FizaAR: An Augmented Reality Learning Kit Integrating Social Cognitive Theory in Learning Physics

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Abstract—**Physics education involves abstract concepts and mathematical problem-solving skills that can be potentially improved using Social Cognitive Theory (SCT). Although SCT has the potential to improve the learning of physics that involves abstract and mathematical problem-solving skills, there is still a lack of studies that examine the use of theories in the design and development of the topic of Gravitation. Based on a need analysis conducted in the preliminary step, there is a need to develop a learning kit to help students visualize abstract concepts and solve mathematical problems in the Physics subject. Therefore, a study was conducted at a high school to design and develop an Augmented Reality (AR) learning kit named FizaAR, specifically in the topic of Gravitation. FizaAR is an abbreviation that stands for Physics (*Fiz*), animation (*a*) and Augmented Reality (AR). The study utilized Design and Development Research (DDR). The implementation was carried out on 15 students at a high school. The result revealed that the desired learning outcomes on abstract concepts and solving mathematical problems in the Physics subject, especially in finding the escape velocity were achieved after the implementation of SCT that focused on observational learning. In this implementation in a classroom utilizing FizaAR as media and peer learning and SCT, the interaction between students during their class presentation was included in the expected learning outcomes. SCT states that peer learning approach could be useful to help students understand abstract concepts and problem solving. Thus, it might improve the learning of physics among high school students. This study suggested that the application of SCT, Cognitive Theory of Multimedia Learning (CTML), and AR is beneficial in developing Physics learning materials for high school students. Additionally, a step-by-step process of the design and development stages found in the DDR framework assisted the learning material design and development systematically.**

Keywords—**augmented reality, physics, social cognitive theory**

I. Introduction

The term "Science, Technology, Engineering, and Mathematics (STEM)" [1] refers to the establishment of educational policies and curricula in schools to make pupils more competitive in the fields of science and technology. This is codified in the Malaysian Education Development Plan 2013–2025 [2], which places a strong emphasis on STEM education through extracurricular and curricular activities in schools with assistance from a range of partners. The younger generation needs to be proficient in STEM fields to meet the difficulties of Industry 4.0. In the field of future technology, which is the foundation of Industry 4.0, this is done to generate skilled human capital.

The development of STEM curricula in Malaysia is an important topic of study due to the issues in the decline in student interest in STEM areas [3, 4]. There were also challenges on the significance of proficient STEM educators for high-quality education [5] and programs to improve problem-solving abilities into the curriculum [6]. Enhancing teacher competencies, tackling human capital development challenges, and introducing cutting-edge teaching strategies are all part of Malaysia's efforts to improve STEM education and provide students with the tools they need to succeed in science, technology, engineering, and mathematics in the future [7].

In comparison with Japan, their emphasis on education for sustainable development has influenced the country's STEM curriculum development [8]. There exists a strong emphasis on STEM education, which is in line with international goals for workforce preparedness in innovation and technology [9]. Though it occasionally results in a segregated perspective of subjects, the Japanese approach to STEM education, which is strongly influenced by the American model, emphasizes a strong foundation in multiple fields through liberal arts and general education classes. A comprehensive STEM teacher training program and initiatives to raise student engagement and self-efficacy in STEM topics are required considering challenges in STEM education in Japan, including gender gaps, teacher quality disparities, and student indifference [10].

On the other hand, in Finland, developing STEM curricula is essential for both academic achievement and competitiveness in the global market [11]. The focus on comprehensive student development in the Finnish educational system, which is achieved through curriculum transformation and formative assessment methods, has proven crucial in producing autonomous, motivated students with enhanced creativity and adaptability abilities [12]. Teachers, schools, municipalities, universities, and other educational stakeholders have worked together to implement twenty-first-century competencies in Finnish schools. As a result, there has been a notable advancement in the integration of these competencies into the curriculum and teacher education programs [13]. Finland's national core curriculum highlights the nation's dedication to innovation and continual improvement in education by providing a framework for educational transformation. It outlines the aims, values, and fundamental topics for every subject as well as the development of learning environments [14].

Science is one of the components of STEM, and one of its basic components is physics [15]. The Physics subject is included in the Pure Science Stream with other subjects like Chemistry, Biology, and Additional Mathematics. The choice of the Pure Science stream will give students everything they need to pursue their education to a higher degree, particularly

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in professional domains like technology, engineering, architecture, and doctorate, creating a pool of experts capable of competing for the advancement of the nation. The Physics subject is often labeled as boring [16] and a difficult subject to learn either at the high school level or at a higher level in the tertiary education [17, 18]. This is supported by Nordin [19] who states that physics is something abstract and difficult to imagine through imagination. Physics emphasizes concepts and principles that cannot be imagined through the senses.

To improve physics education, a variety of teaching strategies have been investigated; each has advantages and uses specific to it. Systematic reviews have demonstrated the beneficial effects of Problem-Based Learning (PBL) on learning attitudes and academic achievement in physics, science process skills, critical and creative thinking, problem-solving abilities, cooperative learning, and mental model building [20]. The learning analytics technique has demonstrated a modest level of success in enhancing students' comprehension and representation skills in physics. It entails examining problems through numerous representations, such as graphical and mathematical skills. To further improve learning outcomes, this method highlights the necessity of creating learning products or models that incorporate both graphical and mathematical representations [21].

