CHAPTER III
RESEARCH METHODOLOGY

3.1 Research Method

This research uses developmental research method. This developmental research was chosen because it has been defined as a systematic study of designing, developing, and evaluating instructional programs, process, and product (Richey, 1994). Therefore, this research method was suitable with this research objectives, which was to develop comic as a learning media. The model uses to develop AR-based flashcard is ADDIE model: Analysis, Design, Development, Implementation, and Evaluation.

The reason for choosing this development model is because it has a flexible framework and can be used for various types of product development. This is also as described by Soraya (2022) that this model can be utilized in the development of various learning components, including models, strategies, methods, media, and teaching materials. With a framework designed in the form of a continuous cycle that continues to develop from the planning stage to implementation. In addition, this model also allows for feedback based on ongoing assessments throughout the media creation process.

Furthermore, according to Spatioti et al. (2022), This model has several distinctive characteristics, namely clear stages, objectives that are based on the needs of students, an evaluation process that is measured by experts and valid. Based on the results of the needs analysis and the development of real behaviors to ensure the suitability of learning outcomes with the results of the initial analysis.

3.2 Research Design

This research uses the ADDIE model for developing digital flashcard media. In the procedure, this research collects quantitative data in the form of questionnaires and analyses the data statistically to test the research questions. ADDIE stands for Analysis, Design, Development, Implementation and Evaluation. Intentionally complicating the learning environment by responding

to different situations, interactions within context, and interactions between contexts is made easier by the application of ADDIE to learning system design (Branch, 2010) . However, this model is very good to use as a guide in building equipment and infrastructure for the program for implementing electronic learning media, namely effective and efficient in improving students' mastery of current student subjects (Uda et al., 2024).

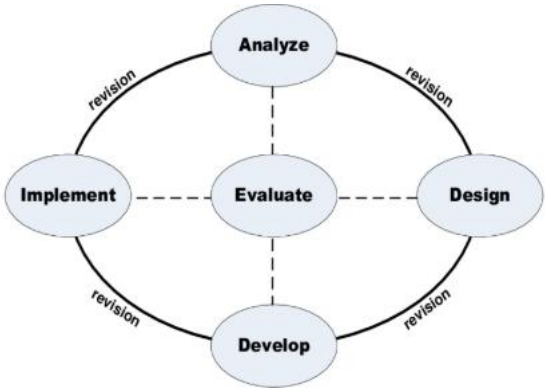

Figure 3.1: The Stage of ADDIE Model

Source: Panji (2022), ResearchGate

Based on Figure 3.1 the ADDIE (Analysis, Design, Develop, Implementation, and Evaluation) model process was used in the development of media or learning systems. Data were collected using product quality assessment form and student response form. The results from the product are used to evaluate the quality of the AR-based flashcard learning media being developed. While the students' responses aimed to discover the application of AR-based flashcard media in helping students understand the basic concepts of earth layer topic.

3.3 Participants

This research done in 8th grade students of Junior High School, also for all students that have been studying earth's layers topic. In total there are 35 students who involves in this research. While the expert's judgement that involve in this research are 3 (three) lecturer and 2 (two) teachers, that experts in the related fields that use in the AR.

While the sampling the researcher decides to use purposive sampling. Purposive sampling is a non-probability sampling technique in which participants are deliberately selected based on specific characteristics or criteria that are relevant to the research objectives. The sample are selected with certain consideration: (1) Students from 8th grade at Junior High School in Bandung; (2) School that facilitate the technology for learning or support the use of technology for learning, so students can access the AR.

3.4 Research Instrument

Experts conducted data collection in this study using assessment rubrics and questionnaires for students and teachers.AR-based flashcard were provided in the form of access links and cards, accompanied by a guidebook as a supporting tool for use. The assessment rubric used by experts includes assessment for use. The assessment rubric used by experts includes for data collection is used with the help of google form and review writing is at the end of the assessment which contains criticism and suggestions for future media development. The instrument and guidebook of this research can be seen in Appendix A. Detailed explanation is described as follows:

3.4.1 Observation Rubric

A research instrument is a means of gathering data. The researcher employed expert opinions and students' responses from the questionnaires to gather data from five research objectives.

