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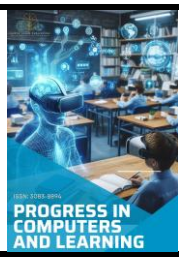

Design and Development of ExploreGeo Kit: Integrating Social Constructivism Theory in Game-Based Learning to Enhance Geography Concept Mastery

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ABSTRACT

As Malaysia's education landscape continues to evolve rapidly, the integration of technology-driven learning approaches has become more essential than ever. Thus, this paper presents the development of a learning kit called the ExploreGeo Kit. This kit serves as a learning material that employs a game-based learning approach to enhance secondary school students' understanding of fundamental geography concepts, specifically for the topics of Wind Direction and Angular Bearings. Despite proven benefits and positive responses towards multimedia-assisted teaching and learning, interactive multimedia applications or learning materials for geography subjects remain limited. Therefore, a systematic design and development of teaching aids was undertaken by applying the ADDIE instructional design model, which encompasses the phases of Analysis, Design, Development, Implementation, and Evaluation. In addition, Vygotsky's Social Constructivism Theory, which includes scaffolding, peer collaboration, and experiential learning, was integrated into the design and development process of the ExploreGeo Kit. Therefore, this paper provides educators with insights into developing interactive multimedia that foster enjoyment and engagement in learning.

1. Introduction

The rapid advancement of technology has revolutionised various sectors, including the field of education [1]. This development has also driven education in Malaysia to progress in tandem with global technological advancements through the adoption of technology-based teaching and emerging instructional approaches, such as game-based learning, which has gained increasing prominence [2]. This is because the integration of technology in education contributes to improved student achievement through a variety of methods that support its effective implementation in the learning process [3]. This approach integrates multimedia elements, including audio and images, to create an immersive learning environment that simulates real-world scenarios, enhancing students'

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engagement, comprehension, and problem-solving skills [4]. Existing studies indicate that game-based learning effectively facilitates more efficient knowledge transfer and long-term retention [5].

In the context of secondary school geography education, foundational topics such as Wind Directions and Angular Bearings are essential for mastering geographical skills and must be thoroughly understood before progressing to more complex concepts, as highlighted in the Ministry of Education Malaysia's Professional Circular Letter No.9 of 2016 [6], which includes topics such as latitude and longitude, mapping, weather, and climate. In alignment with the Malaysia Education Blueprint (2013-2025), the revised Geography curriculum under the Integrated Secondary School Curriculum (KSSM) underscores the mastery of 21st-century skills, which are crucial for students' holistic development and future workforce requirements [7].

The integration of game-based learning and multimedia technology not only enhances content delivery but also contributes to the development of essential skills such as collaboration, communication, and creative thinking [8]. Furthermore, the effectiveness of instructional implementation also depends on the credibility of the teacher as a facilitator and mentor who is capable of planning, managing, and coordinating the learning process systematically in alignment with the objectives set by the curriculum [9].

Although the effectiveness of multimedia-assisted instruction has been widely recognised, this approach does not necessarily lead to improvements in the mastery of core skills in education [10]. Learning materials that effectively integrate game-based learning remain limited, as most existing games do not emphasise key principles from learning theories, thus limiting their effectiveness in supporting meaningful learning. This is because the main challenge in implementing game-based learning lies in the complexity of game creation and the difficulty of integrating it into the learning process [11], while most educational games today are generally less capable of capturing players' interest compared to commercial games [12].

This reveals a significant gap in the availability of innovative educational resources tailored to foster student engagement and deepen understanding in the subject of geography. In response, this paper integrates Social Constructivism theory into the development of ExploreGeo Kit, a game-based interactive learning material crafted to strengthen students' foundational geographical knowledge. This initiative promotes deeper learning and supports the advancement of 21st-century educational goals, particularly in fostering academic excellence and student competencies [13,14].

2. Background of Problem

Geography education in Malaysia has undergone significant transformations in alignment with national educational requirements and contemporary developments. However, these changes present various challenges, including a shortage of qualified geography teachers, weaknesses in teaching strategies, inadequate school facilities, ineffective assessment methods, and the need for curriculum enhancement [15]. One of the most pressing concerns is students' difficulty in comprehending geographical concepts, which directly impacts their academic performance.

Teaching approaches remain predominantly teacher-centred, resulting in low student engagement and failing to cater to students' needs, interests, and learning preferences [16-20]. Consequently, many students struggle to grasp fundamental geographical principles, leading to a decline in interest in the subject [18,20,21]. Furthermore, an overreliance on teaching materials such as PowerPoint slides, textbook notes, and worksheets has contributed to student disengagement and boredom [20,22]. Therefore, there is an urgent need to integrate innovative approaches such as multimedia-based learning to enhance students' understanding and interest in geography [23].