Learners' conceptual understanding of electrostatics is much improved when Interactive Simulation Technology (IST) is used in a guided-inquiry strategy; experimental groups demonstrate more improvement than control groups utilizing traditional methods [22]. Furthermore, studies show that to fully benefit from new technologies, both teachers' and students' roles must change. It has been demonstrated that active learning in a blended learning environment, where students interact with the content, raises scientific reasoning levels more successfully than passive learning aided just by technology [23].

Technology integration in physics education has improved learning outcomes and drastically changed teaching strategies. It has been demonstrated that a variety of technological techniques, including virtual and augmented reality, interactive software, and simulations, increase student engagement and comprehension of difficult physics ideas that traditional teaching methods frequently find difficult to communicate [24]. Research has indicated that the utilization of technology in education results in better learning outcomes and a deeper understanding among students, as indicated by elevated exam scores and heightened motivation [25].

In physics education, Augmented Reality (AR) has become a game-changing tool that greatly improves students' comprehension and engagement with difficult ideas. Studies with Physics professors and Matematik dan Ilmu Pengetahuan Alam (MIPA) as in subject of Mathematics and Science Environment of Class XI students, show that AR-based learning resources are not only practical but also well-liked by both groups, as evidenced by the high acceptance ratings [26]. AR's ability to improve students' comprehension of high school validation tests from media and content experts as well as encouraging comments from instructional practitioners back up the physics content [27]. AR has the potential to supplement conventional teaching techniques; in Kazakhstan, its use in high school physics classes has been linked to improved cognitive learning capabilities, especially among pupils with greater baseline physical talents [28].

A preliminary study was conducted to identify the problems faced by students on the topic of Gravitation. This study was carried out using interviews with Physics teachers at high school and among excellent Physics teachers from different schools to identify the needs and problems faced by high school students. Findings exhibited a need for an intervention or a learning kit to help students in this chapter. Students struggle to understand difficult, abstract scientific ideas or phenomena that call for a lot of imagination [29].

Understanding how theories of human behavior and cognition can inform the design and application of these technologies is crucial in maximizing their efficacy as the use of learning kits in educational contexts grows. SCT is a theory of conduct in humans that incorporates Bandura's [30] .The social cognitive theory integrates behavioral and cognitive perspectives to explain human conduct. Three factors influence behavior, according to the theory: an individual's personality, their behaviors, and their environment [31].

Additionally, SCT highlights how behavior, environment, and individual characteristics interact to shape human motivation and learning. This dynamic interplay of influences provides a useful lens through which to examine the potential of mobile apps to enhance self-efficacy, facilitate observational learning, and support self-regulation in educational contexts. By applying the components of SCT and AR in the design and development of Physics learning material for high school students, the objectives of this study are to identify the need of developing FizaAR, design and develop, and implement and evaluate FizaAR.

II. Literature Review

A. Social Cognitive Theory (SCT)

Social Cognitive Theory (SCT) places a strong emphasis on how people learn through social interactions and how environmental, behavioral, and personal factors are continuously linked [32]. The key aspect of SCT is the concept of reciprocal determinism, which emphasizes the dynamic interplay between personal factors, behavior, and the environment in shaping human cognition and action [33, 34]. Furthermore, the use of SCT in the classroom emphasizes how crucial modeling, reinforcement, and observation are to the learning process [34]. Comprehending social cognitive theories can facilitate the creation of physical activity–promoting interventions that consider cognitive and motivational aspects [35]. Furthermore, the incorporation of social interactions into computer-based learning aids has resulted in the creation of social mindtools, which improve cognitive engagement and collaborative learning [36]. Thus, by stressing social connections, self-regulation, and environmental effects, learning activities can be greatly enhanced by utilizing SCT.

Within the framework of SCT, observational learning and behavioral learning have received significant attention in the literature. Observational learning, also known as vicarious learning or modeling, refers to the process by which individuals acquire new knowledge and skills by observing the behavior of others [37]. Numerous studies have demonstrated the efficacy of observational learning in various domains, including skill acquisition, social behavior, and academic performance [38–40].

Researchers have explored the mechanisms and factors that influence observational learning, such as attention, retention, reproduction, and motivation [30]. Attention to the modeled behavior, the ability to retain and mentally represent the observed actions, the capacity to reproduce the learned behavior, and the motivation to engage in the modeled behavior are essential components of successful observational learning [40].

Studies have shown that learners are more likely to attend to and emulate models who are perceived as similar, competent, and socially attractive [41]. Virtual agents in digital environments have also been explored as potential social models, with research demonstrating their effectiveness in promoting observational learning [42].

Behavioral learning, on the other hand, refers to the acquisition of knowledge and skills through direct experience and reinforcement [30]. Within the context of SCT, behavioral learning is viewed as a dynamic process influenced by personal factors, such as self-efficacy beliefs, outcome expectations, and self-regulation [43].

Researchers have examined the role of self-efficacy in behavioral learning, demonstrating that individuals with higher self-efficacy beliefs tend to set more challenging goals, persist longer in the face of difficulties, and achieve better performance outcomes [40]. Strategies for enhancing self-efficacy, such as providing mastery experiences, vicarious learning opportunities, verbal persuasion, and reducing physiological and emotional arousal, have been explored in various educational and clinical settings [43].

