Key Knowledge Generation

A Framework of Educational Augmented Reality App for Improving Pre-schoolers' Creative Thinking

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PLEASE SCROLL DOWN FOR ARTICLE

A FRAMEWORK OF EDUCATIONAL AUGMENTED REALITY APP FOR IMPROVING PRE-SCHOOLERS' CREATIVE THINKING

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Abstract. This paper proposes a scaffolding development framework for designing and developing mobile educational augmented reality (AR) app. The purpose of creating this app is to improve the level of creative thinking among pre-schoolers. The development framework is created based on prior instructional system design models and pedagogical support for designing and developing the AR app. The framework will be presented to provide a foundation for researchers who are interested in AR app. Applying the proposed framework would leverage future researchers' understanding of how learners cooperate in the AR environment and perceive the factors to improve creative thinking. The framework expanded the generic ADDIE model of instructional system design because it has five systematic phases that guide building effective instructional materials. Selected relevant learning theories are connected to each phase to improve pre-schoolers' creative thinking.

INTRODUCTION

This paper proposes a scaffolding development framework for an empirical research on educational Augmented Reality (AR) app that examines the effect of mobile AR on students' creative thinking. According to [1] e-learning is a method to improve specific job performance. However, this goal is only an illusion when e-learning is not effectively developed to meet the requirement of outcomes. There is a need for the framework, to establish a proper development plan of e- learning products. The effective outcomes will depend on the quality of the instructions embedded in the designing, building, or selecting the e-learning products.

This paper will provide some findings of prior empirical studies on the issue to develop effective instructional materials. The development framework is created based on prior then instructional system design models and pedagogical support for designing and developing the AR app. The framework will be presented to provide a foundation for researchers who are interested in AR app. Applying the proposed framework would leverage future researcher understanding on how learners cooperate in AR environment; and perceive the factors to improve creative thinking.

Augmented Reality

According to [41] augmented means having been made greater in size or value and reality refers to things as they actually exist. The term augmented reality refers to a technology that superimposes a computer-generated image on a user's view of the real world, thus providing a composite view [41].

It is concurrent with [36] that define AR as a medium in which interactive computerized information is overlaid on the physical world that is in both spatial and temporal registration with the physical world. Spatial refers to applications that allow you to place some object at the specific location while temporal registration is related to time. Registration refers to registering the real and virtual world, such that objects coincident with both worlds appear to be in exactly the same place and at all times.

[2] describes AR as a variety of virtual environments or virtual reality (VR). According to [2] enhances reality, such as adding extra information rather than completely replacing it. AR concept can be best described by visualization called "Milgram's Reality-Virtuality Continuum" (Figure 1) generated by [40] that has been received and referred to by the majority of researchers until now.

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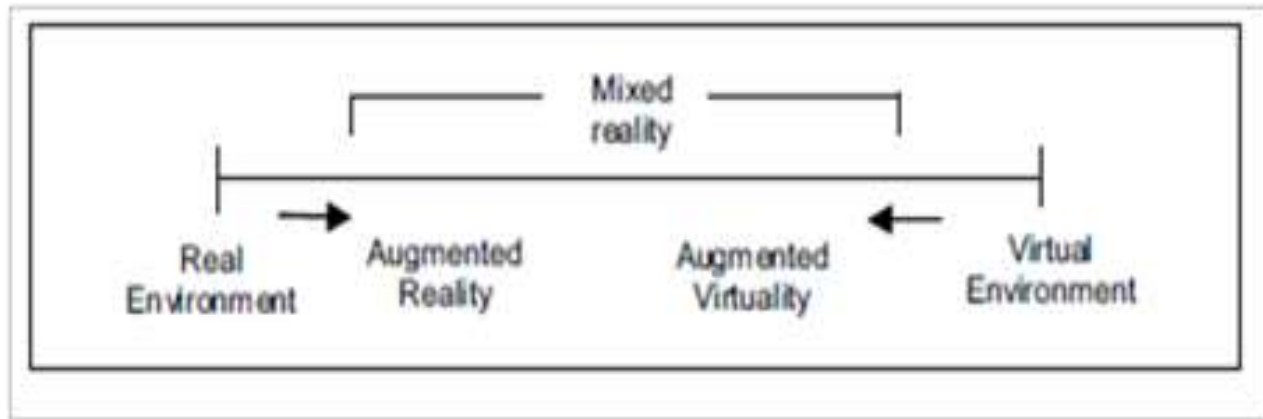E-mail: dilahkmpk@gmail.com

Fig. 1. Milgram's reality-virtuality continuum" generated by [40]

The use of AR as a medium in learning and teaching requires technology that will be able to engage students with experience and thus provide effective learning. AR has the potential to do things that are not possible in a normal interaction with the real world.

