" or "AR" refers to an environment in which the boundaries between the real and virtual worlds created by computers are blurred (Oranc & Kuntay, 2019). This system is more similar to the real world, so it is different from virtual reality (VR) which is completely immersive and artificial. With augmented reality technology, the physical environment will be digitally engaged. Data about objects and the surrounding environment can be entered into an augmented reality system, which will then present the information on a real-world display as if the data were genuine. AR has significant potential in both industrial applications and academic

research (Alahmari et al., 2019).

The use of Augmented Reality is able to bring the virtual world into a real environment, able to transform ordinary objects into 3D objects and display text, images, videos and simulations. AR can be an alternative learning media in higher education, because AR supporting tools use PCs, laptops, tabs and smartphones in the form of software. According to Mustaqim and Kurniawan (2017) the use of augmented reality as a learning medium has several advantages, including; 1) Interactive, 2) Effective, 3) Can be used widely in various media, 4) The number of objects displayed is limited, so object modeling is easy, 5) Easy to use. The effectiveness of AR as a learning medium makes it easier for teachers not to need to bring large learning media, teachers only need to bring an Encyclopedia Marker to the classroom and then the Marker will be read via a Smartphone camera to then display the 3D shape of the desired material. Efforts are being made to connect learning with today's rapidly developing technology through the use of AR in the learning process (Klimova et al., 2018).

RESEARCH METHODS

In this research, the approach used is known as research and development (R&D). Meanwhile, the approach used is qualitative and quantitative research. The activities in this research were carried out at the FIKES Public Health Study Program, Ibn Khaldun University, Bogor.

Research and development is an industry-based development model in which research findings are used to design new products and procedures. Field trials are then methodically conducted, assessed, and improved until the research findings meet previously established standards of quality, effectiveness, or other factors. Development research, according to Sugiyono (2009: 297), is a fundamental research activity that collects data about user needs (needs assessment), followed by continuous development activities that produce products and evaluate their efficacy.

The Hannafin and Peck Model and the Waterfall Model with Tessmer formative evaluation (Mixed Methods) are the development models used in this research. The Hannafin and Peck model is at the following development stages: 1) Analysis, 2) Planning, 3) Development and Implementation, 4) Assessment and Revision.
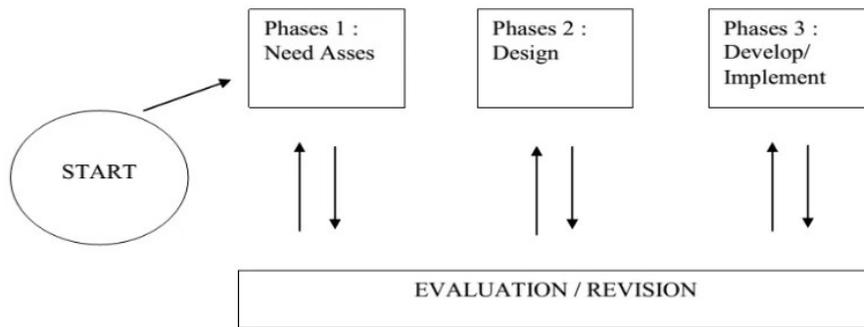

Figure 1. Hannafin and Peck models

In addition, the following waterfall model phases are applied: 1) Requirements definition and analysis 2) System and software design, 3) Unit testing and implementation, 4) System integration and testing and 5) Operation and maintenance.
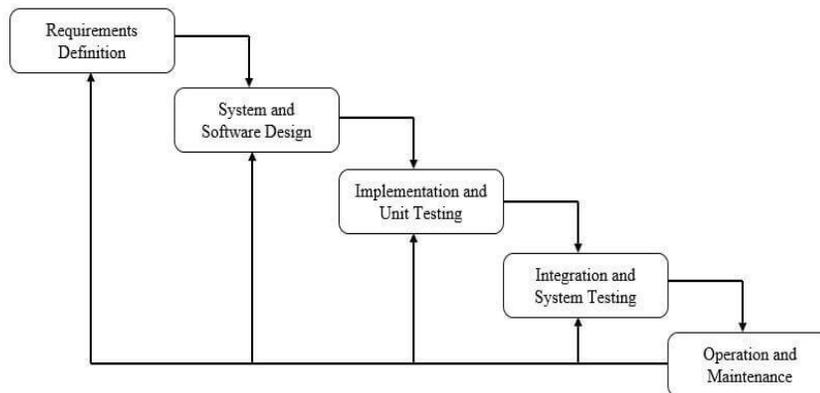
Figure 2. Waterfall Model