Weaknesses in teaching strategies and the lack of high-quality teaching materials are among the key factors contributing to students' poor performance in the subject [19]. Additionally, the abstract and extensive nature of geographical content poses challenges in developing a clear conceptual understanding [24]. To address these issues, educators are encouraged to utilise visual media as teaching aids, as visualisation plays a crucial role in helping students comprehend geographical concepts related to spatial aspects [25]. Furthermore, instructional materials should be tailored to students' cognitive levels and presented concisely to maximise understanding [26]. However, constraints such as limited time for curriculum delivery restrict opportunities for students to engage in enrichment and remedial activities essential for their academic development [19,27,28]. Thus, the enhancement of more innovative and effective teaching strategies is critical to improving the quality of geography teaching and learning.

In response to these challenges, active learning has emerged as an increasingly recognised pedagogical strategy due to its proven ability to enhance student engagement, critical thinking, and deeper conceptual understanding. Grounded in constructivist learning theory, active learning emphasises student-centred approaches that encourage participation, collaboration, and the application of knowledge in real-world contexts [29]. The increasing complexity of modern education necessitates a shift from passive information transmission to instructional strategies that cultivate higher order thinking skills. Empirical studies indicate that strategies such as collaborative problem-solving, inquiry-based learning, and peer teaching effectively improve academic performance and student satisfaction [30]. Moreover, active learning aligns with the principles of Education 4.0, which emphasises mastery of complex thinking skills required in the digital era and knowledge-based economy [31].

Despite its advantages, the implementation of active learning faces several challenges, including resistance from educators accustomed to traditional teaching approaches, resource constraints, and the need for intensive training for teachers and lecturers [32]. Nevertheless, increasing evidence underscores the importance of active learning in addressing misconceptions and reinforcing deep understanding [30]. Interactive learning experiences not only have a positive impact on students' academic achievement but also support their emotional and social development [29]. Thus, the integration of active learning is a fundamental necessity to ensure high-quality, dynamic education that aligns with 21st-century learning needs.

One of the principal theoretical foundations of active learning is Social Constructivism, introduced by Lev Vygotsky. This theory posits that cognitive development is dependent on social interaction before internalisation occurs within the learner. According to a previous study [33], learning is an active process in which students construct knowledge based on prior experiences, rather than passively receiving information. Although influenced by Jean Piaget's constructivist learning model, which was highlighted in a previous study [34], Social Constructivism places greater emphasis on the role of cultural and linguistic interaction in shaping cognitive development [35]. One of its key concepts is the Zone of Proximal Development (ZPD), which refers to the difference between a learner's ability to solve problems independently and the level of development achievable with guidance and support [33].

The concept of scaffolding, where structured support is provided, has been proven effective in helping students tackle more complex tasks with the assistance of more knowledgeable peers or educators [36]. Furthermore, the theory advocates for collaborative learning, wherein students interact and benefit from knowledge-sharing with more experienced individuals [37]. While originally introduced as a learning theory, Social Constructivism has been extensively adapted in modern pedagogical practices, a study [38] identifying four core principles underpinning its implementation in the classroom.

In light of the issues discussed, this study aims to develop a learning material named ExploreGeo Kit. This kit integrates game-based learning with a learning video. The innovative learning activities are designed to enhance students' understanding of geographical concepts. The study will focus on the effectiveness of learning strategies based on Social Constructivism principles by a study [33] in strengthening students' comprehension of geography.

3. Development of ExploreGeo Kit

The development phase begins with the production and evaluation of the ExploreGeo Kit**.** During this phase, the core components of the kit are developed based on the ADDIE Model and Social Constructivism Theory to ensure a systematic and effective instructional design. Once these core components have been fully developed, an evaluation process is conducted to assess the content validity and effectiveness of the ExploreGeo Kit in supporting a holistic and student-centred learning approach**.**

3.1 Analysis Phase

This analysis was conducted to identify the types of challenges faced by students in learning Geography, in line with findings from previous studies, which indicate that the primary obstacle in this subject arises from a misalignment between teaching methods and students' learning styles [39], as well as students' heavy reliance on conventional teaching approaches, which hinders the development of geographical skills, particularly in problem-solving [40]. Accordingly, teachers are encouraged to adopt more effective instructional strategies to create a more interactive, conducive, and engaging learning environment in the classroom.

To ensure the development of a high-quality learning kit, the researcher conducted interviews with ten students from a school in the Johor district to gather feedback on the development process of the ExploreGeo Kit, particularly regarding students' preferred learning approaches in Geography. These students were involved solely to provide initial insight during the development phase and do not represent the actual research sample, as the study is not intended to be generalised to the broader population but rather focuses on a specially selected sample for an in-depth investigation. The participants comprised Form 1 students who had undergone Geography lessons and were randomly selected as respondents for the preliminary study.

During the interview session, students were asked: "What kind of approaches did you prefer in learning Geography?". The responses indicated that all students favored the game-based learning approach, as they perceived it to be more engaging and enjoyable, thereby enhancing their interest in learning. Students favoured game-based activities as they helped them grasp the topics more easily while enjoying the learning process. Additionally, students stated that games enhanced their ability to retain information and facilitated a better understanding of the lesson content.