A. Media Expert Judgement

A rubric with five criteria for judgement and a few indicators was used to present the expert opinion. A grading scale used for data collection; the rubric comprises a category or aspect, assessment gradient, score, and a comment section for recommendations or ideas about the educational materials. The Learning Object Review Instrument (LORI) v2.0 served as the model for thus rubric (Nesbit & Leacock, 2009). The adaptation

mapping of this rubric can be seen in Appendix A.1. The details of the questionnaire and the rubric shown in Table 3.1 and 3.2.

Table 3.1 Media Expert Judgement Questionnaire

Aspect	Indicator	Score				
		1	2	3	4	5
Accessibility	AR media can run smoothly on common device s (smartphones/tablets/laptops).					
Presentation Design	The placement of text does not cover important parts of the visual object/animation.					
	The font used is easy to read and consistent.					
	The text supports effective delivery of the material.					
	The layout of visual elements is well organized and not confusing.					
	The colours used are harmonious and not excessively flashy.					
	The colour contrast is sufficient for readability (especially the text and background).					
	Animation supports the delivery of material and does not distract attention.					

Aspect	Indicator	Score				
		1	2	3	4	5
	Visual Quality					
	The display quality of 3D objects (resolution, and detail) is quite good and does not break.					
	The display quality of 3D objects (resolution, and detail) is quite good and does not break.					
Content Quality	Information about the layers of the earth is presented accurately and scientifically					
Criticism and suggestions:						

Table 3.2 Rubric of Media Expert Judgement

No	Aspect	Assessment Gradient				
		1	2	3	4	5
		Worst	Poor	Enough	Good	Excellent
1	Accessibility	media is very difficult to access: it does not run on most common device, users are very annoyed by this constraint.	Media only runs on high-specification devices (does not run properly), and cannot be accessed on other devices	Media can be run on general devices, but sometimes there is light lag, delay loading on the initial menu	AR media runs smoothly on most common devices, but occasionally experiences slight lag or slow loading. It does not interfere with the user experience	AR media runs very smoothly on a variety of common devices (smartphones, tablets, laptops) without any issues (fast loading, no crashes, no lags)

No	Aspect	Assessment Gradient				
		1	2	3	4	5
		Worst	Poor	Enough	Good	Excellent
2	Presentation Design	Visual design is very poor: text covers important objects and is illegible, colours are inappropriate and garish, layouts are disorganized, animations are distracting. 3D display quality is very low and disrupts the learning experience.	Many design elements do not support the delivery of the material: text is difficult to read, colour are mismatched, layout is confusing. 3D quality is poor, often broken or fractured.	Some design elements are less effective. For example: text is not very clear, layout is a bit dense, colours contrast is not right. Animations are sometimes distracting. The 3D display is quite good but sometimes blurred or broken.	Most of the design elements are excellent. There are a few minor flaws (e.g. text slightly covering the animation, colours a little too flashy), but they do not interfere with understanding the material. The 3D visual quality is good, just a little blurry or lacking in detail.	All visual design elements are excellent: text does not cover important parts, it is easy to read and consistent, layout is neat, colours are harmonious and contrast is good. Animations support the material and are not distracting. 3D display quality is very good: sharp, detailed, not broken.
3	Content Quality	Information contains many fundamental errors and does	Information contains some misconceptions or misleading simplificat	Information is mostly correct, but there are one or two minor errors in	Information is accurate and scientific, but there is a slight	Information about the layers of the earth is presented in a very accurate,

No	Aspect	Assessment Gradient				
		1	2	3	4	5
		Worst	Poor	Enough	Good	Excellent
		not reflect a correct scientific understanding of the layers of the earth. Potential to mislead learners.	ions. Does not comply with scientific principles.	scientific terms or concepts. Explanations lack depth or are rather general.	lack of completeness or depth of explanation. Contains no errors, just lacks detail.	comprehensive and up-to-date science-based manner. There are no errors in concepts or terms. The language used is clear and appropriate for the learners' level.