After carrying out the development plan for the Hannafin and Peck show and the Waterfall show, the next step was to assess the formative material presented in the form of an AR-based STEAM show in the form of a computer program. The development assessment used by Tessmer is based on stages:1) Self-Assessment, 2) Parent Survey, 3) One-on-One Assessment, 4) Small Group Assessment, and 5) Field Trial. Development assessments are carried out to measure the validity/feasibility and fairness of a media as well as the adequacy of the related media.

RESULTS AND DISCUSSION
a. Result

In this research, the data results were obtained based on tests of validity, practicality and effectiveness in developing learning models. These results were obtained from formative evaluation tests carried out at the Expert Review stage, namely instructional design experts, material experts, media and graphics experts, and language experts. Meanwhile, evaluations and trials are carried out in class, including one-on-one assessments, small group evaluations, and field trials. Overall, the results of the assessments from experts and class assessments of the Augmented Reality-Based Basic Biomedical learning model state that the learning model developed is included in the very valid and practical category. This is shown in table 1.3 as follows.

Table 2. Recapitulation of Formative Evaluation Results

No	Assessment Group	Average	Percentage (%)	Criterion
1	Instructional Design Expert	3,8	97%	Valid
2	Material Expert	3,28	82%	Valid
3	Media and Graphics Expert	3,7	92%	Valid
4	Linguist	3,5	87%	Valid
	Average	**3,57**		
5	*One-To-One* Evaluation	3,37	84,3%	Practical
6	*Small Group* Evaluation	3,59	89,7%	Practical
7	*Field Trial Evaluation*	4,89	97.8%	Practical
	Average	**3,95**		

Based on table 2 above, the root pvalue of Instructional Design shows an average value of 3.8 with a percentage of 97% valid criteria. The results of the root p value of the Material show an average value of 3.28 and a percentage of 82% with valid criteria. The results of the root p value for Media and Graphics show an average value of 3.7 and a percentage of 92% with valid criteria. Finally, the value of the planguage root shows an average value of 3.5 and a percentage of 87% with valid criteria. So it can be concluded that the results from 4 experts state that the learning model developed is valid. Next is a class evaluation assessment to see practicality.

Based on the results of the One-to-one assessment, it shows an average value of 3.37 and a percentage of 84.3% with practical criteria. The results of the Small group assessment show an average value of 3.59 and a percentage of 89.7% using practical criteria. In the final stage of formative evaluation, namely field trials, an average result of 4.89 and a percentage of 3.95% were obtained with effective criteria, after assessment measurements were carried out using pre-tests and post-learning tests. Overall it can be said that the Basic Biomedical learning model combined with the STEAM approach based on Augmented Reality can be applied and is beneficial for the learning process.

b. Discussion

The development of a learning model that incorporates augmented reality within the STEAM framework produces a model that is well defined conceptually, procedurally, and physically. The conceptual model of the augmented reality-based STEAM approach describes the provision of academic support or guidance from lecturers (tutors) to students (tutees). This support is aimed at facilitating students' independent learning, both individually and in groups, and connected to teaching materials, all achieved through the use of smartphone

technology. The procedural model created represents the phases (syntax) in the learning journey of the augmented reality-based STEAM method, which consists of six steps: introduction, presentation of information, questions and answers, evaluation of responses, feedback and improvement, and conclusion.

The findings of this development research show that the learning model using the STEAM approach based on Augmented Reality which was developed according to the results of expert assessments, including instructional design experts, material experts, media and graphics experts, and language experts, obtained an average score of 3.57, making it feasible to apply. Meanwhile, the average score obtained from student assessments in face-to-face, small group and field trials is 3.95, which shows that the established model is practically used in student assessment.

