Early Mathematics Module for Stem Learning with Flipped Classroom Concept Using Augmented Reality

Idris, H.[1]*, Md Nor, M.[2] & Abdul Rahman, M.N.[1]

[1]Fakulti Pendidikan, Universiti Malaya, Malaysia
[2]Faculty Pendidikan, Bahasa dan Psikologi, SEGi University, Malaysia
*corresponding author: ku_lissa78@yahoo.com.my
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Abstract

Early Mathematics is one of the critical subjects and the concept of learning should be introduced to students at an early stage so that there is no misunderstanding of the concept of this subject. Beginning in the 1970s, teaching methods have traditionally been more focused on the memorization of Mathematical concepts. This research aims to increase students' understanding of pattern topics in the subject of Early Mathematics by integrating the concept of Flipped classrooms with an Augmented Reality application known as the EM-Flip module. This research was conducted using a combination of the ADDIE model (Analyze, Design, Development, Implementation, and Evaluation) and DDR (Design and Development Research) techniques. In the first phase, open-ended questionnaire items were distributed to 60 TADIKA teachers and 60 parents. Document analysis of 25 students was carried out in TADIKA. The Delphi Fuzzy Technique was implemented in the second phase, involving 10 experts including early childhood experts, curriculum experts, ICT, Flipped Classroom experts, policymakers, theorists, and Early Mathematics experts. In the third phase, the TUP model from Bednarik was implemented to evaluate the usability and effectiveness of the modules. The findings of the study found that students were more engaged and showed their interest in class when they were given more opportunities to actively engage with the teacher. In addition to active learning in the classroom, the combination of technology also plays an important role in the flow of current learning methods.

Keywords: Flipped Classroom, Augmented Reality, Early Mathematics, patterns, Fuzzy Delphi

Introduction

Early Mathematics is one of the critical subjects and the concept of learning should be introduced to students at an early stage so that there is no misunderstanding of the concept of this subject. Beginning in the 1970s, teaching methods have traditionally been more focused on the memorization of Mathematical concepts. This research aims to increase students' understanding of pattern topics in the subject of Early Mathematics by integrating the concept of Flipped Classroom with an Augmented Reality application known as the EM-Flip module. This research was conducted using a combination of the ADDIE model (Analyze, Design, Development, Implementation, and Evaluation) and DDR (Design and Development Research) techniques. In the first phase, open-ended questionnaire items were distributed to 60 TADIKA teachers and 60 parents. Document analysis of 25 students was carried out in TADIKA. The Delphi Fuzzy Technique was implemented in the second phase, involving 10 experts including early childhood experts, curriculum experts, ICT, Flipped Classroom experts, policymakers, theorists, and Early Mathematics experts. In the third phase, the TUP model from Bednarik was implemented to evaluate the usability and effectiveness of the modules. The findings of the study students 'achievement in the subject of Mathematics is actually closely related to students' mastery of learning Early Mathematics while in kindergarten. Failure to master these basic concepts will greatly impact them while furthering their learning at the primary and secondary school levels. Memorization teaching techniques need to be given a new lease of life by recognizing the abilities of students to be helped by teachers so that learning sessions become interesting and effective and students can apply the methods of Mathematics in their daily lives.

Among the latest teaching methods mentioned in PPPM 2013-2025 is the teaching method through the concept of Flipped Classroom or better known as Flipped Classroom. Through the expansion of this method at the preschool level, the government is focusing on teaching and learning strategies, classroom layout, and parental involvement in the student learning process. Emphasis is also given to students' learning experiences in the 21st century where students are exposed to interactive, creative play activities and explore various mediums (Malaysia Education Development Plan 2013-2025).