Findings from a previous study [41] indicate that game-based learning empowers students to actively engage in the learning process by leveraging prior experiences to solve new problems. Furthermore, simulation-based games have been proven to accelerate the construction of new knowledge by providing students with opportunities to test their understanding in an environment that is both enjoyable and intellectually challenging [42,43].

Therefore, this study applies a game-based learning approach through the ExploreGeo Kit to facilitate students in constructing new knowledge based on prior experiences acquired in Mathematics. In this context, students engage in a simulation-based game activity, *Treasure Hunt*,

which is designed to require minimal preparatory complexity and can be conducted within an optimized timeframe to enhance learning efficiency.

3.2 Design Phase

The ExploreGeo Kit is developed based on the principles of Social Constructivism Theory [33] to enhance the effectiveness of learning in the topics of Wind Directions and Angular Bearings. This study adapts four key principles outlined by a study [38], namely Previous Experiences, Social Process, Situated Process, and Metacognitive Process. These principles are systematically integrated into the development of the ExploreGeo Kit to ensure a meaningful and effective learning experience. The four key principles of Social Constructivism Theory identified by a researcher [38] are explained as shown in Table 1 below.

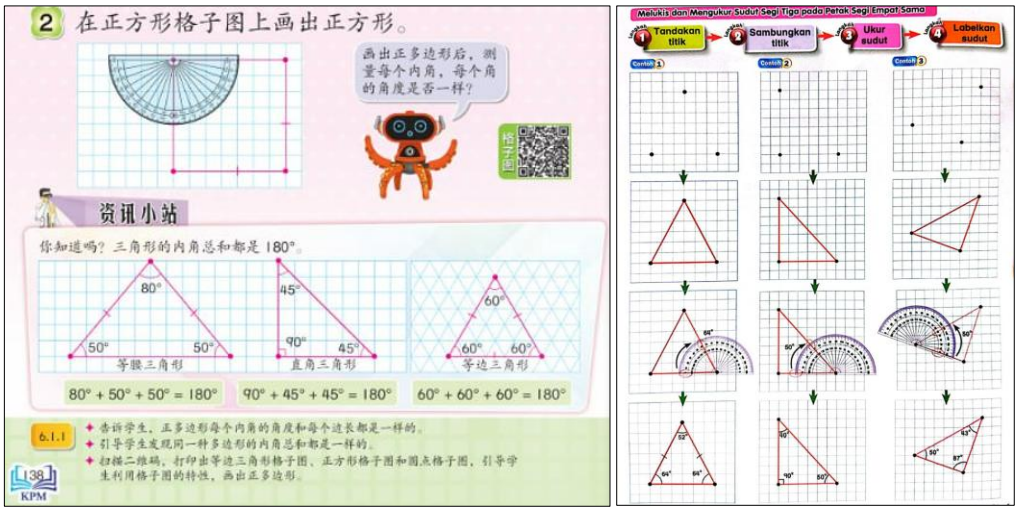
Table 1
Social Constructivism Theory [38]

Principle	Definition
Previous Experiences	Students need sufficient prior knowledge to learn new things and make connections
Social Process	Social Interaction should be fostered through group discussions
Situated Process	Placing the topics in a relevant context is important
Metacognitive Process	Students should be encouraged to become aware of their thinking processes through their learning

Based on the table above, the details of the design for the kit were designed as explained in the subtopic below.

3.2.1 Previous experiences

Previous Experience refers to the necessity for students to possess sufficient pre-existing knowledge as a foundation for mastering new concepts. This knowledge plays a crucial role in establishing connections between prior information and new concepts, thereby strengthening comprehension and enhancing learning effectiveness. In this study, students had prior knowledge of using protractors for angle measurement, as introduced in Unit 6: Space of the Year 6 Mathematics curriculum. Figure 1 illustrates this content, where (a) is sourced from *Mathematics Year 6 Sekolah Jenis Kebangsaan Cina* (KSSR Revision 2017) [44], and (b) is sourced from *Mathematics Year 6* (KSSR Revision – Latest Edition) [45]. This foundational knowledge serves as a critical element in supporting the effective learning of the newly introduced topic.



(a) (b)

Fig. 1. Content of Unit 6: Space in the Year 6 Mathematics Subject: (a) Source from Mathematics Year 6 Sekolah Jenis Kebangsaan Cina (KSSR Revision 2017) [44] (b) Source from Mathematics Year 6 (KSSR Revision - Latest Edition) [45]

Studies conducted by previous researchers [37,39] indicate that students with prior knowledge are better able to relate new information to existing contexts, thereby facilitating more meaningful and enduring learning. Accordingly, this study employs a game-based learning approach through the ExploreGeo Kit to support students in constructing new knowledge based on their previous experiences acquired in the mathematics subject. This approach aims to train and guide students in the effective use of protractors for angle measurement, following the procedural steps applied in Geography. It emphasizes the systematic and structured acquisition of bearing measurement techniques, ensuring alignment with geographical principles. Figure 2 shows the map used in the ExploreGeo Kit.