The developed Augmented Reality-based STEAM approach learning model has several advantages, including starting with a strong needs analysis through preliminary research involving study program heads, lecturers, alumni, and DU/DI as well as students, using a combination of Hannafin and Peck learning design models and Waterfall, has a clear learning syntax, various reaction principles, social systems, and STEAM approach support systems, AR applications, and Marker-Based Encyclopedias, and the resulting models are tested through formative evaluations by experts, face-to-face evaluations with students, groups small scale, and field trials. The challenge in implementing the learning model developed is that students' motivation for independent learning must remain strong, it must be supported by the availability of internet technology, and the blended learning system requires lecturers to actively evaluate student learning outcomes periodically. Supporting factors for success in developing and testing this learning model are support from Ibn Khaldun University Bogor institutions such as the chancellor or vice chancellor, faculty and Public Health study program, the willingness of lecturers who teach Basic Biomedical courses as sources of data and information and the existence of institutional collaboration with other parties. external or DU/DI as well as support from students causes the process of developing learning models and evaluating models to run smoothly.

The effectiveness of the learning model developed was evaluated by analyzing pre-test and post-test data. A summary of the pre-test and post-test results regarding student learning outcomes shows an increase, based on table 3 below:

Table 3. Student Learning Completion Results

No.	Respondents	Average Pre-test	Completion	Average Pos t-test	Completion
1	Agung Surya	90	Complete	86	Complete
2	Akhmad Al Fakhri	58	Incomplete	76	Complete
3	Akhmad Eka Sihabudin	55	Incomplete	90	Complete
4	Alya Ariani	50	Incomplete	84	Complete
5	Andini Salsa	30	Incomplete	90	Complete
6	Annisa Shofia Rani	85	Complete	90	Complete
7	Annisa Luthfiani	20	Incomplete	84	Complete
8	Azzam Sahrul	60	Incomplete	83	Complete
9	Deviana Maulidia	80	Complete	86	Complete
10	Farid Fadillah	60	Incomplete	83	Complete
11	Fathan Kamal	65	Incomplete	85	Complete
12	Helmalia Rahman	65	Incomplete	80	Complete
13	Jihan Aura	65	Incomplete	80	Complete
14	Khudri Assidiqi	55	Incomplete	80	Complete
15	M. Ghaots Janan	58	Incomplete	78	Complete
16	M. Zahran Aditama	75	Complete	90	Complete
17	Mahesa Subakti	50	Incomplete	79	Complete
18	Mery Handayani	80	Complete	83	Complete
19	Nabiilah Shafiyah	95	Complete	82	Complete
20	Nabilah Silfani	45	Incomplete	83	Complete

21	Princess Alpina	65	Incomplete	85	Complete
22	Puspa Ayuningtyas	78	Complete	89	Complete
23	Rasti Musdalifa	45	Incomplete	86	Complete
24	Salsa Delia	70	Incomplete	88	Complete
25	Siti Nurhalizah	55	Incomplete	90	Complete
26	Thoriq Ibn Anwar	75	Complete	85	Complete
27	Yuliza Prime	45	Incomplete	83	Complete
28	Zaki Romdon	50	Incomplete	84	Complete
	Average	61,67		84,35	

Based on the pre-test and post-test results, it can be seen that the average pre-test score does not meet the reference standard, namely 61.67, because only 8 students or 23.5% completed it. After students followed the augmented reality-based STEAM learning model that had been created, their post-test average score was quite high, namely 84.35, and many students completed it. Analysis of students' scores showed an average score of 22.68, ranging from 61.67 to 84.35, which shows their overall performance and level of completion. It can be concluded that the STEAM approach based on augmented reality has been effective in increasing learning outcomes, especially in terms of comprehensive understanding of public health students in basic biomedical courses. Post-test score data is used to assess the effectiveness of the learning model developed.

Max Value:100
Minimum value: 0
X_i =1/2 (Max + Minimum)
    = 1/2 (100-0)
    = 50
SBI = 1/6 (Max Value – Minimum Value)
    = 1/6 (100-0)
    = 16.67
Completeness criteria
    X > 80: Excellent
    $60 < X \leq 80$: Good
    $40 < X \leq 60$: Enough
    $20 < X \leq 40$: Less
    $X \leq 20$: Very Lacking
Value Classification :
    X_i + 0.6 SBI = 60
    X_i – 0.6 SBI = 40
    X > X_i + 0.6 SBI : Effective
    X $\leq$ X_i + 0.6 SBI : Ineffective
    Effective if > 60
    Not Effective if $\leq$40

