THE PROTOTYPE OF ACCDR MODEL: M-LEARNING MULTIMEDIA DEVELOPMENT DESIGN MODEL STEM-BASED FOR THE ONLINE SCIENCE LEARNING

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Abstract
Online learning is learning carried out without face-to-face but supports the development of virtual academic mobility. It can be integrated with multimedia either in e-learning or m-learning. M-learning is a learning paradigm that takes advantage of developments in wireless and mobile technology. It is flexible, independent, and accessible anywhere and anytime. Integration of science and technology in multimedia m-learning becomes more comprehensive when combined with the principles of Science, Technology, Engineering, and Mathematics. STEM-based multimedia m-learning is developed using a specific development design model. The multimedia m-learning development design model is a structured framework or reference for developing multimedia m-learning. Some of the existing m-learning multimedia development design models do not fully cover the criteria for a suitable model for developing STEM-based multimedia m-learning. One solution that can be given is to develop a new model concept using the F2-O1-S1-A2 type model development procedure through literature studies. The instrument consisted of the model development matrices. Afterward, a STEM-based multimedia m-learning development design model for science learning consisted of five syntaxes, namely: analysis, concepting, design, development, and review. The ACDDR model is a linear diagrammatic-narrative procedural model which is then shortened to the ACDDR model and presented in a prototype form. The ACDDR prototype model is expected to be able to be used for the development of STEM-based multimedia m-learning in the 21st century learning.

Keywords: development design model, multimedia m-learning, science online learning, STEM

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Introduction

Online learning has been known since 1995 by using a Learning Management System (Singh & Thurman, 2019). It is flexible (Joosten & Cusatis, 2020) and supports the development of virtual academic mobility. In addition, it can minimize the cost of educational services and expand access to education (Aman et al., 2020; Larionova, Brown, Bystrova, & Sinitsyn, 2018; Muhaimin et al., 2019; Prasojo et al., 2020). Online learning is very suitable to be applied during the current Covid-19 pandemic. According to the circular from the Ministry of Education and Culture of Higher Education, number 1 states that all tertiary institutions are required to conduct distance learning during the Covid-19 pandemic as an effort to decrease the spread of the Covid-19 pandemic (Kemendikbud, 2020; Mukminin et al., 2020; Mukminin et al., 2020). The development of science online learning more broadly opens opportunities for multimedia integration (Muhaimin et al., 2019). Learning multimedia can be in online learning form, either e-learning or m-learning. Mobile learning is a method to break through the limitations of traditional learning (Georgiev, Georgieva, & Smrikarov, 2004; Prasojo et al., 2018; Sofwan et al., 2021;). So that it is more effective (El-Hussein & Cronje, 2010) and can be reached anywhere and everywhere (Peters, 2007).

The integration of science and technology into multimedia m-learning becomes more comprehensive when combined with the principles of Science, Technology, Engineering, and Mathematics (STEM). STEM is an integrated educational approach to solving problems (Breiner, Harkness, Johnson, & Koehler, 2012), and it can increase student motivation and learning outcomes (Becker & Park, 2011). The multimedia m-learning development design model is a structured framework or reference for developing multimedia m-learning (Prasojo et al., 2019). According to Trifonova and Ronchetti (2004), three things need to be considered consist of context finding, material management, content, and operational support. Development models that have been used previously include the Rudric and Cluric Problem Solving model (Mahazir, Norazah, Rosseni, Arif, & Ridzwan, 2015), then the R2D2 model (Jumaat & Tasir. 2013), the ADES model (Kim & Jin. 2015), the 4D model (Jazuli, Azizah, & Meita, 2017) and the Waterfall model (Taufiq, Amalia, Parmin, & Leviana, 2016) and others.

Some of the M-*learning* multimedia development design models have not fully covered the criteria for a suitable model to develop STEM-based multimedia m-learning that is needed along with technological advances. Therefore, it is necessary to develop a STEM-based multimedia development design model for science online learning, so the title of the literature review is "Prototype of ACDDR Model: Model of multimedia m-learning development design for science online learning".

Literature Review

Development design model

The development design model is a framework for designing multimedia learning, so it has proper references, flow, and development targets. The multimedia development design model is a learning program development procedure consisting of combining text, images, paragraphs, or learning materials that have been compiled and are interrelated (Van Merriënboer & Kester, 2014). It aims to create more effective and accessible learning products (Nazir, Rizvi, & Pujeri, 2012).