B. Material Expert Judgement

The expert judgement presented in rubric that involved some indicators with 5 criteria judgement. Collecting data is using rating scale, the rubric includes category or aspect, assessment gradient, score, and comment space for suggestions or recommendations regarding the learning media. This rubric was adapted from the Learning Object Revies Instrument (LORI) v2.0 (Nesbit & Leacock, 2009). The adaptation mapping of this rubric can be seen in Appendix A.2. The comment and assessment are given for revision of the learning media by the developer. The details of the questionnaire and the rubric shown in Table 3.3 and 3.4.

Table 3.3 Material Expert Judgement Questionnaire

Aspect	Indicator	Score				
		1	2	3	4	5
Content quality	Depth of material presented in accordance with basic competencies					
	Suitability to the curriculum					
Alignment with Learning Objectives	Learning objectives are in accordance with the material displayed					
	Activities in AR support the achievement of basic competencies.					
Facilitating Learning	AR animation clarifies abstract concepts.					
	AR media provides relevant examples of the layers of the earth in everyday life.					
Criticism and suggestions:						

Table 3.4 Rubric of Material Expert Judgement

No	Aspect	Assessment Gradient				
		1	2	3	4	5
		Worst	Poor	Enough	Good	Excellent
1	Content quality	The material is not in line with the curriculum and far from the demands of the basic competencies. Very	The materials are not in line with the curriculum and do not adequately reflect the basic competencies. Depth	The material is appropriate in general, but not in-depth and only covers the core without further	The material is quite in-depth and in line with the curriculum, although there is a slight lack of	The material is in-depth and fully in line with the basic competencies and curriculum. Explanatio

No	Aspect	Assessment Gradient				
		1	2	3	4	5
		Worst	Poor	Enough	Good	Excellent
		superficial and irrelevant	of material is very limited	elaboration	coverage or detail	ns cover important aspects thoroughly
2	Alignment with Learning Objectives	There is no alignment between AR objective, materials, and activities. Does not support the achievement of basic competencies	Objectives are less relevant or not fully in line with the material, and AR activities are not clearly directed towards competencies	Objectives are appropriate to the material, but only some activities directly support the basic competencies	Objectives are appropriate to the material and most activities support the achievement of competencies, although not yet maximized	Learning objectives are very clear and all AR materials and activities fully support the achievement of basic competencies
3	Facilitating Learning	Animations are confusing or do not help understand the concept. No examples that relate the material to real life	Animations are less effective in explaining abstract concepts, and real-life examples are irrelevant or very limited	Animations are helpful in general, but explanations still lack concreteness. Daily life examples are present, but not strong enough	Animations are clear enough to explain abstract concepts and there are relevant examples, although they could be more varied or in-depth	AR animations are very helpful in explaining abstract concepts in a visual and engaging way. The media also presents examples that are very relevant to everyday life

C. Students Questionnaire

The student questionnaire is piloted to collect feedback from students after they learn to use digital flashcard media to facilitate mastery of the concept of earth layer material. The questionnaire rubric will be given to students with the following details in Table 3.5.

Table 3.5 Students' Questionnaire

Category	Statement	Score				
		1	2	3	4	5
Use of Concept	This media helps me master the concept of the layers of the earth					
	I feel more confident in mastering the concept of earth layers after using AR-based flashcards.					
	I can remember and apply concepts about the layers of the earth better after learning using AR-based flashcards.					
	I can explain the content of the material again after learning using the AR animation application.					
Visual quality	The visual elements are interesting and help me understand the material.					
	AR-based flashcards provide a more enjoyable learning experience.					