The use of games and technology in education can encourage children's involvement in hands-on activities of a scientific nature (Ratchel Lechmann (2016). This means the use of technology can help to stimulate children to build their knowledge during the learning process. Flipped Classroom is This is because the Flipped Classroom concept that incorporates the use of technology will be a catalyst throughout the student learning process. Student-centered learning methods encourage active student involvement whether individually or in groups become more effective with the use of technology elements and activities as suggested through the actual Flipped Classroom method. Integrating technological elements in the development of Early Mathematics modules in the Flipped Classroom concept will stimulate students’ interest and positively impact the learning sessions. At the same time, students were more engaged and showed their interest in class when they were given more opportunities to actively engage with the teacher. In addition to the active learning in the classroom, the combination of technology also plays an important role in the flow of current learning methods.

There are several software and applications sold in the market for children to explore the learning of the subject. However, the best teaching materials implemented in applications that are on the market should be interactive, meet and in line with the curriculum in school, and in turn can contribute to student learning objectives (Nor Aizal, 2015; Nooriza & Effandi, 2015). In addition, an appropriate and child-centered pedagogical approach is also important where they explore teaching materials while being guided by teachers as well as encouraged to learn collaboratively to achieve learning goals, share ideas, and foster support among peers.

The first issue that became the focus of discussion was the level of qualification of teachers who teach the subject of Early Mathematics at the Early Childhood Education level. Teachers are important individuals who play a role in creating a meaningful learning environment as well as contributing to quality teaching and student learning success. Studies have shown that an important factor influencing student learning is quality teaching sessions. Pupils 'errors in interpreting basic concepts will give a different picture of the real meaning.

Issues that are also given attention are related to the method of teaching Early Mathematics. Early education is very important for the development of mathematical skills. This is because a good start in the subject of Early Mathematics is a determinant of student success while in primary, secondary, and higher levels (Nguyen *et. al*., 2016). The problem of inconsistent teaching and facilitation quality can also be seen when teaching and facilitation approaches are teacher-centered and students are less likely to think critically, creatively, and innovatively.

The level of students' mastery of pattern topics in the subject of Early Mathematics is also seen as an important issue in the study. Patterns are one of the topics covered in the Early Mathematics curriculum. Among the past studies that have been conducted related to the title of the pattern is on the need for students to master the concept of pattern or pattern to enable them to develop this concept at a higher level (Perry *et. al.,* 2015). A study conducted by Sharifah Norul Akmar and Nor Adlina (2014) has discussed the importance of pattern topics as a link to higher levels in Mathematics subjects such as multiplication, multiplication operations, and division. The researcher has stated five different dimensions and pattern arrangements based on the instrument adapted from the study by Gadzichowski (2012) which contains 25 items. The results of the study have found that students have difficulty in recognizing and connecting some specific pattern rules.

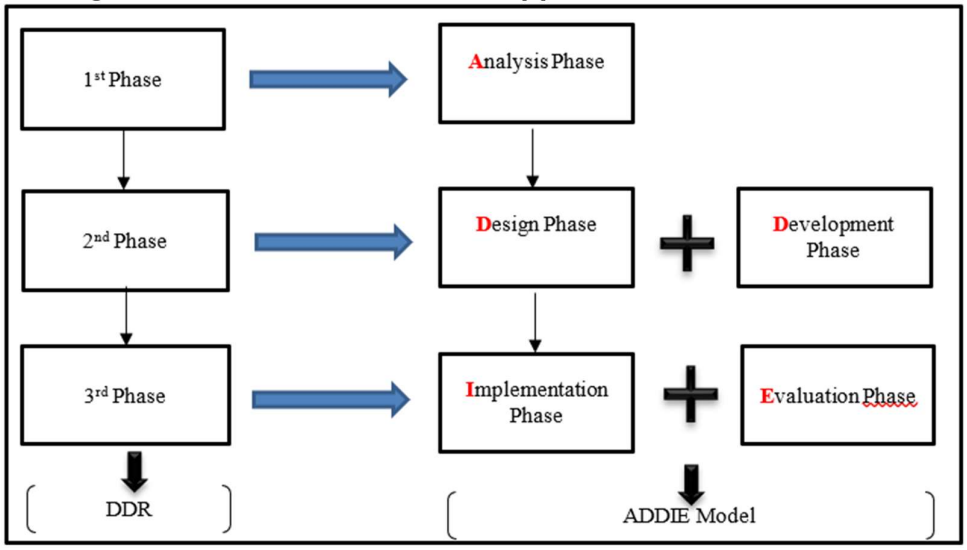
The objective of this study is to develop an Early Mathematics module based on the Flipped Classroom concept using an Augmented Reality application based on the ADDIE model combined with DDR.