The m-learning multimedia development design model is a framework or reference for developing m-learning multimedia products consisting of several structured and sequential syntaxes and procedures. The multimedia development design model is implemented in the development of multimedia m-learning. According to Georgiev et al. (2004), m-learning can be classified based on the primary indicators, namely the type of supported devices and wireless communication used to access learning materials and administrative information. Van Merrienboer and Kester (2014) stated that there are several criteria for a good m-learning multimedia development design model, including the following:

1. There is an element of cognitive architecture from the designer, which is in the form of design elements from human cognitive work so that the resulting model contains a combination of human creativity and multimedia principles.
2. Containing elements of multimedia principles as the basic principles of combining images and words that can be understood by students (Mayer, 2009).
3. Goal-oriented, that is, the target of a development design model must be proper and objective.
4. Efficient is a beneficial value of a model in the product design process. Efficiency can be seen from the procedure of the multimedia m-learning development design model.
5. Attractive, the development design model will be better if it has particular characteristics, so it becomes more attractive to use.

M-learning multimedia

Mayer (2009) defined multimedia as a material presentation using words and pictures. According to Korucu and Alkan (2011), mobile learning is a distance learning model designed for educational needs using mobile devices that provides opportunities for students to learn independently both in terms of time and place. According to Udell and Woodill (2015), m-learning is a way to disrupt normal daily activities because using a mobile phone can change human activities, ideas, and thoughts to be more flexible. M-learning can make a shift in learning from face-to-face to a form of performance support. M-learning has become an inseparable component of educational technology in higher education learning. It can make the students easier to study learning material, collaborate, and share creative ideas among students along with the development of technology and the internet (Al-Emran, Elsherif, & Shaalan, 2016). Furthermore, Sarrab, Al-Sihhi, Al-Mantahari, and Bourdoucen (2018) also added that m-learning is a learning paradigm that utilizes developments from wireless and mobile technology to be applied in the learning process to develop student academic abilities through interactions between lecturers and students.

The following are some of the things that make STEM-based m-learning very important adopted from Udell and Woodill (2015):

1. M-learning makes users easier because it can be used every time and everywhere. Mobile phones are now commonplace because almost every community, including students, has had a mobile phone for daily activities. Therefore, the integration of m-learning in learning will be easier to implement.

2. Mobile is global, which is easily accessible by anyone. Ease of access to mobile phones increases the growth of mobile phone users in the world. Currently, there are more than 6 billion mobile phone users worldwide. In a third of countries in the world, mobile phones are not only used as a learning medium but can also be used to control water or electricity infrastructure.

3. M-learning can increase productivity and performance in life. Today, a successful business is not a widely known business by many people but more efficiently by developing business information through mobile learning, like adding a delivery feature to make it easier for consumers to get the goods they need.

4. M-learning can load more information. The information can be increased through mobile learning, and information packaged using mobile learning can be more accurate and efficient.

5. M-learning is contextual because, with m-learning, learning can take place instantly when people do other work. In contrast, e-learning must be prepared properly and takes more time since it has to do ILT (instructor-led training) in front of the computer.

6. M-learning is not too expensive, M-learning learning that does not require ILT (instructor-led training) can support optimal time and cost-effectiveness because the costs to develop m-learning will be less than traditional learning or other learning.

7. M-learning is reusable; Learning with m-learning can be accessed every time whenever the information is needed by the user. In addition, a type of m-learning learning media can be used by other users in the future so that no material is wasted or no longer used.

8. M-learning has high adaptability and speed, with well-designed mobile learning, the latest and updated information can be received quickly by users. It can be in notifications about the latest products or others obtained by simply updating the M-learning application.

9. M-learning can access the data updates easily, in traditional learning, training and learning are carried out directly and prepared in a definite time to be distributed to students. However, with mobile learning, updating and sharing information can be done by itself.

10. M-learning is convenient, unlike traditional learning that must be carried out in class with a definite schedule or e-learning with a personal computer, mobile learning is learning with convenience, so it can adjust to whenever the information is needed.