Category	Statement	Score				
		1	2	3	4	5
	Movement/animation on 3D objects runs smoothly and does not break					
Quality of content	AR-based flashcards are easy to use.					
	Images and animations help me understand the material					
Alignment with learning objectives	Activities in the app help me achieve learning objectives					
Motivation	I feel more enthusiastic about learning by using AR media					
	I really enjoy learning with the help of AR media					
Uses of Interaction	AR-based flashcards are easy to use.					
	The visual elements helped me understand the layers of the earth better.					
Presentation design	The typeface (font) used is easy to read and consistent					
	App display is attractive and easy to use					
	Sound from the media can be heard clearly					
Accessibility	AR media can run smoothly on common devices (smartphones/tablets).					

3.5 Data Processing Techniques

Rubrics of experts, teachers and students use data processing with different techniques. After the media was developed, researchers asked for the availability of experts to assess the media and provide criticism and suggestions for better media development. Experts fill out a rubric to validate the media and provide feedback and suggestions for improving AR-based flashcards. After the media was revised according to the input and criticism from the expert, the researcher conducted research at the school and gave questionnaires to students and teachers. Students will study with researchers using the learning media that has been developed, while the teacher also assesses AR-based flashcards and completes the questionnaire. The results of the teacher and student questionnaires will be processed by calculating the average of each aspect with the following formula:

$$\mathrm{X} = \frac{\sum x}{n}$$

The average percentage is interpreted using the criteria provided in Table 3.6 based on the computation above.

Table 3.6 Criteria of Average Percentage

Percentage	Interpretation score
0% - 20%	Very poor
21% - 40%	poor
41% - 60%	Acceptable
61% - 80%	Good
81% - 100%	Very good

Based on Table 3.6 there are five intervals which describe categories such as Very Good, Good, Fair, Poor, and Very Poor for the result of scoring.

The result of the expert rubric where analysis using Aiken's Validity theory (Aiken's V) for the eligibility of media. Aiken formulates the Aiken Validation formula to calculate the content-validity coefficient based on the results of a panel of experts as many as n people on an item in terms of the extent to which the item can represent the construct being measured. The Aiken formula used to assess the validity of the instrument is as follows.

$$V = \frac{\sum s}{n\,(c-1)}$$

In this formula, V is a validity index; s is the score of each rater minus the lowest score used in the category, in this case it becomes (s=r-lo, r = given score from rater, and lo = lowest score); n is the number of validators; and c is the maximum score in the category or number of categories obtained from the validator (Retnawati, 2016).

The validation value of the experts determines the level of validity of the learning media. The correlation category of learning media validity test can be seen in Table 3.7. (Dr.Riduwan, M.B.A.,2019)

Table 3. 7 Validation Value Criteria

Interval Score	Criteria
>0.80	High
0.60 – 0.80	Moderate
0 < 0.60	Low

Based on the Table 3.7 there are 3 criteria of validation value which described categories such as high, moderate, and low.

3.6 Research Procedure

As mentioned in the research method, this research and development will use the ADDIE (Analysis Design Development Implementation Evaluations) model. The ADDIE development model has five development steps, namely: (1) Analysis Stage, (2) Planning Stage, (3) Development Stage; (4) Implementation stage, (5) Evaluation stage, which is described in the following syntax:

3.6.1 Analysis Phase

The analysis stage aims to identify learning needs, problems, and characteristics of students as the basis for designing effective learning media. The needs analysis was conducted based on the author's experience in teaching the earth layer structure material in the previous

school year. additionally, the curriculum and subject matter were reviewed to ensure that the development media aligned with the expected competencies. Problem analysis was carried out to identify the gap between the current learning conditions and the predetermined learning objectives. Meanwhile, task analysis was conducted by breaking down the learning objectives into specific concepts and skills that students need to master.