Fig. 2. Map used in ExploreGeo Kit

Furthermore, quiz-based learning has been shown to accelerate the construction of new knowledge by providing students with opportunities to test their understanding in an engaging yet challenging environment [42,43]. Consequently, each checkpoint in this game incorporates a timed

quiz task, which players must complete within two minutes to receive instructions for progressing to the next checkpoint, ultimately leading them to exit the zoo area. The quiz questions are designed based on the topics of Wind Directions and Angular Bearings, aiming to assess students' knowledge and skills related to these concepts. Figure 3 below presents an example of a quiz question from one of the checkpoints.

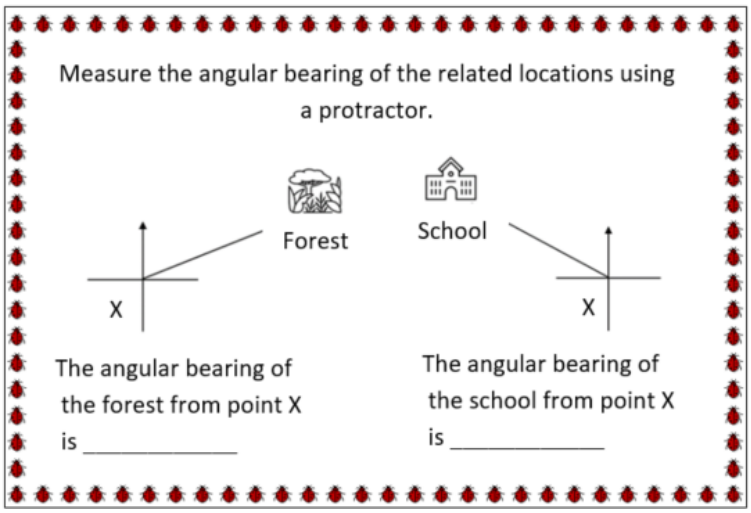


Fig. 3. Sample quiz question from a checkpoint

3.2.2 Social process

Social Constructivism Theory emphasizes that social elements, such as conversation, interaction with others, and the application of knowledge, are fundamental components in achieving learning objectives. As highlighted in a previous study [38], social interaction through group discussions should be facilitated, as interactions between students and more knowledgeable peers act as scaffolding within the ZPD, assisting students in acquiring new knowledge [33]. Therefore, the process of knowledge construction in this study is reinforced through social interaction and group discussions that occur as students engage in the game using the ExploreGeo Kit. Figure 4 shows an example of group discussion questions at one of the checkpoints.

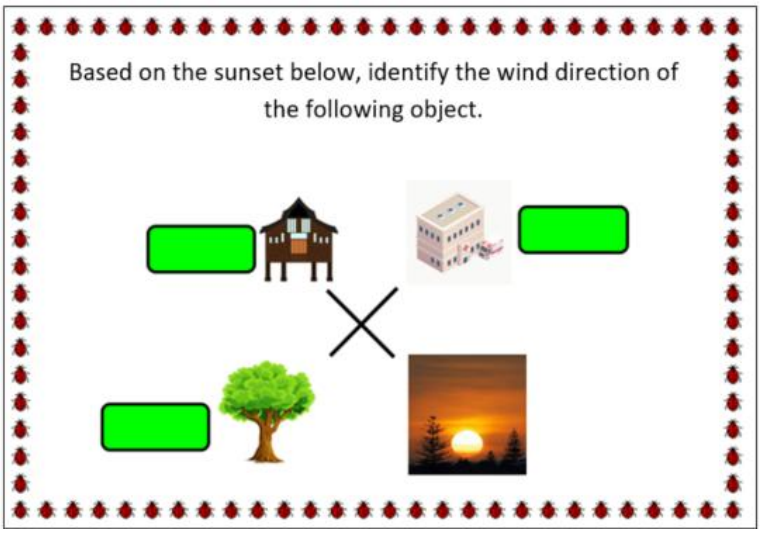


Fig. 4. Example of group discussion questions at one of the checkpoints

Additionally, while engaging in the game, students interact and share knowledge with their group members as they work collaboratively to complete the tasks assigned at each checkpoint. Group discussions are essential in this process, enabling students to determine the most accurate answers required to receive instructions for progressing to the next checkpoint. Thus, the principle of social interaction within Social Constructivism Theory serves as a catalyst for collaborative learning, where discussion and cooperation among students enable them to complete tasks more effectively and overcome learning challenges through peer support. This demonstrates that structured social interaction can enhance understanding and foster deeper, more meaningful knowledge construction.