STEM

STEM which is an approach to learning that focuses on integrated content, involves practical work, uses innovative technological tools and procedures (Brown, Brown, Reardon, & Merrill, 2011). The STEM approach used in this review is the integrated STEM approach, which is an approach that integrates the four aspects of STEM in one product or learning (Ward, Fitzallen, Lyden, & Panton, 2018). The integration of multimedia m-learning in the principles of the STEM approach (Science, technology, engineering, and Mathematics) is a very comprehensive blend because it is by learning standards in the 21st century. STEM is an educational approach that integrates the fields of science, technology, engineering, and mathematics in one integrated unit to solve problems (Breiner et al., 2012). Then, learning carried out with the STEM approach can increase interest in learning and improve student learning outcomes (Becker & Park., 2011).

The following are the principles of the STEM approach that will be integrated into the components and sub-components of them-learning multimedia development design model:

a) Science, science is knowledge and understanding of scientific concepts and processes aimed at decision making, increasing critical thinking skills, problem-solving abilities, scientific investigation activities, and so on. Concepts in science include biology, chemistry, physics, economics, and others.

b) Technology, principles that involve technology in learning or learning products aim to improve creativity, communication, collaboration, and critical thinking skills in finding strategies for developing and evaluating technology (Zollman, 2012). The technology principle also demands novelty in the use of technology in learning. It is manifested in the form of designed, modeled, and developed from sources of knowledge so that it is more useful in learning (Hasanah, 2020).

c) Engineering, engineering is a procedure for developing technology through the designing learning products process. The design process is carried out using a detailed sequence of scientific stages. In the development of learning products, activities related to engineering can be seen from the preparing product design activities, material preparation, and so on.

d) Mathematics, the mathematical principle applied in STEM is the relation or relationship between the four STEM principles themselves. Furthermore, the ability to read, listen, think creatively, communicate, solve problems and develop ideas to find new products or new works is a manifestation of mathematical understanding. Therefore, the principles of the STEM approach are needed to achieve a balance in the development of 21^{st} century learning.

Science online learning

Online learning is included in distance learning. Georgiev et al. (2004) explained that distance learning consists of e-learning and m-learning. Several essential elements in online learning applications are technology, application models (synchronous and asynchronous), selection of material concepts, so they do not overlap. Online learning is implemented during the Covid-19 pandemic (Singh & Thurman, 2019). Online learning is an alternative to learning during the Covid-19 pandemic. Some of the advantages of online learning are that it can facilitate learning using short videos, digital learning materials, interactive assignments, discussion forums, and learning quizzes (Sandars et al., 2020).

Online learning also requires several supporting things, such as a supportive learning environment, a particular curriculum, appropriate perspectives, interactions between students, professors, and students themselves, and not less essential is task-based learning (Hunt & Oyarzun, 2019).

Methodology

The method used for literature studies was the analysis of several sources in the form of national and international reputable journals, relevant books, and social media regarding multimedia development design models for M-learning applications for science learning during the Covid-19 pandemic. These data were primary, and literature search results were carried out through the web of sciences or Google Scholars. Furthermore, relevant articles were also collected from several scientific databases such as Science Direct, Elsevier, Wiley, Sage, Taylor, and Francis which have been indexed by Scopus. The synthesis method was carried out in a literature study regarding a STEM-based m-learning multimedia development design model concept. The main stage in this literature study was the conceptual development of a model. The development procedure used was the F2-O1-S1-A2 type with a comparison to the ADDIE concept (Branch, 2009). The model development procedure was as follows:

Collecting and analyze data

The collecting data process was by reviewing relevant literature related to theory. The data were obtained regarding the topic and problems of the literature study. Analyzing the data obtained from the previous literature was carried out by linking the ADDIE framework as a linear and complex framework for the construction of development design models. The data analysis process used development design matrices.

The matrices consisted of three matrices, namely 1) the summary matrix of the components of the M-learning multimedia development design model, this matrix consists of the main components syntax of each existing m-learning development design model arranged by grouping in the ADDIE component, 2). The matrix of the component analysis results of the M-learning multimedia development design model. This matrix consists of the main activities, elements, and the model separation based on the orientation of the learning or learning system, and 3). Matrix for the formulation of components and sub-components of the analysis results of the M-learning multimedia development design model consisting of the proposed main components and sub-components.