3.6.2 Design Stage

The process at this stage focuses on careful planning and a clear understanding of the learning objectives to be achieved. To meet these objectives, the proposed solution is to develop Augmented Reality (AR)-based learning media in the form of digital flashcards. The design stage includes material verification, formulation learning objectives, creation of digital flashcard using the Assembler EDU platform, and the development of instruments such as expert assessment rubrics, teacher evaluation rubrics, and student response questionnaires for the completed media.

3.6.3 Development Phase

The development stage is the process of transforming the design into a ready-to-use learning product. This stage includes content creation, testing, and revision of teaching materials. According to Gustiani & Sriwjaya (2019), the development process must be carried out carefully to ensure that the product quality aligns with the design. This is in line with Zamsiswaya et al. opinion (2024) who states that the development stage plays a crucial role in determining the success of learning media. Validation is conducted by media experts, material experts, and science teachers through an assessment questionnaire to identify weaknesses and provide suggestions for improvement (Latief, 2009). In addition,

preparing guidelines for teachers is essential to ensure that the media can be used effectively.

3.6.3 Implementation stage

At this stage, researchers implement the developed learning media directly in the learning process. This stage is carried out in two phases, the first is content validity testing by learning media experts, subject content experts and learning design experts. The second is practicality testing by students. Successful implementation requires through preparation and readiness of the teacher to deliver the material effectively (Pernama, 2013). In addition, classroom conditions and technological support also need to be considered, as they can influence learning outcomes (Sugiyono, 2021).The results of this implementation will be used for evaluation at a later stage.

3.6.4 Evaluation Stage

At this stage, the evaluation is carried out in two stages of data analysis, namely quantitative data analysis and qualitative data analysis. Qualitative analysis is derived from experts suggestions and criticisms regarding the develop learning media, while quantitative data analysis is based on numerical data from questionnaire in the final feasibility test.

The procedure explained above is furthermore expressed by the research flowchart as shown in Figure 3.2:

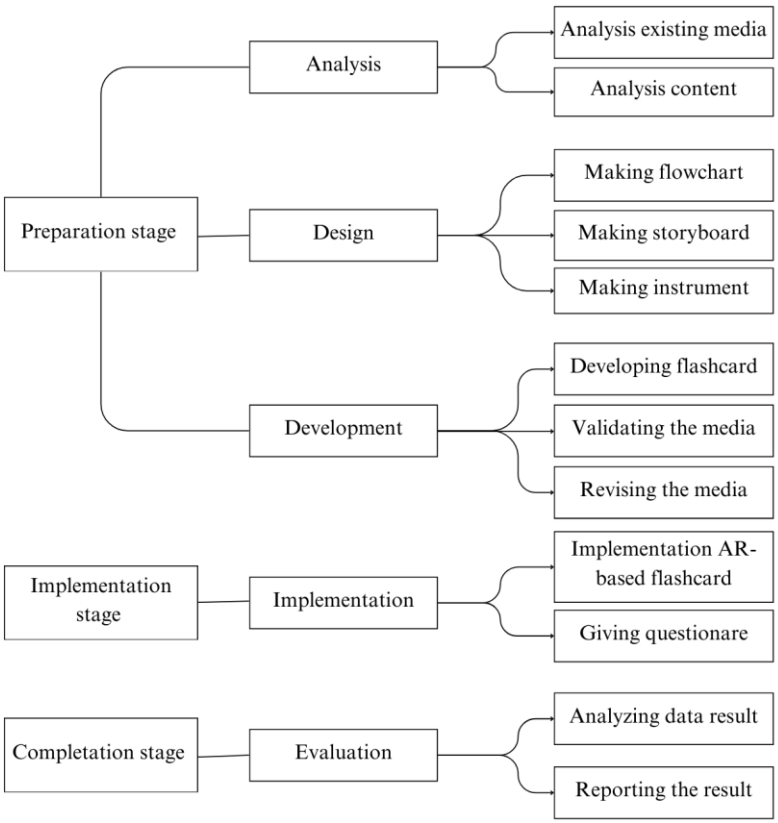

Figure 3.2: Flowchart of the ADDIE Process