Methodology

Research Design

The study design is a framework for data collection and analysis. The choice of study design will influence the results that will be given to the various methods of the research process. In this study, the study design used is based on the DDR approach combined with the ADDIE model that involves quantitative and qualitative data. According to Richey and Klein (2013), the study design for DDR consists of three main phases namely the needs analysis phase, module design, and development phase, as well as module usability evaluation phase. Figure 1 shows the DDR approach combined with the ADDIE model for this research.

Figure 1: Combination of DDR Approach with ADDIE Model



The entire development of this EM-Flip module uses a combination of ADDIE and DDR models. In the first phase, through the ADDIE Model at the needs analysis level, there are two studies implemented, namely the pilot study and the actual study. These studies were conducted to obtain approval to conduct a development study of this module. Researchers use descriptive data analysis by obtaining mean values and also analysis of student achievement records.

In the second phase through the ADDIE Model at the design and development stage, ten experts were appointed to seek agreement for the development of teacher manuals. The findings for the design stage are continued for the development stage where the aspects of hardware, software, and cost are also taken into account. The next process involves the application developer who develops the application using Augmented Reality i.e. Prototype 1. Review by researchers and feedback from information technology experts is used for the improvement of the production of Prototype 2.

The third phase through the ADDIE Model, which is the implementation and evaluation, involves three groups of respondents, namely teachers, students, and parents. In the implementation stage, the module is handed over to the respondents

based on the needs of the study findings. At the evaluation stage, the data were analyzed using the TUP Bednarik Consumption Model. The model involves unstructured questionnaires and questions are openly supplied to provide an opportunity for researchers to obtain information more comprehensively.

Research Analysis Method

The first phase uses the ADDIE Model, A, which is a needs analysis of a pilot study conducted to obtain the reliability of the items found in the questionnaire. After that, a process of data collection through the distribution of actual research questionnaires was conducted to obtain descriptive statistics of mean and standard deviation.

When the second phase was implemented using the ADDIE Model, D, experts in specific fields were involved to obtain consensus on the module design process. This is to ensure that the modules built can meet the needs of students and further meet the concept of Flipped Classroom which is one of the main focuses of the development of the EM-Flip module in this study. Field experts are selected through specific criteria and module design agreement is obtained through the Delphi Fuzzy Technique. Erten, .H., and M. Williams (2008) argue that the determination of criteria when selecting group members, the determination of the correct set of questionnaires, as well as the method of implementation of pilot studies can improve aspects of validity and reliability. Table 1 shows a summary of the validity and reliability of the research instruments used in the three phases of the development of this module.

Table 1: Validity and Reliability of Research Instruments

Phase	Instrument	Resource of validity dan reliability	Methodology
Need analysis	Teacher questionnaire items	Institute of Continuing Education & Professional Studies (iCEPS), UiTM.	Mix method
	Parental questionnaire items		Quantitative
	Analysis of student documents	Standard Pentaksiran Dalam Kurikulum Standard Prasekolah Kebangsaan (Modul Pentaksiran Perkembangan Murid Di Prasekolah, 2010)	Quantitative

Design and development	Fuzzy Delphi Method	Methods of literature review, validation of questionnaire items by field experts (early childhood education, curriculum and educational design, Early Mathematics, theory and practice experts, Flipped Classroom experts, a policy maker, and information technology experts), and adapted questionnaires from a literature review (Dullfield, 1993).	Quantitative
Implementation and Evaluation	TUP Bednarik	Adapted questionnaire items from Muhammad Nidzam Yaakob (2017), University Utara Malaysia.	Qualitative

The third phase through the ADDIE Model, D, is the module development process. In this phase, the development of Prototype 1 and Prototype 2 is underway. This is to ensure that respondents can use the EM-Flip module smoothly and provide the required findings. While the fourth phase using the ADDIE Model, I, involves the implementation process in which a total of 120 respondent's teachers, parents and 25 students were selected by purposive sampling technique.