There are several interesting connections between Social Cognitive Theory, Augmented Reality (AR), and peer learning, especially when it comes to social and educational settings. By incorporating three-dimensional virtual items into actual environments, AR provides a dynamic learning platform that can greatly increase students' motivation and engagement [44, 45]. When planning to manage cognitive load, this technology is very useful for learning new material or difficult activities, to find out if students can use the AR tools efficiently and whether the technology encourages creative processing. AR's capabilities are in line with social cognitive theory, which promotes learning through social interactions and the environment. This theory emphasizes the role that self-efficacy plays in motivation and information acquisition, and it emphasizes the significance of vicarious, symbolic, and self-regulatory processes in learning. By producing immersive, interactive experiences that mimic social interactions and offer quick feedback, Augmented Reality (AR) can assist these processes and improve learning outcomes and self-efficacy. A study using the Montessori training method to promote toddlers' social functioning and cognitive development has shown that AR-based systems can be utilized to build young children's cognitive and social abilities through gamified learning experiences [46]. Another study suggests the Cognitive-Affective-Social Theory of Learning in Digital Settings (CASTLE) to promote learners' motivational, affective, and metacognitive processes. These processes can be improved by activating social schemata through the incorporation of social signals in digital learning settings [47]. Therefore, an effective basis for creating instructional tools that are both interesting and useful is provided by the interaction of peer learning, AR, and SCT.

Self-regulatory systems and the cognitive processing of multidimensional standards from SCT, which can be selectively engaged or disengaged depending on the environment, have an impact on moral thinking and behavior [48]. When working with abstract notions, which frequently call for flexible cognitive processing, this adaptability is essential. Additionally, social-cognitive processes are flexible and adaptable to the social goals and contexts of the perceiver, implying that abstract concepts are better understood and used when placed within pertinent social and communicative contexts [49]. A study highlighting the socio-social theory of learning emphasizes the zone of proximal development and social cognitive approaches as essential for improving instructional practices and comprehension, particularly in fields requiring high levels of abstract thinking [50].

There are several ways to support observational learning of abstract concepts, including Augmented Reality (AR) [51]. By enabling people to acquire new skills and behaviors by observing the activities and results of others, observational learning is essential for improving abstract problem-solving [52]. A study highlights how crucial goal specificity is to learning outcomes. The study illustrates how these variables affect the efficiency of observational learning and problem-solving skills by contrasting specified versus non-specific aims [53]. Observational learning also plays a crucial role in enhancing mathematical reasoning, calculation, and understanding. Teachers' ability to notice and facilitate reasoning during peer-observed lessons is essential for improving mathematical education [54].

B. Abstract Concepts and Problem Solving in Physics

Physics is widely considered one branch of the various STEM disciplines [55]. Many students are less interested in learning physics, because of the assumption that physics is complicated and has abstract concepts [56]. Physics frequently works with abstract concepts and unobservable events [28]. They appear to be struggling to comprehend abstract ideas. Students may experience difficulties in learning physics and develop misconceptions because of the abstract concepts involved [29].

Physics has long been thought of as a challenging science that is hard to understand and has challenges when it comes to solving mathematical physics problems. Students may become disinterested in physics when they struggle with mathematical calculations [19]. Students with low mathematical ability will undoubtedly have poor ability [57]. A study presented great potential in developing an e-module utilized for Mathematics Physics learning activities, which include practice questions that help students in their skills while working through problems and enhance their comprehension of mathematical physics concepts [58]. With the advancement of technology, learning more about complex subjects is now possible with the use of computer and mobile support applications [59].

The creation of AR Problem Solving Laboratory models demonstrates how the use of AR in educational contexts greatly improves students' conceptual understanding [60].

Using Augmented Reality (AR) technology, students can better understand complicated concepts by utilizing interactive features and 3D visuals. Studies have indicated that Augmented Reality (AR) applications improve understanding and involvement, especially in learning the concepts of physics [61].

Augmented Reality (AR) has demonstrated a great deal of promise in tackling the difficulties involving learning and solving complex mathematical problems. The University of the Western Cape's pre-calculus students experienced an immersive and interactive environment in viewing graphing functions through the development of the AR mobile application logAR(ithms). This can help make the learning process more engaging and understandable [62].

Using Optical Character Recognition (OCR) to scan and identify mathematical questions, the Veda app uses Augmented Reality (AR) to solve a variety of mathematical problems, from basic arithmetic to calculus. Step-by-step solutions are then displayed in real time, facilitating understanding and problem-solving [63]. An AR-based educational game was created in Indonesia to help primary school pupils better understand spatial geometry by letting them interact with mathematical items in real-world situations. This led to a notable improvement in learning results [64]. Additionally, a review of studies conducted over the previous five years demonstrates how successful Augmented Reality (AR) is at helping students understand mathematics better and feel less intimidated by it since it turns traditional, less interactive teaching techniques into exciting, participatory experiences [65].