Educational Augmented Reality Apps

In the field of education, several studies have been made in Malaysia using AR technology. In [38] has conducted a study on the level of awareness and perception among Malay Language teachers towards the use of AR in teaching and learning. Results proved that the Malay Language teachers had a 3.4% lower level of awareness towards AR app.

In [39] designed and implemented a visualization framework named Surlens Visualization System. It accomplishes immediate reconstruction and obvious mappings of the internal human brain sufficiently to instantaneously locate possible blockages in the brain blood vessels. In the medical diagnosis and treatment planning, radiologists and surgeons depend intensely on the 2D slices produced by medical imaging scanners. This system is implemented in Microsoft .NET environment and provides high performance computing using Compute Unified Device Architecture (CUDA), augmenting the widely proven ray casting technique in terms of superior qualities of 3D images.

In [37] provided a technique to demonstrate the collaboration between sky hues and objects in an AR app considering shadows. The shadow presence will make the object look more vivid. This study also contributed new algorithm to create shadows with higher quality and higher frames per second.

In Malaysia, there are limited studies in the field of education with the help of AR. We need to constantly enhance and improve the study as this will pave the way ahead for developing AR technology.

Creative Thinking at Pre-school Level

According to [42] creative is involving the use of the imagination or original ideas to create something. Imagination within the definition of creative refers to the faculty or action of forming new ideas, images or concepts of external objects not present to the senses. Creative refers to something new and different that includes novelty, excitement and sometime that can be a little scary [11].

The importance of creative thinking today needs to be emphasized. Creative thinking is the ability to transform conventional method, procedures, ideas and patterns into meaningful new ideas, inventions, forms and methods. Creative children will be the greatest creative assets to the world.

Creativity is a beneficial, interdisciplinary and captivating topic of study, but hard to characterize [12]. It plays a role in education, art, business, culture, science, entertainment, language and numerous different fields. According to [12], the creative process is multifaceted and involves processes such as the imagination, flexibility and insight.

Early childhood education is important because it reflects the thinking when becoming adult. Learning in childhood setting needs cooperation from both teachers and parents. Today's education needs to embrace creative thinking skill because it is crucial for both adults and children [3].

Scaffolding Development Framework

According to [43] framework can be defined as a basic structure underlying a system, concept, or text. Frameworks can come in several
forms of name (conceptual, practical and theoretical), shape, differences of sizes and perspective [4]. In order to support

research, there are many different frameworks used by the researchers to enclose their findings. After developing a conceptual framework for the first stage that provides a guidance of the existing problem statement and clears the ideas of how well the variables are connected together [5], the second stage is to create a design framework.

Background of the Study

Malaysian Education Development Plan 2013-2025 blueprint outlines six key features required by each student to be able to compete on a global level. The most important features are morals and spirituality followed by knowledge, authority abilities, thinking aptitudes, bilingual aptitudes, and national personality. For the thinking aptitudes, every student must ace a variety of cognitive skills, including problem solving, reasoning, creative thinking and innovation. [6] emphasized that the teacher's part is to create an environment that a student will be able to actively and effectively explore. This activity should combine both familiar and new aspects.

In the Malaysian pre-school and primary school education system, formal learning in early childhood education is constantly limited to memorizing concepts, doing calculations and applying formulas in drill and practice settings [7]. The techniques and strategies applied in the pedagogy are hardly synchronized with the needs of being 21st century global students. To make matter worse, the education system is heavily examination-oriented, as seen in KEMBARA (acronym of "Kemahiran membaca, menulis, mengira") examination for pre-schoolers in Perak state. Examination based mode of learning has restricted the level of creativity among students even despite of being a crucial aspect in teaching.