The fifth phase using the ADDIE Model, E, is the consumer assessment phase. The evaluation of the developed modules was conducted to obtain usability evaluation through the TUP Consumerism Evaluation model by Niko Myller & Roman Bednarik (2014). Data were obtained through the distribution of questionnaires. All these processes are implemented to develop the EM-Flip module to enhance the teaching and learning process of Early Mathematics.

Results and Discussion

In the first phase, three components of respondents, namely teachers, parents, and students provide feedback that can meet the first research question, which is a list of module requirements for the development of pattern learning modules for Early Mathematics. Findings from teachers indicate that the existing modules need the

addition of training in the form of high-level thinking skills and the use of more interactive teaching aids. Findings from parents show that parental support in their

PAKAR	SUB KOMPONEN (JENIS ATURAN POLA)														
	Bentuk			Warna			Huruf			Nombor			Objek		
1	0.9	1	1	0.9	1	1	0.9	1	1	0.9	1	1	0.9	1	1
2	0.7	0.9	1	0.7	0.9	1	0.5	0.7	0.9	0.5	0.7	0.9	0.5	0.7	0.9
3	0.9	1	1	0.9	1	1	0.9	1	1	0.9	1	1	0.9	1	1
4	0.9	1	1	0.9	1	1	0.5	0.7	0.9	0.5	0.7	0.9	0.9	1	1
5	0.7	0.9	1	0.5	0.7	0.9	0.7	0.9	1	0.5	0.7	0.9	0.5	0.7	0.9
6	0.9	1	1	0.9	1	1	0.7	0.9	1	0.9	1	1	0.9	1	1
7	0.5	0.7	0.9	0.5	0.7	0.9	0.3	0.5	0.7	0.1	0.3	0.5	0.5	0.7	0.9
8	0.7	0.9	1	0.7	0.9	1	0.5	0.7	0.9	0.5	0.7	0.9	0.5	0.7	0.9
9	0.5	0.7	0.9	0.5	0.7	0.9	0.3	0.5	0.7	0.1	0.3	0.5	0.5	0.7	0.9
10	0.7	0.9	1	0.7	0.9	1	0.5	0.7	0.9	0.5	0.7	0.9	0.5	0.7	0.9
Purata Setiap Unsur	0.760	0.920	0.990	0.740	0.900	0.980	0.600	0.780	0.920	0.560	0.730	0.870	0.660	0.820	0.940
	m1	m2	m3	m1	m2	m3	m1	m2	m3	m1	m2	m3	m1	m2	m3
Nilai Threshold (d)	0.094			0.118			0.179			0.230			0.188		
Peratus Kesepakatan Pakar (%)	100			100			90			50			100		
Average Of *Fuzzy* Number (Skor *Fuzzy*)	0.873			0.857			0.747			0.700			0.807		

children's learning at home is still low, especially in understanding the needs of the KSPK curriculum. Finally, the respondents from the students where a total of twenty-five documents of students in TADIKA have been analyzed and researchers found that students are still weak in completing the training of constant and symmetrical interval patterns.