C. *Augmented Reality in Education*

The technology of Augmented Reality (AR) is a computer-generated system that enables AR applications that are more likely to the user see the object in a real situation. It is a technology that combines Two-Dimensional (2D) and Three-Dimensional (3D) virtual objects into a real three-dimensional environment and then to exactly overlay physical objects in real-time displays [66, 67]. There are three types of AR systems, which are markerless AR, marker-based AR, and location-based [68]. Various AR platforms can be applied to produce good learning material. Among the examples of AR platforms that can be used is the Layar application which is based on printed marker material where it uses GPS as a location trigger [69]. In addition, Blippar is also an easy-to-use AR application. There are various existing resources available for use in Blippar such as text, music, audio, video, diagrams, and 3D images. Users can select and design their own AR materials and share them with other users.

In addition, ZooBurst and Assemblr are also examples of AR material-building platforms using websites. It also provides various resources for "drag and drop" users to build AR materials. In addition, for iOS users, Reality Composer is an AR platform that allows users to develop their AR content. Unity is a powerful, versatile, and popular game development engine that provides immersive and interactive 2D and 3D environment and experience creation [70]. Study shows that AR-based teaching materials can help to improve the learning achievements of high achievers, have a positive impact on students' attitudes [71] and help to close the gap in students' overall learning abilities [72]. AR has shown a huge potential in increasing engagement among students, can enrich their knowledge mastery [45], help to concretize abstract concepts [73], and provide an opportunity to experience the settings that are difficult to access or cannot be created in the world [74, 75]. An investigation using AR by applying it to the effects of Problem-Based Learning (PBL) on learning achievement and attitude toward physics subjects was done and the finding disclosed a great potential for AR [76].

The usage of Augmented Reality (AR) in high schools is growing. A study in Kazakhstan revealed that it has the potential to significantly improve students' cognitive learning abilities during Physics lectures, especially for those with higher beginning physical ability [28]. By offering realistic three-dimensional virtual objects, Augmented Reality (AR) enhances students' learning outcomes and critical thinking abilities by enabling them to visualize abstract physics concepts like electromagnetic waves, electric currents, and magnetic fields [77]. Projects like ARphymedes Plus, which combines interesting stories and experiments with Physics curriculum to make the topic more approachable and entertaining, are another example of how this technology is being customized to fit the needs of kids with special needs [78]. Furthermore, high school students can engage with real-time simulations of physical phenomena like mass, gravity, and friction through AR applications, which promote a deeper comprehension of key concepts through experiential learning [79]. Therefore, integrating AR into physics education not only solves the shortcomings of conventional teaching strategies but also increases learning effectiveness and engagement, which in turn sparks students' enthusiasm in the STEM field.

There have been notable improvements in students' comprehension and academic achievement when physics lessons involve animation. Studies reveal that students instructed with animation materials attain better learning results in contrast to those instructed with traditional techniques, underscoring the usefulness of animation in enhancing physics education [80]. Students' engagement and interest in physics are increased when they use interactive tools like Vascak Physics Animation, which let them visualize and replicate real-world physics occurrences [81]. This is particularly beneficial in settings with limited resources and conventional teaching approaches since animations can offer a more engaging and dynamic way to comprehend physical events [82]. Research has indicated that educational videos using animation can enhance learning outcomes. Notable improvements have been seen in students' post-test results, suggesting a deeper understanding of the subject matter [82]. Furthermore, it has been discovered that using Animaker audiovisual materials greatly increases students' conceptual comprehension and engagement, as seen by higher N-Gain scores and favorable student comments [83]. Research indicates that students need media that allows for independent and repeated learning, which animations may effectively supply. This reinforces the necessity for such innovative learning aids [84]. The use of animation in physics education promotes a more dynamic and engaging learning environment in addition to helping students visualize and comprehend concepts more clearly, thus improving academic performance and increasing their enthusiasm for the subject.

III. METHODOLOGY

The study involved 15 students at the age of 16 years old at a high school in Peninsular Malaysia. Participants of the study were low-achieving Form Four students with low and intermediate scores in Physics, able to use technology such as mobile applications and online courses and have mobile phones. The study used Design and Development Research (DDR) [85], which states that the use of DDR is a systematic approach involving design, development, and evaluation. Fig. 1 shows the marks obtained for the selected students that were being chosen to participate in the implementation of FizaAR.

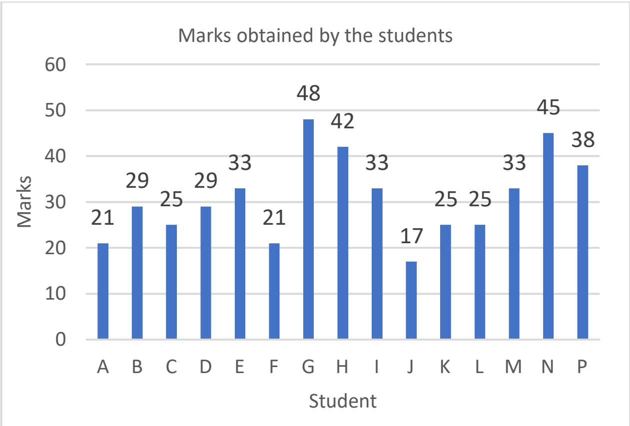

Fig. 1. The marks obtained for the selected students that were chosen.

Table 1 shows the procedures in the development of each phase in the design and development of FizaAR. Each phase involves its participants to design, develop, implement, and evaluate FizaAR.

Table 1. Procedures in the development of FizaAR.