The examination mode triggers student's feelings towards test anxiety. This in turn becomes a common educational issue which is reflected particularly in student's performance, thus leading to physical and psychological problems and causing negative influences on motivation, concentration and achievement negatively [8]. In Nigerian schools, not all teachers agreed with the school-based assessment. 75.6% teachers from Nigerian private schools gave a negative perception about school-based assessment [9]. Teachers also have to embrace technology to suit the needs of pre-school students nowadays such as integrating it with audio and musical aids to add extra benefits to knowledge, personal and social development [10].

Problem Statement

The infusion of 21st century skills that focus on creativity, critical thinking, communication and collaboration is essential in education to ensure every child's success as citizens and workers in the future. According to [13], top students achieve a proficiency level 5 or 6 in problem solving, which means they can solve complex problem scenarios with multi-step solutions that consider all limitations, and modify their strategies based on the feedback received. Compared to Japan, Singapore and Korea, Malaysian students perform less than 2% at level 5 or 6.

PISA assessment is unique because it develops tests which are not directly associated with the school curriculum program. The tests are intended to evaluate what degree students achieve towards the end of compulsory education, can apply their knowledge to real-life circumstances and be prepared for full participation in the society. Questions in PISA injected by higher order thinking skills (HOTs) are elements which require students to have creative and critical thinking. This issue leaves us to wonder why Malaysian students lack creative and critical thinking.

What is the actual problem domain for the lowest level of creative thinking of Malaysian students? There are many contributing factors to this problem such as teaching pedagogy, learning environment, motivation, current teaching practices and many others. Education system in Malaysia does realize the importance of the elements of creativity in teaching and learning, but still show low achievement in PISA 2012 results. Education system in Malaysia has applied the elements of creativity in teaching and learning, however, the extent of its effectiveness in enhancing creativity is still uncertain.

In Malaysia, there are no such studies in the field of education that have been conducted regarding AR that focused on creative thinking. Creative thinking is necessity in 21st century learning environment [3]. It must be fostered since childhood because it affects life through the way people think of the new possibility, collaborate with physical and social environment [14]. That's why this scaffolding development framework is important to develop an effective app for pre-school.

Scaffolding Development Framework

The development of the AR application itself involved a creative process such as refinement of the application concept, storyboarding, 3D modeling, which were implemented by many creative talent contributors such as artist, designer, programmer and storyteller [15]. The creative potential of AR is believed to be able to enhance the human condition.

Since the creation of the Internet, our world is divided into digital world and real world. AR app can be the best application that can merge these two different worlds. The app will be able to generate creative people who want to have fun exploring the possibility of AR. For children, LEGO AR app for example displays the complete 3D model when they scan the toy box [16]. The image represented will help children to boost imagination and think of inventive new ideas.

For AR app development, a popular instructional design model is followed, known as the ADDIE model. ADDIE is an acronym for Analysis, Design, Development, Implementation and Evaluation. The generic ADDIE itself is not sufficient for designing and developing educational AR app for preschoolers' creative thinking that is why the model has been expanded. Below is the scaffolding development framework connected with model and theory related to building effective instructional material that can help educationalists and game developers to design and develop educational AR app which can improve creative thinking level of preschoolers.

Fig. 2. A framework for the design of EDAR.

Analysis Phase of EDAR Framework

During the analysis phase, prerequisite investigations are completed whereby the objectives and goals of the app are laid out. The intended interest group is determined alongside the earlier arrangement of aptitude and information needed for comprehending the subject matter of the app.

Exploratory Survey Research

Before designing the development model of AR app, the survey research was conducted to determine the best research design, perception in the learning by using Information Communication Technology (ICT), target respondents' attitudes, opinions and behavior, data collection method and selection of the subject matter.

The survey questions were adapted from the ARCS Model of motivation [17] that has been used extensively in predicting intention to use a particular technological innovation. In this case, the use of mobile computer will be studied. The ARCS model is a motivational outline transform that incorporates a synthesis of motivational concepts and theories that are clustered into four dimensions [18]. The four dimensions are attention (A), relevance (R), confidence (C) and Satisfaction (S).

Design Phase of EDAR Framework

In order to optimize learning, e-learning courses must consider the human cognitive processes. The design of the computer-based training courses ought to be in view of how the human mind learns.