3.2.3 Situated process

The Situated Process emphasizes the importance of embedding learning topics within relevant contexts [38]. Therefore, this study aligns the topics of Wind Directions and Angular Bearings with appropriate real-world contexts to ensure a holistic and effective instructional approach, thereby strengthening students' understanding of the dynamic relationships between environmental elements. The student activities in this study, specifically the gameplay using the ExploreGeo Kit, are intentionally structured to embed the concept of Wind Directions and Angular Bearings within a context that is both meaningful and pedagogically relevant.

The ExploreGeo Kit, developed based on twelve game elements [46], is designed to actively engage students in understanding the topics of Wind Directions and Angular Bearings while ensuring they can relate this knowledge to real-world contexts. This approach enhances relevance, practicality, and effectiveness in reinforcing both conceptual understanding and applied skills. As students' progress from one checkpoint to the next, they must apply their skills in determining Wind Directions and measuring Angular Bearings using a protractor, following predefined instructions. An example of these instructions is illustrated in Figure 5 below.

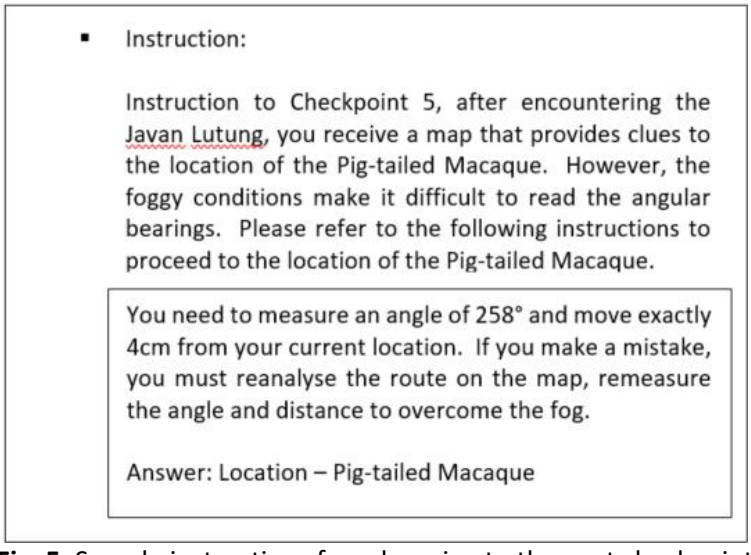


Fig. 5. Sample instructions for advancing to the next checkpoint

Based on Figure 6, students are required to accurately apply their skills in measuring Angular Bearings using a protractor on a map to ensure precise navigation towards the designated location. In the event of a measurement error, students must reanalyse the mapped route and carefully remeasure both the angle and distance to overcome the challenge. This process is designed to

reinforce students' understanding of the importance of accuracy in measuring Angular Bearings to reach their destination precisely. Figure 6 shows a protractor used to measure angular bearing.

Fig. 6. A protractor used to measure angular bearing

Furthermore, at each checkpoint in the ExploreGeo Kit game, students are required to answer a quiz related to the topics of Wind Directions and Angular Bearings within a two-minute time limit to receive instructions for proceeding to the next checkpoint. These quiz questions are designed based on four relevant subtopics within Wind Directions and Angular Bearings, aiming to enable students to apply these concepts in a practical and meaningful learning context. Figure 7 below illustrates a quiz question from one of the checkpoints.

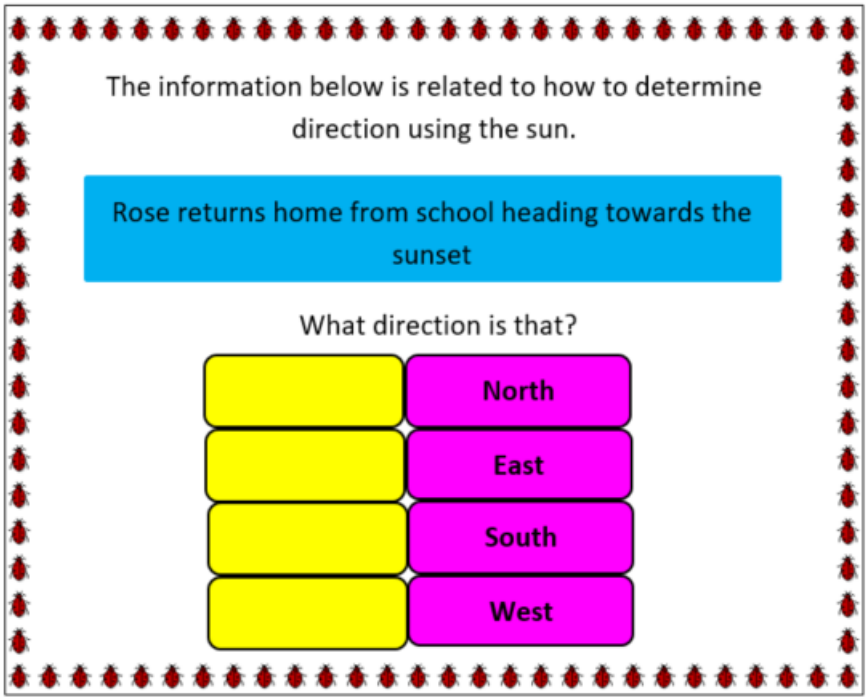


Fig. 7. Quiz questions at one of the checkpoints

3.2.4 Metacognitive process

The Metacognitive Process refers to the effort to encourage students to become aware of and understand their thought processes during learning [38]. Challenging tasks in gameplay have the potential to enhance students' metacognitive abilities, as such tasks require players to think creatively, adapt strategies according to the situation, and explore multiple solutions through discussion and collaboration within their groups to overcome obstacles encountered.