Increasing the level of learning completeness during field trials is shown in figure 3 diagram as follows:
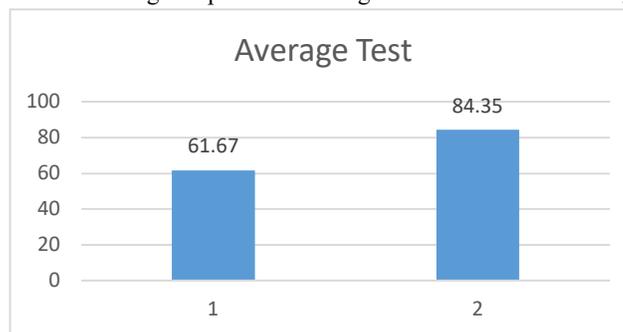

Figure 3. Learning Completeness Percentage Graph

The calculation results based on criteria and value classification can be seen in table 4 as follows:

Table 4. Results of recapitulation of criteria and classification of values

No.	Respondents	Average Pre-test	Average Post-test	Kriteria	Keffectiveness
1	Agung Surya	90	86	Very Good	Effective
2	Akhmad Al Fakhri	58	76	Very Good	Effective
3	Akhmad Eka Sihabudin	55	90	Very Good	Effective
4	Alya Ariani	50	84	Very Good	Effective
5	Andini Salsa	30	90	Very Good	Effective
6	Annisa Shofia Rani	85	90	Very Good	Effective
7	Annisa Luthfiani	20	84	Very Good	Effective
8	Azzam Sahrul	60	83	Very Good	Effective
9	Deviana Maulidia	80	86	Very Good	Effective
10	Farid Fadillah	60	83	Very Good	Effective
11	Fathan Kamal	65	85	Very Good	Effective
12	Helmalia Rahman	65	80	Good	Effective
13	Jihan Aura	65	80	Very Good	Effective
14	Khudri Assidiqi	55	80	Very Good	Effective
15	M. Ghaots Janan	58	78	Very Good	Effective
16	M. Zahran Aditama	75	90	Very Good	Effective
17	Mahesa Subakti	50	79	Very Good	Effective
18	Mery Handayani	80	83	Very Good	Effective
19	Nabiilah Shafiyah	95	82	Very Good	Effective
20	Nabilah Silfani	45	83	Very Good	Effective
21	Princess Alpina	65	85	Very Good	Effective
22	Puspa Ayuningtyas	78	89	Very Good	Effective
23	Rasti Musdalifa	45	86	Very Good	Effective
24	Salsa Delia	70	88	Very Good	Effective
25	Siti Nurhalizah	55	90	Very Good	Effective
26	Thoriq Ibn Anwar	75	85	Very Good	Effective
27	Yuliza Prime	45	83	Very Good	Effective
28	Zaki Romdon	50	84	Very Good	Effective
	Average	61,67	84,35		

Maximum value: 100
Minimum value: 0
X_i = 1/2 (max + min): 50
S_{bi}=1/6(max-min): 16.67

X_i +0.6 S_{bi}: 60
X_i – 0.6 SBI : 40

Based on the table above, the effectiveness of the learning model developed was 84.35%.

CONCLUSION

From the results of research carried out by researchers, several conclusions were obtained as follows:

1. The STEAM approach learning model based on Augmented Reality (AR) was developed using the research and development (R&D) research method, with research steps using the Hannafin and Peck research design model combined with the Waterfall model in developing learning materials.

2. The feasibility or validity of the model can be proven by the results of expert assessments and student assessments in formative evaluation. The expert assessment or Expert review produced an average score of 3.57, so that according to the experts the learning model developed was valid or suitable to be implemented. Furthermore, student assessments in class evaluations resulted in an average score of 3.95 on a scale of 5 (very good) so that according to students the learning model developed was practical to use.

3. The learning model was declared effective by looking at the increase in post-test scores from pre-test scores, and the level of student learning completeness. An increase in the average student score between the pre-test and post-test was obtained, namely from an average of 61.67 in the pre-test to 84.35 in the post-test, and the completion rate reached 84.35% (all 28 students got a post-test score above the standard, namely 75), so it was concluded that the learning model developed by the researcher was declared effective in improving student learning outcomes.

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