Motivation

According to [44] motivation can be defined as enthusiasm or the desire or willingness to do something. As indicated by [1], the cognitive process is highly influenced by the motivation of the learner to make sense of the material. The power of ICT application can enable users to repeat tasks, choose activities based on their level, resulting in higher order thinking skills (HOTs), better recall, and gain confidence in learning [19]. These features will increase the motivation level of the students.

In order to achieve the high impact of e-learning, some designers endeavor to flavor up their materials by adding motivational elements such as dramatic stories, pictures, or background music. However, adding fascinating, yet superfluous material to the e-learning can distract the learning and teaching process. The following is the foundation that applies in EDAR in order to produce the quality and efficient apps.

Cognitive theory of multimedia learning

In order to promote the best learning, the instructional material must be guided by the human cognitive process. The material is not only to present information but also to present it in a manner that depends on how people learn. Thus, the

cognitive theory of multimedia learning is adopted in which

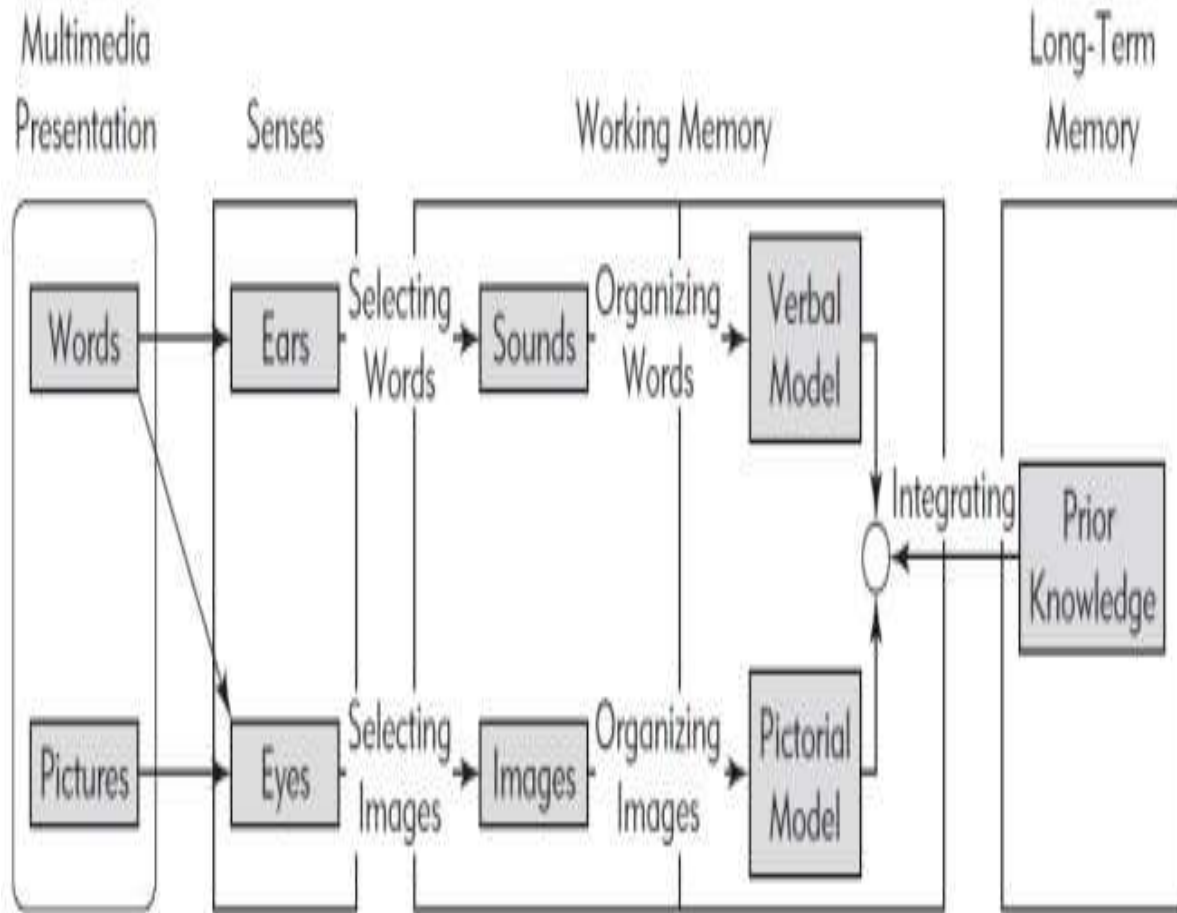learning is consistent with both circumstances.