Coming up with a model idea

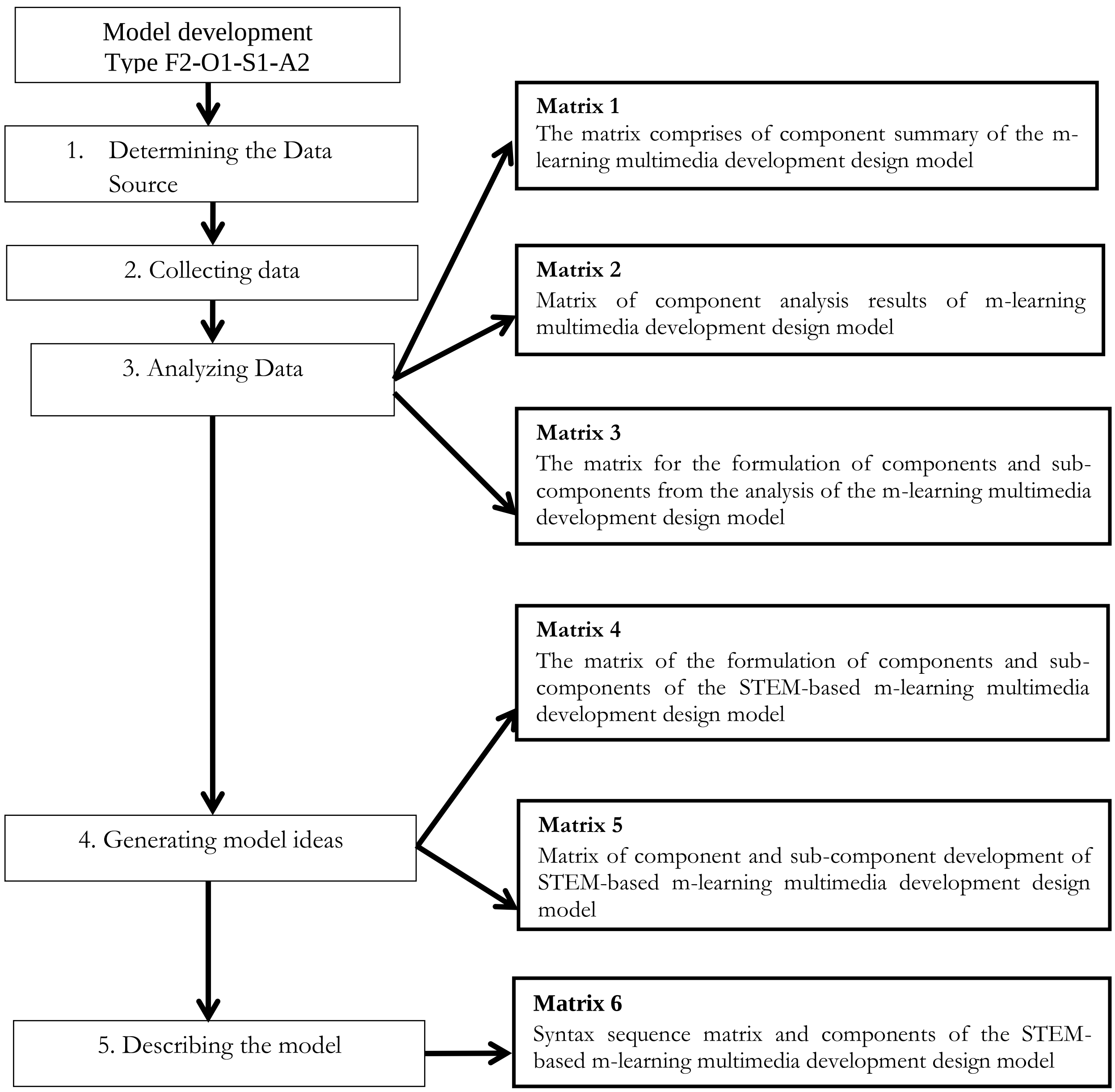
Generating model ideas by relating the procedural model components related to the main elements as a single process that has been previously analyzed. At this stage, there are two matrices used, namely, matrix 4 consisting of the formulation of components and sub-components by integrating the principles of the STEM approach. Furthermore, matrix 5, which is the development of components and main sub-components from the previous summary and analysis results, can be used as components and sub-components of the STEM-based m-learning multimedia development design model. These components and sub-components have novelty values or the result of adaptation from previous ones.

Describing the model

Creating a conceptual model through a flow diagram where the processes are interrelated according to the components that have been prepared previously. The conceptual model is then described according to its stages. In the last stage, there is a matrix consisting of syntax sequences, primary components, and main sub-components of the compiled STEM-based multimedia m-learning development design model. The development design model is then described in a diagram along with the description of its syntax.