Thus, this study has designed challenging tasks within each checkpoint instruction by integrating obstacle elements that players must overcome. Players are required to devise optimal strategies to navigate these obstacles, ensure the selection of the correct route, and apply critical thinking to reach their intended destination safely. Figure 8 below illustrates an instruction containing obstacle elements at one of the checkpoints.

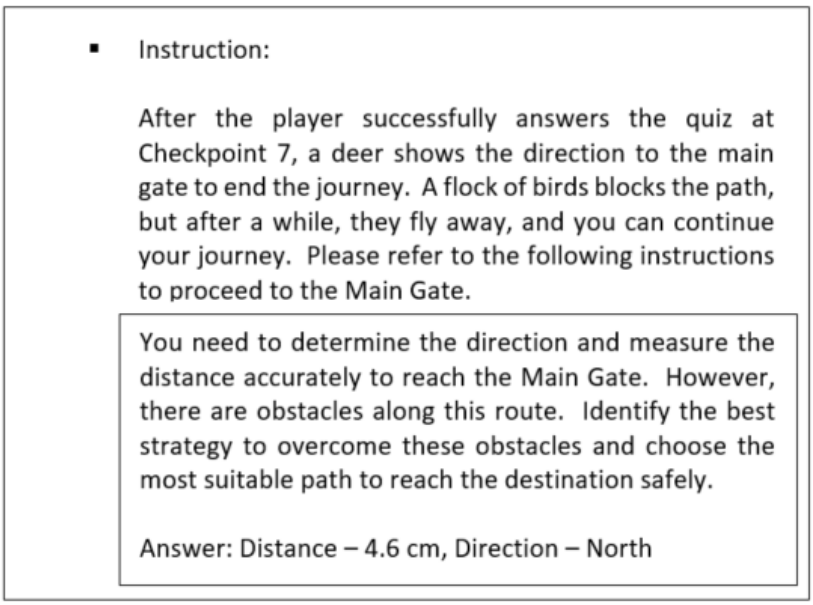
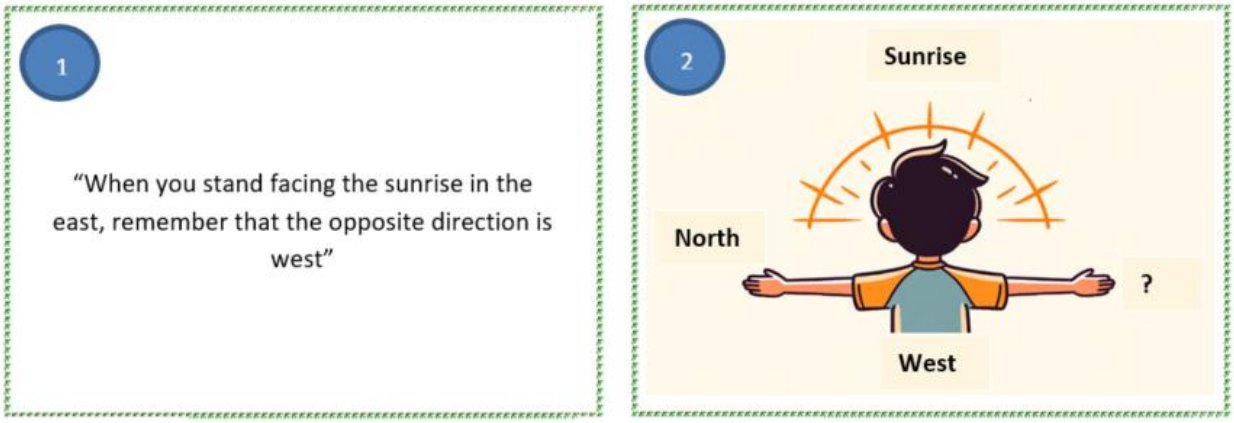


Fig. 8. Instruction containing obstacle elements at one of the checkpoints

Furthermore, the metacognitive process can be developed through gameplay that provides immediate feedback when students give incorrect answers. This enables them to identify weaknesses in their strategies or understanding, analyse the causes of errors, and correct misconceptions. This is because students are encouraged to actively reflect on, monitor, and evaluate their learning processes.