Fig. 3. Cognitive theory of multimedia learning [1]

According to [1], the theory is based on the assumptions that (1) all people have separate channels for processing verbal and pictorial material, (2) each channel is limited in the amount of processing that can take place at one time, and (3) learners actively attempt to build pictorial and verbal models from the presented material and build connections between them. These beliefs are consistent with research in cognitive science and represent a perspective of learning to avoid cognitive overload in students' mind.

Gamification

According to [45] gamification means the application of typical elements of game playing (e.g. point scoring, competition with others and rules of play) to other areas of activity. [22] defined gamification as the use of game design elements in non-game contexts. This relationship between gamification against two dimensions of playing/gaming and parts/whole can be described in the figure 4.

Gamification is not a game but it uses parts of games such as game-based mechanics, aesthetics, and game-thinking to solve problems, engage, motivate and promote learning [20]. The objective of Gamification is to deliver specific learning contents effectively in a fun and enjoyable environment. In order to ensure that these efforts succeed, SMEs and game experts could collaborate to design and develop games depending on the modes of learning [21]. The guidelines are very important for instructional success and to avoid cognitive overload among students [1].

Development Phase of EDAR Framework

The development phase involves the construction of instruction based on the specific learning context. The specific instructional management plan and selecting material i s also determined in this phase. In this study, EDAR will apply augmented reality via mobile device to deliver the content of learning and teaching.
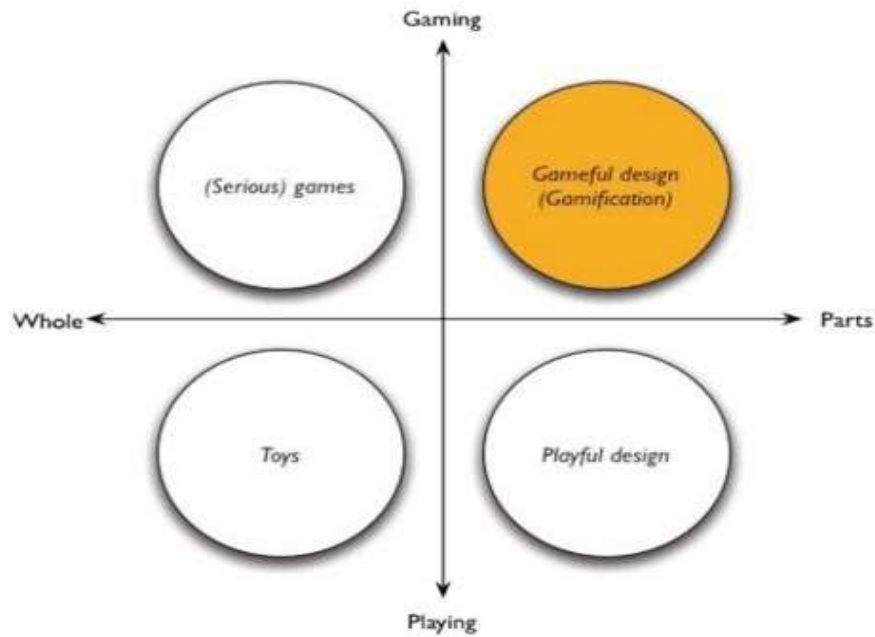
Fig. 4. Gamification between game and play, whole and parts [22].

AR and Mobile Device

In this research, AR technology will be applied in app and delivered via mobile devices or simply call mobile AR. Mobile devices have experienced phenomenal growth in recent years due to lower costs, sleek in size and capability to act as a computer at any times [23]. Industry case studies reveal that people are already achieving real outcomes through mobile solutions such as closer customer relationships, faster solution times and easier tracking.

The mobile devices also become more powerful force the developers to produce content that can work on a broad diversity of program and wide variety of platforms. It allow user to be productive by using familiar device and capable all the time. This all could be done ubiquitously, as needed and without advance preparation [24].

Mobile devices are transformative devices and add host of fresh possibilities for business and personal software because they are truly the first mobile computing platforms. Although laptops and notebooks are moveable, their size significantly impacts how easily they are transported. Very few people carry a laptop during their every waking hour to every location they visit. However, if this was their only advantage, mobile devices would not be making such a shift because there are lots more [25]. Playing mobile apps are the supreme catalyst that permits children to practice skills they may require later in life. When we play, we pick up practice on controlling things and results of events. Playing also invent a new solutions for old problems and make another completion for our experiences.