Phase	Procedure
Phase I Needs Analysis	Interview with Physics teachers on the needs for learning materials on the topic. A Five-Likert scale questionnaire for the students involved to get their views on Physics learning environment.
Phase II Design and Development	Validation using a checklist by experts to design and develop learning materials to fit in the Physics curriculum. The experts involved were the technology experts and content experts in Physics Education.
Phase III Implementation and Evaluation	Implementation to high school students in Peninsular Malaysia. The implementation involved students to 'Bring Your Own Device '(BYOD). The lessons using FizaAR fit into the learning outcomes of the Physics curriculum. The evaluation of the lessons was based on rubric analytics.

- **Phase 1: Needs Analysis**

Needs analysis is a phase where a value judgment is made that a specific group has an issue that needs to be resolved [86]. It is to ensure and evaluate the needs of the study to achieve the learning outcome. In this phase, one-to-one interviews were done among Physics teachers. There were Physics teachers from Peninsular Malaysia, one Expert teacher in Physics, and one lecturer from the Teacher Training Institute (IPG) involved in these interviews. The students involved were given a Five-Likert scale questionnaire to seek their views on their Physics learning environment.

- **Phase 2: Design and Development**

The design and development phase involved the development of FizaAR integrating the Cognitive Theory of Multimedia Learning (CTML) [87]. The five principles involved in this phase are the Coherence Principle, Signaling Principle, Redundancy Principle, Spatial Contiguity Principle, and Temporal Contiguity Principle [88]. The experts went through a validation process using a checklist in each of the aspects and they further discussed each of the elements in the process. The validations were crucial to ensure FizaAR achieved the desired learning outcomes.

Table 2 shows the experts involved in validating FizaAR. Each of the experts involved was interviewed and the final suggestion in each design phase was discussed.

Table 2. The experts involved in validations of FizaAR

Experts Code	Academic background	Position
P1	PhD	Lecturer in National University of Malaysia
P2	PhD	Lecturer in Teacher Training Institute (IPG)
P3	PhD	Lecturer in Teacher Training Institute (IPG)
P4	Master	Lecturer in Teacher Training Institute (IPG)
P5	Bachelor	Physics Teacher
P6	Bachelor	Physics Teacher

Fig. 2 shows the abbreviation of the AR learning kit named FizaAR. It stands for *Fiz* which is Physics in the Malay language, *a* which refers to animation that has been available for the students to help them in understanding or further explanation, and *AR* which refers to augmented reality.

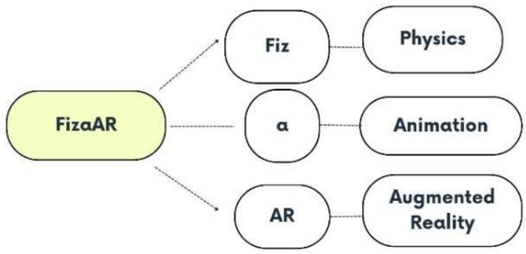

Fig. 2. The abbreviation of the AR learning kit named FizaAR.

- **Phase 3: Implementation and Evaluation**

The implementation encompassed a high school in the Seremban district. Each of the students had received permission from their parents and the school principal. The study also acquired permission from the District Education, State Educational Centre, and Educational Research of Malaysia (ERAS).

The implementation was using the Bring Your Own Device (BYOD) approach where the students downloaded FizaAR.apk to their mobile phone. The students would then learn from the video and experience AR simulations on the topic of Gravitation. After each implementation, students would answer questions and do presentations for the whole class.

Fig. 3 shows a student using FizaAR as a learning material to help him understand the abstract concepts in Physics.

Fig. 3. The implementation AR elements in the topic of gravitation.

Fig. 4 exhibits the indicator of interactivity in the exercises available in FizaAR at the end of the lessons. Students would have to calculate the value of escape velocity and type in their answer in the allocated section.

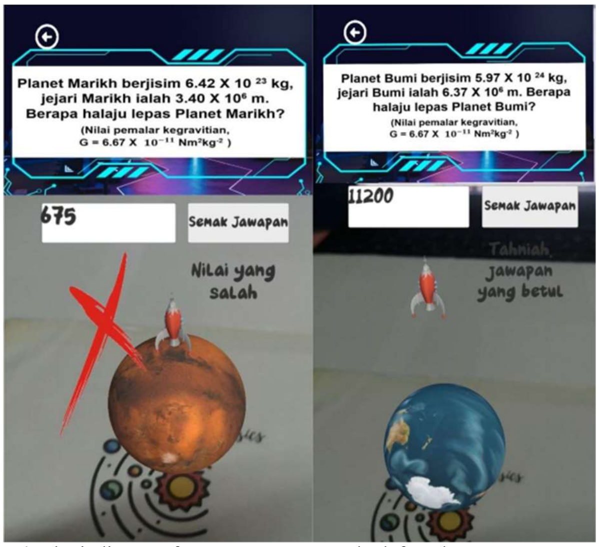

Fig. 4. The indicator of a wrong answer on the left and a correct answer on the right.

Fig. 5 displays a video as a learning material available in FizaAR to help students understand the lessons whenever they need it.