Therefore, this study provides immediate verbal feedback from the game moderator on the answers given by players after responding to quiz questions on the question card, indicating whether the answer is correct or incorrect. If the answer is correct, the game moderator will announce, "Congratulations, your answer is correct," and reward the player with two cartoon stickers. However, if the answer is incorrect, the moderator will state, "Your answer is incorrect, please try again," and provide a hint to assist the player in arriving at the correct answer. Figure 9 below illustrates a hint given at one of the checkpoints: (a) Hint 1 and (b) Hint 2.



(a) (b)

Fig. 9. Hint at one of the checkpoints: (a) Hint 1 (b) Hint 2

Players are given the option to use either Hint 1 or Hint 2. A player who selects Hint 1 and provides the correct answer will receive one cartoon sticker, whereas a player who chooses Hint 2 will not receive a sticker, even if their answer is correct. Therefore, players must engage in group discussions to decide whether to select Hint 1 or Hint 2 to ensure the accuracy of their responses.

Furthermore, reflection plays a crucial role in the metacognitive process, as it involves the ability to monitor, evaluate, and regulate one's thinking to enhance learning effectiveness. Previous studies have demonstrated the significance of structured metacognitive reflection in improving cognitive and decision-making processes. A previous study [40] found that systematically implemented metacognitive reflection enhances the efficiency of decision-making strategies, while another study [47] reported that students who engaged in reflection after receiving their test results showed a significant improvement in academic performance. Additionally, it has been confirmed in a previous study [48] that post-action reflection significantly enhances students' problem-solving abilities.

Therefore, in this study, after each intervention, students are required to engage in verbal reflection on their experiences in the game and their learning of the topics Wind Directions and Angular Bearings. Students are encouraged to evaluate the strategies they employed, the decision-making processes they undertook, and the improvements needed to enhance their performance in subsequent gameplay. The goal is to become the winning team by collecting the highest number of cartoon stickers**,** answering quiz questions as accurately as possible, and being the first group to complete the game's mission.

3.2.5 The interconnection between social constructivism theory principle in learning activities

The interconnection between the four core principles of Social Constructivism Theory – Previous Experiences, Social Process, Situated Process, and Metacognitive Process is demonstrated in the design and implementation of learning activities using the ExploreGeo Kit. These principles do not function in isolation; rather, they form a cohesive pedagogical framework that enhances students' cognitive and social development. Learning begins with students' previous experiences, where prior knowledge serves as a foundation for grasping new concepts. For example, students' familiarity with using a protractor in mathematics enables them to apply this skill effectively in measuring angular bearing in geography. This foundation is further enriched through the social process, where group discussion and collaboration allow students to share ideas, clarify misunderstandings, and support each other's learning within Vygotsky's ZDP. Peer interaction thus becomes a bridge that connects existing knowledge to new understanding.

Simultaneously, the situated process embeds learning in a real-world context, which strengthens the relevance and applicability of the content. By navigating tasks related to Wind Direction and Angular Bearing within a simulated environment, students can engage with the content in a meaningful and authentic way. This contextual learning reinforces their comprehension and allows them to apply theoretical knowledge to practical challenges. These experiences are then internalised through the metacognitive process, where students are encouraged to reflect on their strategies, assess their problem-solving methods, and adjust their thinking based on feedback received during gameplay. Immediate verbal feedback and reflective prompts promote self-regulation and critical thinking. Together, these four principles create a dynamic and integrated learning environment where knowledge is co-constructed, contextually grounded, socially supported, and cognitively processed, resulting in a deeper, more holistic learning experience.

3.3 Development Phase

The development of the ExploreGeo Kit environment begins with establishing clear learning objectives, aligned with curriculum requirements to enhance students' understanding of geographical concepts, develop problem-solving skills, and foster social interaction. This is followed by the structured and systematic design of the game framework, integrating game-based learning elements as outlined by previous researcher [46], which include fun, play, rules, problem-solving, goal, interactivity, interaction, representation, adaptability, outcome & feedback, winning, and conflict**.**

The ExploreGeo Kit game is designed as a group-based activity, involving four to five students, with one student acting as the game moderator, responsible for managing the game and providing instructions to players throughout its implementation. The gameplay is structured into multiple checkpoints, each containing tasks and quizzes. The game procedures are meticulously designed to guide the overall process and clearly define the roles of both players and the game moderator, ensuring that the game is conducted in an organised, engaging, and pedagogically effective manner**.** Figure 10 illustrates the game procedures of the ExploreGeo Kit.