Mobile Learning

As mentioned before, the used of AR require technology to support effective learning. In this research, mobile device or mobile computer will be used as a mediator to deliver learning content. The application will be downloaded to the mobile device known as a mobile app [26]. Mobile app often exploits elements of the device such as cameras, GPS, touch screen to empower user to get information. The following is the definition of the word "mobile" and "learning" is extracted from [46].

Based on the figure 5, the mobile learning can be defined as gain knowledge which is part of studying, teaching and experiencing by using a mobile device. The question is, why mobile learning? It is because of the remarkable development numbers of mobile computers, mobile devices and people are already accomplishing real results through mobile solutions such as closer customer relationships, faster solution times and easier tracking [24].

Another reason is that the transformation of the mobile devices itself. They have gained popularity because of lower cost, computing capabilities, easy to use, small in size and portable.
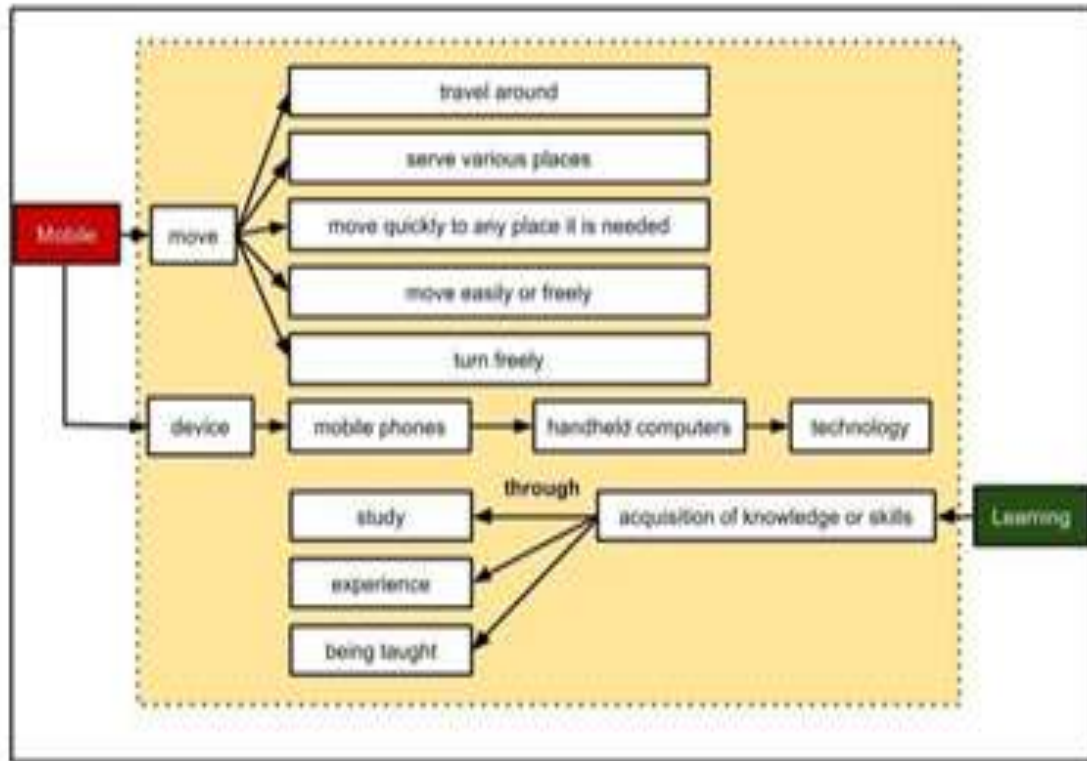
Fig. 5. Definition of mobile learning is extracted from [46]

Learning via mobile device could be done on the go, as needed without advance preparation because people always bring the devices anywhere because their size significantly impacts how easily they are transported [25].

However, learning is not about delivering the whole content or e-learning courses using mobile. M learning is more about performance support, augmenting learning, complementing learning and allowing people to become more productive, not just learn [24].