The development design model is then described in the following flowchart:

Figure 1. *Flowchart of STEM based m-learning multimedia development design model*



Findings and Discussion

The design model for developing STEM-based m-learning multimedia is carried out using matrices according to the stages of development of the F2-O1-S1-A2 type model, as follows.

Table 1. *The summary matrix of M-learning multimedia development design model components*

Development design model	Main component of development design model	Grouping into ADDIE Components
Rudric & Cluric Problem Solving Model	Read & Think	Analysis
	Explore & Plan	Design
	Select a strategy	
	Find an answer	
	Reflect & Extend	Evaluation
R2D2 Model	Recursive	Evaluation
	Reflective	
	Design	Design
	Development	Development
ADES	Analysis	Analysis
	Development	Development
	Evaluation	Evaluation
	Solution	
Waterfall Model	Requirements definition	Analysis
	System and software design	Design
	Implementation and unit testing	Developing & Implementation
	Integration and system testing	
	Operation and maintenance	
4D	Define	Analysis
	Design	Design
	Development	Development dan Implementation
	Disseminate	

Table 2. *The matrix of component analysis results of m-learning multimedia development design model*

Main activity	Main element	M-learning multimedia development design model				
		System Oriented				Learning Oriented
		R2D2 (*Social & Behavioral Sciences, 2013)* (1)	**ADES** (*Computers & Education,2015)* (2)	**Waterfall** (Jurnal Pendidikan IPA,2017) (3)	**4D** (Jurnal Pendidikan IPA Indonesia,2016) (4)	**Rudric & Cluric** (*Social & Behavioral Sciences, 2015)* (5)
Analysis	Student needs for m-learning	Gather necessary information	Analyze problems from various aspects	-	Analyze the needs of students and teachers	Gather information through questions
	Determining the purpose of creating	-	-	Elaborating material related to the	Analyze problems on certain materials	-

	multimedia m-learning and content analysis			developed topic		
Design	Determine the type and criteria of m-learning	-	-	-	-	Explore and plan the right m-learning multimedia design
	Designing m-learning storyboards and m-learning validation instruments	-	-	-	-	Explore and plan the right m-learning multimedia design
	Integrating the principles of the STEM approach	-	-	Setting up software	Designing instruments for review by material and media experts	Choosing strategies and solutions related to multimedia m-learning
Development	Adding materials, images, animations and other supporting materials	Developing m-learning products	Developing m-learning multimedia	Developing m-learning by integrating the system	Prepare storyboards and flowcharts	-
	Validating multimedia display and m-learning content	Conduct expert reviews and feedback from users	-	Conduct material and media expert reviews	Conduct material and media expert reviews, individual and field trials and validity tests through dissemination	-
Implementation/ Evaluation	Conduct reviews and evaluations	Recheck changes from each stage if needed	Conduct field tests, test expert opinions and evaluate usage	Doing maintenance	-	Reviewing and reflecting on m-learning and the results of its implementation
	Make repairs recursively	-	Make improvements based on expert opinions	-	Make improvements after material and media expert reviews, individual and field trials and validity tests through dissemination	-

Table 3. *The matrix for formulating components and sub-components resulting from component analysis of the m-learning multimedia development design model*

Main activity	Main element (1)	Proposed Main Components (2)	Proposed Main Sub Component (3)
Analysis	Student needs for m-learning	Analyze student needs	Identifying learning problems related to m-learning needs
		Analyzing the characteristics of students	Identifying student abilities Identifying student learning styles and student learning interests
	Determining the purpose of creating multimedia m-learning and content analysis	Analyze material content	Identify material that is difficult for students to understand
		Analyzing the availability of m-learning multimedia support facilities	Analyze internet availability Identify the availability of students' smartphones Analyzing the type of smartphone of students
		Develop goals for making m-learning multimedia and create learning goals	Formulating the purpose of making m-learning multimedia according to the results of the previous analysis of student needs and making learning objectives
Design	Determine the types and criteria of m-learning	Determining the concept of m-learning	Determine which software to use Choose the type of m-learning based on multimedia or games
	Designing m-learning storyboards and m-learning validation instruments	Designing m-learning storyboards and selecting m-learning validation instruments	Develop a framework for m-learning storyboards and a grid of validation instruments and user testing instruments Develop storyboards and instruments
	Integrating STEM learning principles	Define STEM principles related to multimedia m-learning	Applying STEM principles adapted from STEM skills such as: adaptability, complex, consistent and critical in m-learning design in the form of interactive menus or buttons and others.
Development	Adding materials, images, animations and other support	Collecting materials and supports	Develop m-learning with the integration of materials and supporting facilities such as animation, video and so on. Integrating menus containing e-books, online discussion forum menus, as well as menus for online learning media, such as blogs or websites and YouTube. Checking m-learning
	Validating multimedia display and m-learning content	Conduct material and media expert tests as well as user trials	Validating m-learning with material and media expert tests Conducting trials of m-learning users (students)
Implementation/ Evaluation	Conduct reviews and evaluations	Reviewing and reflecting on m-learning	Reviewing m-learning according to the results of material, media and user trials
	Make repairs recursively	Recheck changes from each stage if needed	Ensure that the repairs made have been optimal.