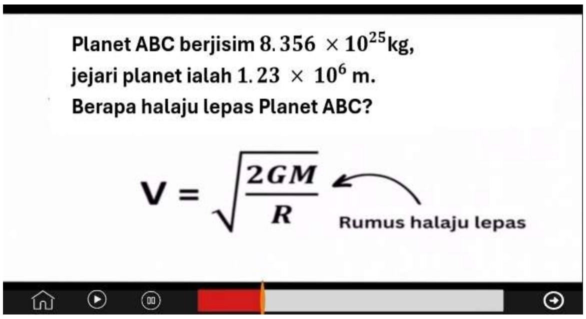

Fig. 5. The explanation of solving mathematical equations in Physics.

Fig. 6. A presentation from students.

Fig. 6 shows a presentation from students after each session using the AR learning kit. The students prepared the slides using their mobile phones within the allocated time. Then, the students did the presentation at the end of the class. The evaluation was done based on the presentation and observation of the students.

IV. Analysis and Findings

The demographic of the students involved 15 students aged 16 years old. As illustrated in Fig. 7, there were two male students and thirteen female students involved in the implementation.

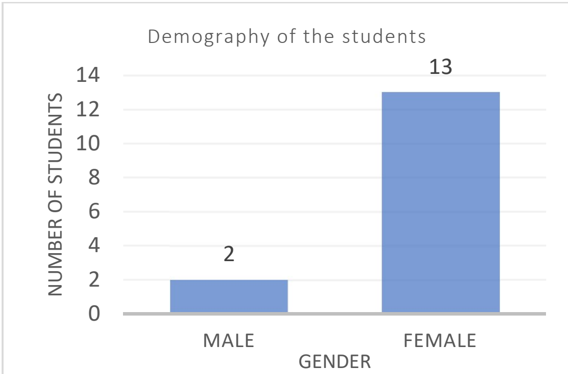

Fig. 7. The demographic profile of the students.

The findings of the study are discussed in each phase.

- **Phase 1: Need Analysis**

The interview from the needs analysis phase found that there is a need for development in the topic of Gravitation since this topic contains abstract concepts. They suggested a learning kit based on technology that might help the students to be able to understand abstract concepts. The teachers also stated that the students have problems in calculating since the calculation in this topic involves huge numbers.

This finding is supported by students' view on the need for a learning kit to help them learn Physics. When presented with a Five-Likert scale from 1 to 5 with Strongly Disagree (SD), Disagree (D), Intermediate (I), Agree (A) and Strongly Agree (SA), most students chose SA, which implied that they strongly agreed with the need for teaching aids to be applied in teaching and learning. There was no rating for Strongly Disagree (SD), Disagree (D), and Intermediate (I), and only four students chose A, which indicated they agreed with the need for teaching aids as shown in Fig. 8.

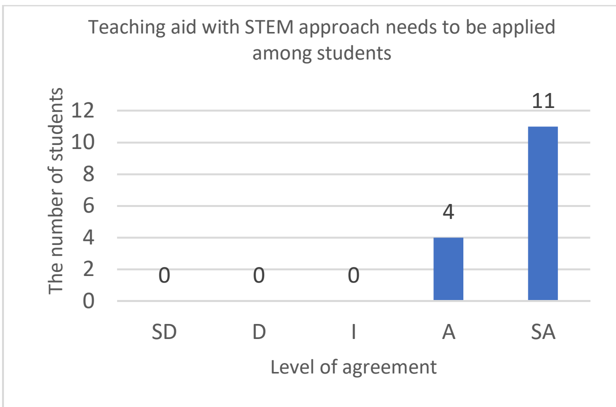

Fig. 8. Students' view on the need for a physics teaching aid.

Students also strongly agreed that Physics is best taught using activity-based learning. As shown in Fig. 9, eight students Strongly Agreed (SA), and four students Agreed (A) that activity-based learning is the best approach to teach Physics.

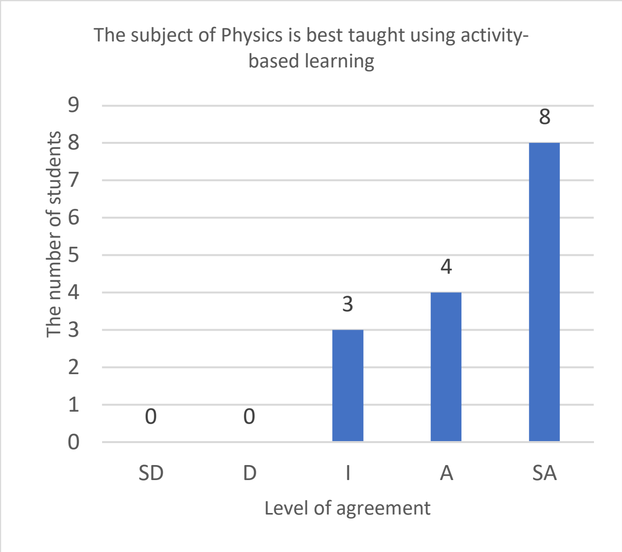

Fig. 9. Students' view on the best approach for learning physics.

The finding further illustrated that most students Strongly Agreed (SA) that interactive learning approach is the best approach to learn Gravitation topic in Physic. As shown in Fig. 10, nine students Strongly Agreed (SA) and six students Agreed (A) that interactive learning approach is the best approach to learn Gravitation topic in Physics.