The findings in this design phase can be broken down into several parts. The first part involves expert agreement on the type of pattern arrangement. Table 2 shows the findings of the study for the types of pattern order based on the agreement of individual experts. These findings indicate the threshold value (d) for the sub-components and are based on analysis using the Fuzzy Delphi Technique (FDM). Some conditions must be met to receive the sub-components that have been listed:

a) Triangular Fuzzy Numbers
- Threshold value (d) ≤ 0.2
- Expert Agreement Percentage ≥ 75.0%

b) Defuzzification Process
-Fuzzy score (A) ≥ value α – cut = 0

Table 2: Threshold Value (d) Type of Pattern Rule Based on Delphi Fuzzy Technique Analysis

At this stage, there are five items listed and the threshold value results show only four pattern order type items that comply with the first condition of Triangular Fuzzy Numbers. The fourth item is removed from the content component. Table 3 shows the main items of the EM-Flip module based on the FDM analysis that has been implemented to obtain the percentage of expert agreement.

Table 3: Item Findings Type of Order Based on Expert Agreement

Type	*Triangular Fuzzy Numbers Rule*		*Fuzzy Evaluation Rule*				Expert Agreement	Order
	The threshold value, d	Percentage of expert agreement, %	m1	m2	m3	*Fuzzy score (A)*		
Shape	0.115	100.0%	0.786	0.929	0.986	0.900	Accepted	1
Colour	0.156	100.0%	0.757	0.900	0.971	0.876	Accepted	2
Alphabet	0.208	87.5%	0.643	0.814	0.929	0.795	Accepted	4
Object	0.192	100.00%	0.729	0.871	0.957	0.852	Accepted	3

There are five types of dimensions that have been listed by researchers to be evaluated by experts whether accepted or rejected. Findings from the expert consensus can be seen in Table 4 below.

Table 4: Dimension Type Findings Items Based on Expert Consensus and Fuzzy Scores

Subcomponent	*Triangular Fuzzy Numbers*		*Fuzzy Evaluation*				Expert Agreement	Order
	The threshold value, d	Percentage of Expert Agreement, %	m1	m2	m3	*Fuzzy Score (A)*		
Simple	0.212	90.0%	0.660	0.820	0.930	0.803	Accepted	2
Additional	0.203	90.00%	0.680	0.840	0.940	0.820	Accepted	1

There were two items accepted based on expert agreement namely simple and incremental dimension types. The Fuzzy score indicates that the first position for this pattern dimension is the incremental pattern dimension interval and then the simple pattern interval.

There are two products produced in this phase namely the teacher manual module and the AR application. Both of these products can be seen in Table 5 below:

Table 5: Products Produced in The Development Phase

No	Product	Methodology	Respondent
1	Manual of EM-Flip Module	FDM	Teacher
2	AR Apps	ADDIE Model	Parents and students

In summary, it was found that the TADIKA operators gave a positive response to the implementation of the EM-Flip module and this shows their openness to the

technological elements in early childhood education. Respondents from the teachers indicated that the implementation went well although there was some feedback received during the implementation period. After a period of three weeks given to the operator, this feedback was submitted to the researcher for evaluation purposes. The total period of this implementation is for thirty -seven days.

The findings of the study are analyzed based on the score scale of the findings of the student study based on training in the classroom after the use of AR application at home is shown in Table 6 below:

Table 6: Student Training Findings After Using AR Application

Activity	Item	Student's Number (N)			Total (N)	Percentage of Dominance (%)			Total Percentage of Dominance
		TM	SM	BM		TM	SM	BM	
Group Activity 1	Simple pattern	18	5	2	25	72	18	10	100
	Additional pattern	15	5	5	25	60	20	20	100
Group Activity 2	Simple pattern	17	6	2	25	66	22	12	100
	Additional pattern	5	9	11	25	15	40	45	100

The activities given to students are divided into two types of activities, namely group activities 1. In this activity, students are required to complete patterns for simple pattern arrangements and addition. Pupils are required to connect the order of this pattern based on the shape that has been given. The first item in this group activity 1 is the simple pattern 72% of students have mastered this activity, 18% of students are mastering this activity and only 10% have not mastered the simple pattern of activity 1. The second item is the increment pattern. As many as 60% of students have mastered the pattern of addition, 20% are mastering it, and 20% have not mastered the practice of this pattern of addition.