Table 4. *Matrix for formulating components and sub components by integrating STEM principles*

Proposed Main Components (1)	Proposed Main Sub Component (2)	STEM Principles *Science (3)*	*Technology (4)*	*Engineering (5)*	*Math (6)*
Analyze student needs	Identifying learning problems related to m-learning needs	√	√	-	√
Analyzing the characteristics of students	Identifying the ability of students	√	-	-	-
	Identifying students' learning styles and students' learning interests	√	-	-	√
Analyze material content	Identify material that is difficult for students to understand	√	-	-	-
Analyzing the availability of m-learning multimedia support facilities	Analyze internet availability	-	√	-	-
	Identify the availability of students' smartphones	-	√	-	-
	Analyzing the type of smartphone of students	-	√	-	-
Develop the purpose of making multimedia m-learning	Formulating the purpose of making m-learning multimedia	√	√	√	-
Determining the concept of m-learning	Determine which software to use	-	√	√	-
	Choose the type of m-learning based on multimedia or games	-	√	√	-
Designing m-learning storyboards and selecting m-learning validation instruments	Develop a framework for m-learning storyboards and a grid of validation instruments and user testing instruments	√	-	√	√
	Develop storyboards and instruments	√	-	√	√
Define STEM principles related to multimedia m-learning	Applying STEM principles adapted from STEM skills such as: adaptability, complex, consistent and critical in m-learning design in the form of interactive menus or buttons and others.	√	√	√	√
Prepare materials and supports	Develop m-learning with the integration of materials and supporting facilities such as animation, video and so on.	√	√	√	√
	Integrating menus containing e-books, online discussion forum menus, as well as menus for online learning media, such as blogs or websites and YouTube.	√	√	√	√
	Checking m-learning	-	-	√	-
Testing material and media experts and users	Validating m-learning with material and media expert tests	√	√	-	√
	Conducting trials of m-learning users (students)	√	√	-	√
Reviewing and reflecting on m-learning	Reviewing m-learning according to the results of material, media and user trials	√	√	√	√
Recheck changes from each stage if needed	Ensure that the repairs made have been optimal.	-	-	√	-

Table 5. *The matrix for the development of stem-based m-learning multimedia development design components for science online learning*