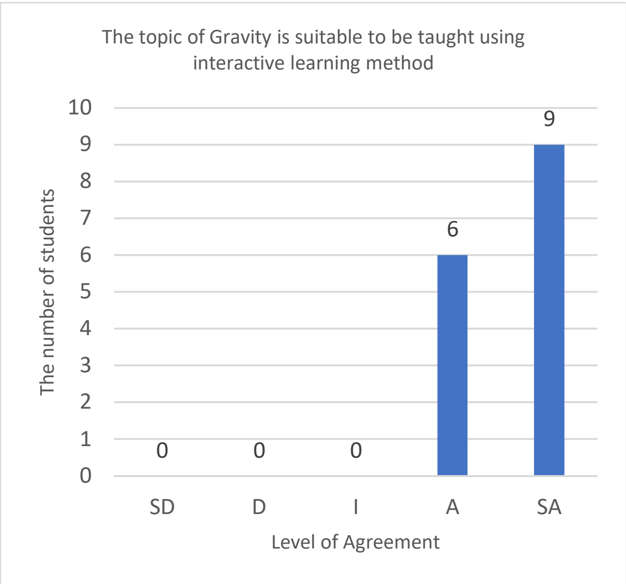

Fig. 10. Students' view on the use of interactive learning method to learn gravity topic in physics.

Finally, students strongly agreed that creative and innovative learning methods would increase their level of understanding in Physics. As illustrated in Fig. 11, twelve students Strongly Agreed (SA) and three students Agreed (A) that creative and innovative learning methods would increase their level of understanding in Physics.

Therefore, based on the questionnaire, students agreed that they learn Physics better in activity-based learning. They also agreed that interactive learning is the best approach in learning, especially in the topic of Gravitation. They also strongly agreed that the approach of creative and interactive learning would help them increase their level of understanding in Physics.

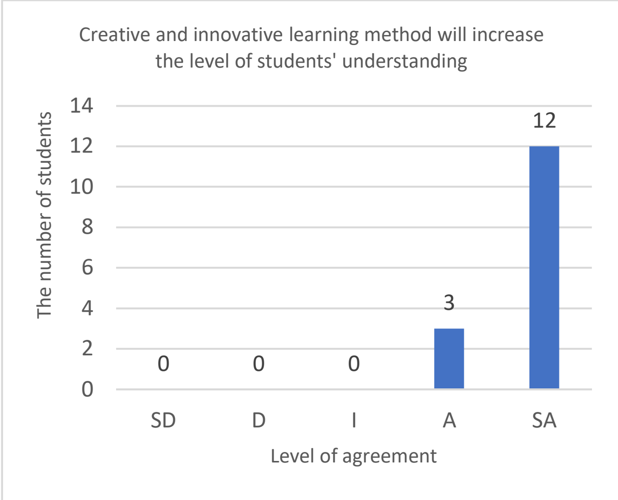

Fig. 11. Students' views on creative and innovative learning method and physics understanding

- **Phase 2: Design and Development**

The design and development phase comprised the experts in validating the AR learning kit. The experts evaluated the aspects of the curriculum for obtaining the learning outcomes desired which is to understand the Keplers' Law I, II, and III. The learning outcome is to determine the escape velocity and to find the value of each escape velocity of the planets. Next, the aspects of the evaluation involved the elements of CTML in the design of FizaAR, including media appearance, ease of use, the relevance of physical material in the media fit, and aspects of self-directed learning in FizaAR.

The criteria for the checklist for the experts in validating FizaAR consisted of a few constructs. It included the criteria for CTML in developing FizaAR, the aspects of designing in presentation, FizaAR in integrating cognitive learning theory, and CTML in the designing process. Furthermore, FizaAR was evaluated in terms of interface and the interactivity element in integrating augmented reality as an approach. FizaAR was evaluated as a learning material in applying self-learning strategies and it matched the curriculum of Physics in high school. Most of the experts agreed on the constructs in the checklist for each criterion.

- **Phase 3: Implementation and Evaluation**

The students who participated in the implementation of FizaAR were asked to do a presentation of each lesson according to the learning outcome.

Table 3 shows the scores achieved by the students during the implementation of FizaAR in the first learning outcome on the abstract concept in the topic of Gravitation, indicating that most groups achieved higher scores within the range of 70% to 80%. There were two groups who achieved more than 80 marks in the presentation. Each element in the rubric analytics was allocated 10 marks. Each presentation was evaluated by the rubric analytics that had already been prepared. Then, the total of each element was calculated for each group.

Table 3. Learning outcome evaluated by rubrics analytics for the first presentation of the students

Group	Element					Total score	Score (%)
	E1 /10	E2 /10	E3 /10	E4 /10	E5 /10		
K1	8	9	9	9	8	43/50	86
K2	8	7	7	8	7	37/50	74
K3	7	8	7	8	7	37/50	74
K4	8	8	9	7	8	40/50	80
K5	7	7	7	7	7	35/50	70
K6	8	7	8	7	7	37/50	74
K7	7	8	7	7	7	36/50	72

Table 4 shows that the second learning outcome evaluated by the teacher indicates most students achieved high marks. The second learning outcome is solving mathematical problems in physics in calculating the value of escape velocity. Two groups achieved 84% and 88% in their presentation at the end of each lesson.