Implementation Phase of EDAR Framework

During the implementation phase, the EDAR will be performed in the specific context. The doctoral research sample is drawn from preschool children and focus is on creative thinking. To trigger the creative thinking among children, the EDAR inspired by revised version of Bloom's Taxonomy by [47], [12], constructivist learning theory and using active learning mode will be discussed below.

Revised version of Bloom's Taxonomy

The demand of HOTs is imperative in this 21st century. Today, livelihood opportunities are requiring people who can think competently, rather than just learning facts [27]. Thinking needs to go beyond knowing the certainties such as having the capacity to control, examine, assess and apply the information. As indicated by [27], workers need to think and react quickly to make discriminating judgments because the information is constantly changing, evolving and updating. There are additionally a couple of models out there that lead students to acquire HOTs, including the revised version of Bloom's Taxonomy [47], [48], [12] and [49], [27].

The original Bloom's taxonomy helps educators plan, convey and access a curriculum that encourages teaching for transferring learning effectively. With the goal that the students can be able to solve new problems and answer new questions, learning new subject matter is facilitated. The knowledge is often applied outside the classroom in the real life situation [28].

The Bloom's Taxonomy has been amended to reflect the importance to twenty first century learner. According to [47] by moving the creating level to the highest point of the hierarchy, making the highest level of cognitive domain of learning as developing something new [28]. The updated model of Bloom's Taxonomy emphasizes enormously on the development of HOTs.
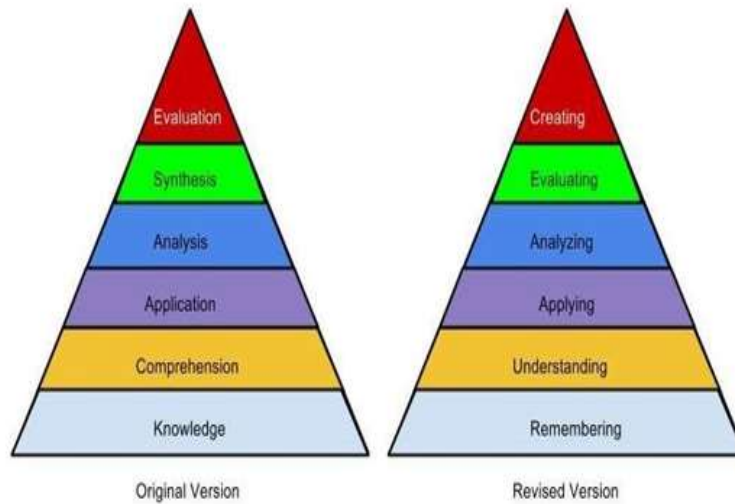
Fig. 6. Bloom's taxonomy (1956) and revised model (2001) [28].

Constructivist Learning Theory

To achieve the research objective, the teaching and learning process must be carefully considered in relation to two vital issues: one relating to the contents; and the other relating to the needs of using the right software and delivery mechanisms. For this reason, the researcher developed the EDAR enhanced with AR that was designed along with the constructivist principles to improve the participants' creative thinking.

The design of the training application was based on the framework espoused by the constructivist view of learning. The EDAR apps apply three broad principles that can lead to the effective learning. The table below describes the three principles according to [29].

TABLE 1
THREE BROAD PRINCIPLES OF CONSTRUCTIVIST LEARNING THEORY [29]

1.	Kant and Dewey	Individual forms his or her own representation of knowledge and there is no particular "correct" representation of knowledge.
2.	Piaget	Learning occurs when learners uncover a deficiency in their knowledge representation or an inconsistency between their current knowledge representation and their experience during active exploration.
3.	Vygotsky	Learning takes place within a social context.