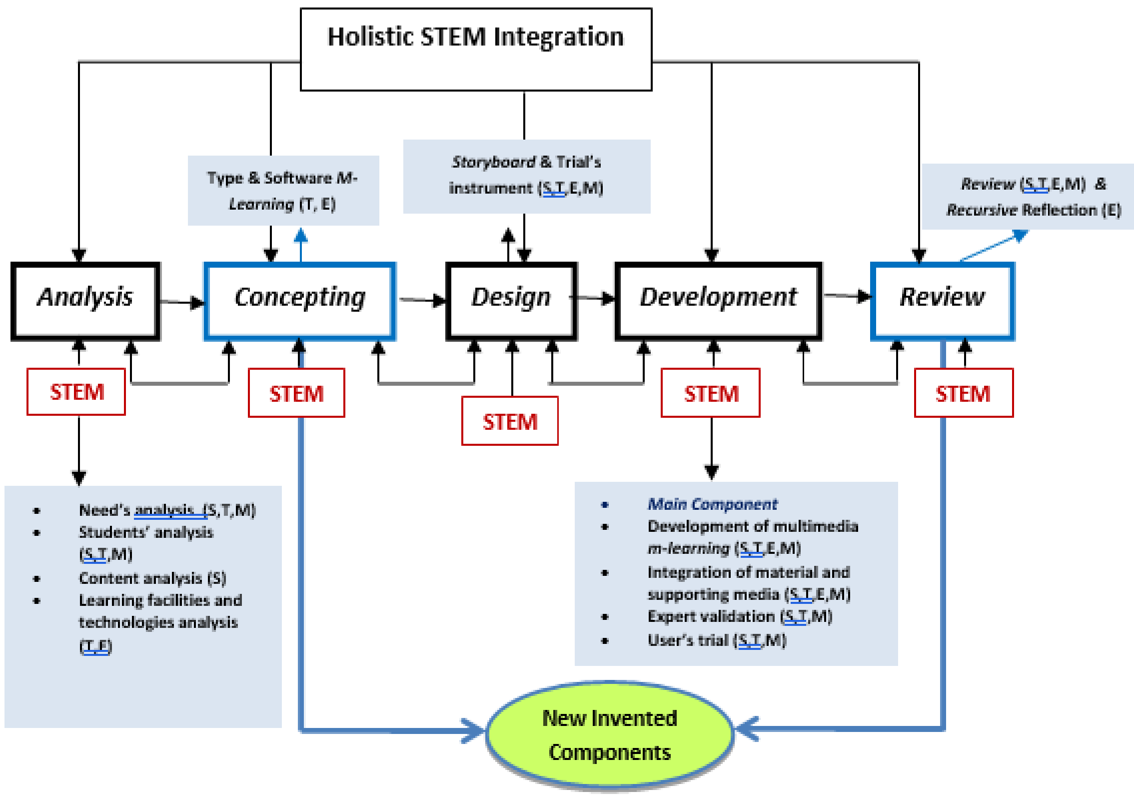
No.	Main Component (1)	Sub-Component Design Development Media developed (2)	Output/ Adaptation (3)	New (4)
1	Needs analysis	Identify problems	√	
		Identifying needs	√	
2	Analyze students	Analyzing the characteristics of students	√	
		Analyzing the abilities and interests of students	√	
3	Content/material analysis	Identify the material, KD, KI and learning objectives that will be developed	√	
4	Analyzing the availability of learning technology facilities	Analyze internet availability	√	
		Identify the availability and types of students' smartphones		√
5	Determining the concept of m-learning	Determine the type of software	√	
		Choose the type of m-learning		√
6	Design storyboards and instruments	Develop a storyboard framework and a grid of validation and test instruments	√	
		Designing storyboards with integration of STEM principles		√
7	Developing m-learning	Integrating materials and support in m-learning design	√	
		Integrating menus containing e-books, online discussion forum menus and online media menus		√
		Validating m-learning material and media experts	√	
		Perform user trials	√	
8	Do a review and reflection	Reviewing the results of expert validation and user trial results	√	
		Make repairs recursively		√

Table 6. *The sequence matrix of the basic components of the stem-based m-learning multimedia development design model for science online learning (ACDDR Model)*

No	Basic Components	Main Component (1)	Sub Component (2)
1	*Analysis*	1.1 Needs analysis	Identifying the problem Identifying needs
		1.2 Students analysis	1.2.1 Analyzing the characteristics of students 1.2.2 Analyzing the abilities and interests of students
		1.3 Content/material analysis	1.3.1 Identify the material, KD, KI and learning objectives that will be developed
		1.4 Analyzing the availability of learning technology facilities	1.4.1 Analyze internet availability 1.4.2 Identify the availability and types of students' smartphones
2	*Concepting*	2.1 Determining the concept of m-learning	2.1.1 Determine the type of software 2.1.2 Choose the type of m-learning Choose the type of m-learning
3	*Design*	3.1 Design storyboards and instruments	3.1.1 Develop a storyboard framework and a grid of expert validation instruments and user trials 3.1.2 Designing storyboards with integration of STEM principles
4	*Development*	4.1 Developing m-learning multimedia	4.1.1 Integrating materials and support in m-learning design 4.1.2 Integrating menus containing e-books, online discussion forum menus and online media menus 4.1.3 Validating material and media experts 4.1.4 Perform user trials
5	*Review*	5.1 Do a review and reflection	5.1 Conduct a thorough review 5.2 Make repairs recursively

The STEM-based multimedia m-learning development design model for science online learning has been designed starting from components and sub-components, and also practical explanations. Then, these components and sub-components are narrowed down into several primary syntaxes so that they are easier for users to understand by users of the STEM-based m- learning multimedia development design model for science online learning. The STEM-based multimedia m-learning development design model for science online learning is grouped into five primary syntaxes, abbreviated as the ACDDR (Analysis, Concepting, Design, Development, and Review) model. The name of the ACDDR model is taken from the first letter of each syntax to make it easier to pronounce. The following is a chart and explanation of the ACDDR model.