Table 4. Learning outcome evaluated by rubrics analytics for the second presentation of the students

Group	Element					Total score	Score (%)
	E1 /10	E2 /10	E3 /10	E4 /10	E5 /10		
K1	8	9	8	8	9	42/50	84
K2	8	9	9	9	9	44/50	88
K3	8	7	8	7	8	38/50	76
K4	8	8	7	8	8	39/50	78
K5	7	8	8	8	7	38/50	76
K6	8	8	7	7	7	37/50	74
K7	7	8	7	7	7	36/50	72

Rubric analytics consists of elements to be evaluated. Element 1 (E1) evaluates the learning outcomes of each lesson and Element 2 (E2) consists of elements of organizational structuring on the presentation that evaluate the information on the presentation as clear and creative, attractive, and clear. Then, Element 3 (E3) consists of elements of content knowledge such as the presentation showing the synthesis of ideas, in-depth analysis, and evidence of original thinking. Element 4 (E4) consists of the style of presentation which demonstrates an engaging presentation style and effectively uses tone and creative use of language, and finally, Element 5 (E5) evaluates the overall quality of the presentation.

The evaluation shows that there was an increased number of scores in the group presentations at the end of each lesson. This is also supported by the interview with the students after the implementation of FizaAR. Three students stated that the study also helped students to have a better understanding of Physics with the use of FizaAR. For example:

AR helps because of its ease of understanding. Compared to the book, it's even more fascinating. (Student 1)

At first, when I study, I don't understand. When I study, I don't comprehend anything at first. After that, I think I can understand when I utilise the AR learning kit. I can understand and can do the calculations. (Student 2)

After using the material, I understand better. (Student 3)

One of the primary strengths of applying SCT to educational mobile apps is the potential to enhance students' self-efficacy beliefs. Well-designed mobile apps can provide tailored feedback for mastery experiences, which can positively influence students' confidence in their abilities to learn and achieve specific academic tasks. As self-efficacy is a strong predictor of academic performance and persistence [30], mobile apps that effectively cultivate self-efficacy can contribute to improved learning outcomes and student engagement.

Moreover, observational learning by multimedia resources, such as instructional videos, animations, and simulations, specifically AR, allows students to observe and model the behaviors and skills being taught. This study uses SCT as in students experience learning through a prototype mobile app. They learned from the video and then experienced simulations in AR with their friends. These features can be particularly valuable for subjects that require the acquisition of complex skills or procedural knowledge, as students can learn vicariously through observing others. When students observe skilled models with the use of technology, they learn knowledge, behavioral norms, cognitive abilities, and new competencies more quickly than when they only use active learning [40].

FizaAR learning kit uses animations and AR simulations to provide tools for goal setting, self-monitoring, and self-reflection, as well as to offer personalized feedback and guidance. Study shows that personalized feedback helps students regulate their learning processes and behaviors [89, 90]. Students take an active role in their learning and make necessary adjustments to their strategies and learning whenever they want to. Students in this study conducted presentations in class based on what they had learned. This promotes behavioral approaches among students. Developers and educators should strive to create intuitive and user-friendly mobile app interfaces or any learning kit using technology to provide adequate technical support and design feedback mechanisms that reinforce students' self-efficacy beliefs.

SCT facilitates comprehension of the elements influencing individuals' cognitive processes, such as their attitudes, beliefs, and motives, as well as how these elements influence behavior [91, 92]. Developers, educators, and researchers can work together to produce and combine educational content that nurtures self-belief with behavioral learning to establish a supportive learning environment by embracing a comprehensive understanding of SCT and its implications in varied educational situations.

V. Discussion and Conclusion

STEM components in this study focus on science components, especially in physics education. The study revealed an increased number of scores from each of the presentations by each of the groups during the implementation of FizaAR. It shows that the integration of technologies in education continues to expand, offering new opportunities to enhance learning experiences and student engagement. As the development and adoption of educational learning kits using technology has grown, it is crucial to ground their design and implementation in established theories of human cognition and behavior. The study suggests an instructional design to develop learning material with the application of Social Cognitive Theory (SCT) focusing on observational learning, CTML, and AR. In this study, the implementation emphasized learning with peers using the AR learning kit. Then, through discussion, the students were given tasks and prepared presentations at the end of each lesson. Students learn by observing teachers, peers, and educational materials. It is important to provide students with role models to foster excellent conditions for observational learning. The limitation of the study is that the study involved specific students in a high school. The study also focused on a small topic in the Physics subjects which is Keplers' Law I, II, and III and escape velocity. The study sought to help students understand abstract concepts and problem solving using technology-aided material.

The study demonstrated the potential of an AR learning kit to support vicarious learning experiences through animations, and AR simulations from the AR learning kit by examining fundamental concepts of SCT, such as self-efficacy and peer learning. Tailored feedback consists of right and wrong prompts whenever a question is either calculated correctly or not. The study shows the learning outcomes had been achieved with the integration of SCT and the use of AR learning kit. Therefore, FizaAR has been used as a complete phase of DDR to guide researchers in developing meaningful learning material systematically. Based on the limitations of the study, it is suggested that future research will include studies that employ robust research design such as quasi-experimental research design, a bigger number of participants, and include different topics in physics in various education settings.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Siti Nurqualbiah Mat Karim conducted the research, design and run the development and data analysis, while Aidah Abdul Karim and Intan Farahana Kamsin compiled the analysis and wrote the paper. All authors had approved the final version.

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