Active Learning

According to [50] active learning refers to an educational approach in which students are encouraged to engage with the material to be studied through activities, such as experimentation, group discussion, and role-play. According to [30] through their article "Educating Young Children: Active Learning Practices for Preschool and Child Care Programs" defined, active learning as a direct and immediate experiencing of objects, people, ideas, and events and it is a necessary condition for cognitive restructuring and hence for development. Beloware is a diagram and a table generated from the active learning study by [30], material after the implementation phase. The process of collecting data is important to determine whether the app will affect the user. This research will apply The Torrance Test of Creative Thinking (TTCT) [31] and Unified Theory of Acceptance and Use of Technology (UTAUT) [32].
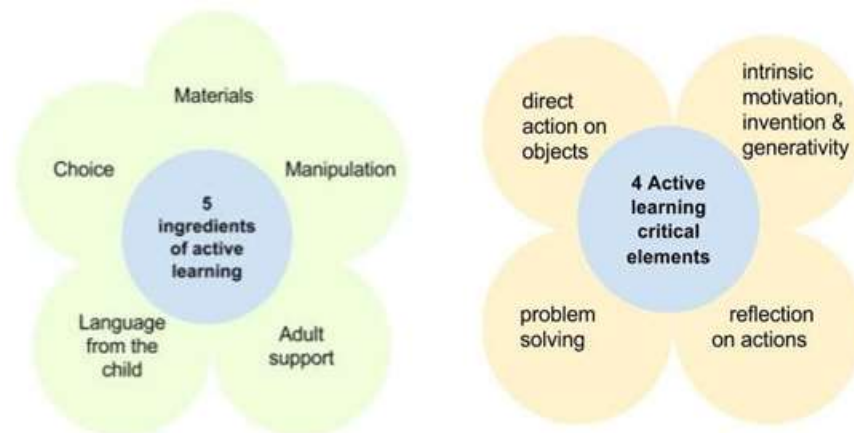
Fig. 7. Active learning critical elements and ingredients [30].

Evaluation Phase of EDAR Framework

Evaluation is the last phase of ADDIE. Its purpose is to evaluate the quality of the training.

Torrance Test of Creative Thinking [31]

The Torrance Test of Creative Thinking (TTCT) was used to define another intellectual quality that has acquired importance in twenty first century of learning. The test was developed for emphasizing classroom experiences that stimulate creativity [33]. Four dimensions of TTCT are fluency, flexibility, originality and elaboration. In this study, the TTCT will be used to measure the level of creative thinking among preschool students who apply AR application in the classroom.

Unified Theory of Acceptance and Use of Technology (UTAUT) [32]

This doctoral research adapts a conceptual model of UTAUT proposed by [32], towards teacher acceptance of EDAR apps. The model is applied to find the answers to what degree does the user acceptance of EDAR apps get affected. The model is chosen because it has eight dimensions in the instrument that also cover the effectiveness of the apps. The other seven dimensions are performance expectancy, effort expectancy, social influence, anxiety, management effectiveness, facilitating conditions and behavioral intention.

DISCUSSION

The proposed framework applied ADDIE instructional design model which has been criticized as a linear model [34]. Linear model represents the step by step process assumed as if the developer knows all the content for development. It also assumes that the development will have no problem along the development. Many developers used ADDIE modification model such as injecting the evaluation at every stage so that every phase has assessment to improve the product [35].

The design framework is presented differently by different authors. To cater the issue, this framework did not apply the generic model of ADDIE. This approach locates the framework as fulfilling an integrating function between established educational theory injected into the ADDIE systematically. The expanded ADDIE model was used as the base to support the development of the quality application to enhance the level of creative thinking.

To measure the effect of the application developed, there is the need for conducting empirical studies. The doctoral research later will provide the empirical data to support the theory of the development and thus will give one solution to increase the level of creative thinking among preschoolers.

CONCLUSION AND RECOMMENDATIONS

This concept paper proposes a scaffolding development framework for designing and developing mobile educational AR app. The purpose of creating this app is to improve the level of creative thinking among preschoolers (part of an ongoing research in the faculty of Art, Computing and Creative Industry, Sultan Idris Education University, Malaysia).

The framework proposed and applied the modification of the famous model ADDIE. Utilizing the expanded ADDIE framework will help to define what theory is driving the research and come out with the proper solution to enhance the creative thinking among preschoolers. The framework also provides the comprehensive and systematic project plan that will imply in more serious texts.

Early childhood learning is crucial because it will reflect the thinking when grown-up. Learning in a childhood environment needs to embrace creative thinking skill to generate a novel idea in problem solving. The proper planning in development of the AR will help to increase the level of creative thinking to support education transformation that takes place

over 13 years. Malaysian education mission is to pursue excellence with increased operational flexibility and improve performance on TIMSS and PISA in top third of the systems [51].

Declaration of Conflicting Interests

It is hereby declared that this study has no conflicts of interest.

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— This article does not have any appendix. —