Figure 2. *ACDDR framework*



The ACDDR model consists of 5 syntaxes. First, synthesis analysis is the process of analyzing the components of the object of research and development of multimedia m-learning to obtain a strong, precise, scientific, and renewable basis. They consist of needs analysis, student analysis, content/material analysis, and analysis of the availability of learning technology facilities. Second, concepting syntax is the stage of determining the concept of multimedia m- learning. Concepting is done by adjusting the results of the first syntax, namely analysis. An essential aspect of this syntax is the type of multimedia m- learning to be designed determination. Designing, syntax design is the process of designing a multimedia m-learning framework. The main aspects that need to be designed consist of designing storyboards and instruments. The storyboard is a reference for M-learning multimedia products development and instruments designed to be used in expert validation and user trials later. Fourth, syntax development is a core stage consisting of the development of multimedia m- learning with the integration of materials, images, menus and other support based on the principles of the STEM approach. The next development stage is expert validation and user trials to see the response and feasibility of m-learning multimedia products. Fifth, syntax review is the completely reviewing process of the development stages from start to finish using a separate review framework. In addition, the steps taken from each syntax are the reflection. Reflection is carried out if some aspects need to be recursively revised at each stage.

Research on the design model for developing STEM-based multimedia m-learning for science online learning has contributed to the latest procedural model specifically for developing multimedia m-learning that is currently the main alternative in online learning (Joosten & Cusatis, 2020). The model is shortened to the ACDDR model (analysis, concepting, design, development, and review). Based on the results of critical analysis accompanied by a matrix, two new basic components are obtained which are called new invented components. The newly invented components consist of concepting and review components. The concepting component is a component found by the author and not adopted from previous models. This component aims to determine the right solution based on the results of the component analysis field. Determining the type and software of multimedia m-learning is the primary and essential thing in this component.
The second newest component is a formative and recursive review. A formative review is carried out at the end of the entire component stage, while a recursive review is to re-check the internal results of each component before proceeding to the next component. The recursive component was adopted from the R2D2 model (Jumaat & Tasir, 2013) which was then combined with the previous formative review. The ACDDR model has also been developed with holistic integration of the principles (Holistic STEM Integration). The principles of science, technology, engineering, and mathematics (Ward et al., 2018) are manifested in the components and sub-components of the ACDDR model that have been clearly explained in the previous fifth matrix.

The ACDDR model was compiled based on the criteria of the M-learning multimedia development design model adopted from Van Merriënboer and Kester (2014). The first criterion, the ACDDR model has been compiled based on the elements of the designer's cognitive architecture in the form of a combination of ideas and creativity of the designer on the concept design and the M-learning multimedia matrix. The second criterion is that the ACDDR model has been prepared by the multimedia m-learning principles adopted from Mayer (2009) in the form of sub-components for each component. The third criterion, the ACDDR model has been goal-oriented to serve as a guide and facilitate the production of STEM-based m-learning multimedia. The fourth criterion is that the ACDDR model is efficient because it consists of linear and detailed components, so the ACDDR model is more focused on m-learning. The fifth criterion is that the ACDDR model is attractive because the ACDDR model was developed by integrating STEM principles, so it becomes a separate value-added and is different from previous m-learning multimedia development design models. The ACDDR model that has been designed belongs to the type of procedural diagrammatic-narrative model. The ACDDR model is equipped with a separate diagram or model framework which explains each component. The ACDDR model was obtained from the theories of the existing m-learning multimedia development design model. The ACDDR model is linear and detailed and forms a detailed sequence.

Conclusion

The ACDDR model developed with type F2-O1-S1-A2 using six types of analysis can provide new references and references to the STEM-based m-learning multimedia development design model for science learning and other learning. Then, it is suggested to do model validation and then proceed with the ACDDR model application in the field to determine the effectiveness and practicality of the model.

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