Figure 2 below shows the results of module development through the application of AR application.

Figure 2: AR Application

Research Implications

Parents are seen to be ready to be involved in terms of mental support and dependence among family members but their involvement in aspects of children's learning is still at a low level. Time constraints are also one of the factors this item gets a low score as more than half of the parents work in the government and private sectors.

There is no doubt that there are a handful of parents who are still less open to exposing their children to the use of gadgets, especially children who are still in the early stages of age. However, the use of gadgets monitored by parents can be a medium that supports student learning at home. However, the score is moderate for the item of parental involvement in children's learning activities at home, especially in understanding the needs of the KSPK curriculum. Nurhusna (2017) argues that parents who are involved in children's learning either at home or at school are able to stimulate their child's growth and development positively in all aspects of development. This is because the concept of Flipped classrooms requires the involvement of parents to also support children's learning at home.

A total of four items are valued based on KSPK's performance standards, namely have mastered, are mastering, and have not mastered the training provided. The findings show that 40% of the respondents are and have not mastered the activity of completing the pattern given in the worksheet. While 80% of respondents are mastering the construction of repetitive patterns according to their own creativity with the form provided. The third instrument related to the recognition of different patterns of order in constant intervals showed that 80% of the respondents were still in the process of mastering this element. For the last instrument i.e. the recognition of different patterns of order in symmetrical intervals, none of the respondents were found to meet the set criteria and it was found that all respondents did not achieve a score above 50%. The findings in this phase underlie the decision to implement the

next phase of the study because it shows that there is a gap in student mastery in the pattern title for the subject of Early Mathematics.

Research Implications

The development of AR applications is also seen to have great implications for student learning in TADIKA. Given the current situation in the world of education, the use of technology is no longer undeniable and has become a necessity. The findings of the study show that parents who have knowledge of technology have the advantage to help and support their children's learning at home. According to Fariza (2017), the training provided to teachers needs to meet the needs of the current circulation of the world of education that incorporates elements of technology. There are several titles that are suitable to be injected with technological elements without neglecting the method of using existing materials in the subject of Early Mathematics.

The findings of the instrument from the TUP Consumption Model by Bednarik indicate that parents have an awareness of the application features needed to support children's learning at an early stage through the recommendations that have been put forward. The selection of quality applications can have a significant impact and implications on the learning development of their children.

The application of technological elements through the development of AR applications is seen as one of the aspects that can attract students to explore the learning experience in this topic. The use of gadgets is something that is not unfamiliar to them, especially students who are in the city. This advantage should be made a component in the structure of the preschool curriculum and in turn can be an added value to student learning. The title of the pattern chosen in this study is not actually focused on simple patterns but teachers also need to introduce other types and dimensions of patterns. This can actually be developed through learning activities through play. The approach of learning through play is actually easier to implement for students if the teacher is clear and knowledgeable to implement this strategy. AR applications are also categorized as one of the approaches to learning through play because the use of these applications in Science subjects has been widely used.

Conclusion

The technological elements involving this AR application have made this EM-Flip module a more interactive module that is needed by teachers as well as students at aged 5 to 6 years. This is in line with the exposure to the technology around them and also fulfills the concept of learning while playing those students need in the early stages of schooling. While the concept of reverse learning that is highlighted throughout the process of this study shows that the EM-Flip Module focuses more on activities that stimulate creativity when students are given more authority to discuss and express opinions in class. This fulfills the concept found in reverse learning which makes homework a medium of discussion in school through group discussion activities and presentations in class. While activities in the classroom are implemented at home with the help of materials or multimedia from teachers (Bergmann & Sam, 2012).

Several suggestions have been put forward and among them are strengthening teachers with technology training and providing more up-to-date modules, focusing on aspects of stimulating and enhancing students' creativity, as well as improving existing

modules based on feedback received from parents. In the current world of education, the use of technology can no longer be denied. The importance of providing interactive modules has also become a necessity not only for teachers but also for students in schools.

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