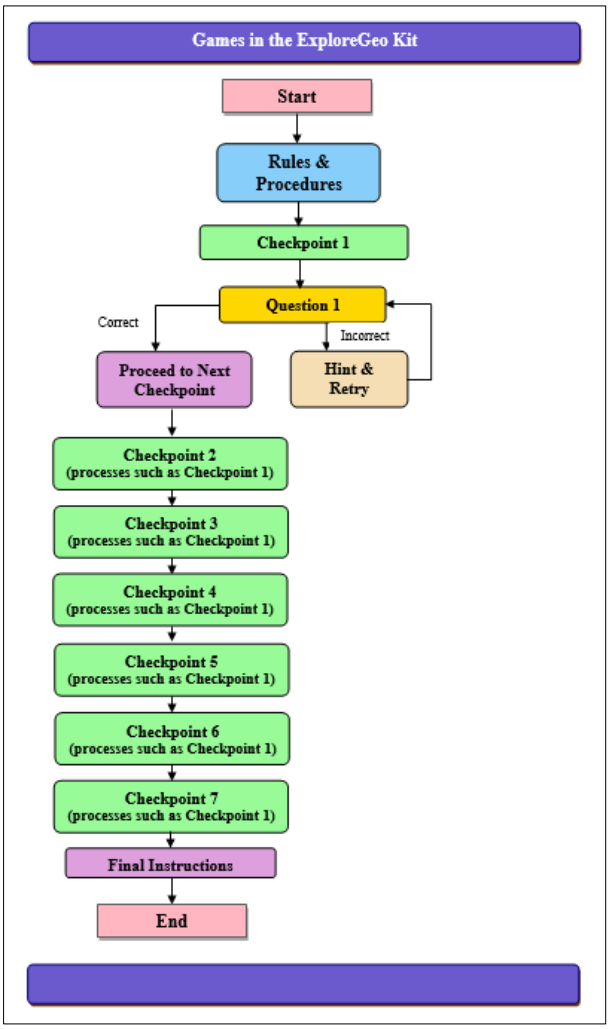


Fig. 10. Gameplay procedures of the ExploreGeo Kit

The gameplay procedures begin with the game moderator explaining the game rules to the players. Players progress through several checkpoints, each containing tasks and quizzes related to the topics of Wind Directions and Angular Bearings. If they answer a quiz correctly, they receive instructions to proceed to the next checkpoint. However, if they answer incorrectly, a hint is provided to assist them in finding the correct answer, and they are given another opportunity to retry. This process is repeated at each checkpoint until players reach the final checkpoint and complete the game's mission, escaping from the zoo. To ensure smooth classroom implementation and provide clear guidance for teachers, a comprehensive user manual has been developed and included in the kit to support the effective facilitation of game-based learning activities. Figure 11 illustrates the cover of the ExploreGeo Kit user manual.

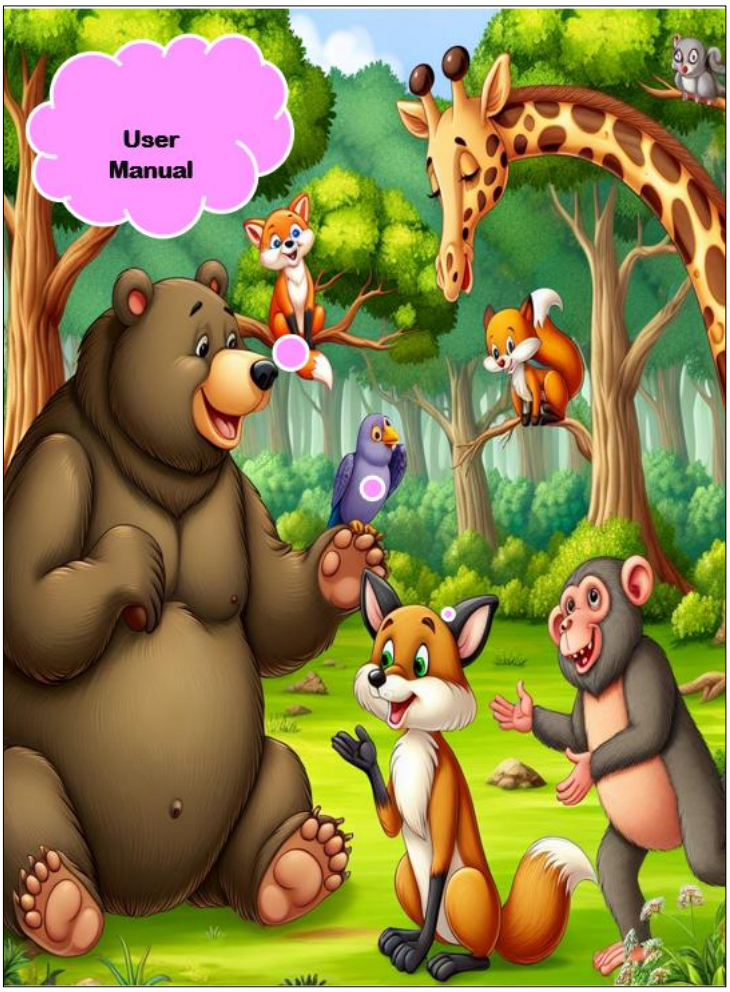


Fig. 11. Cover of the ExploreGeo Kit user manual

3.4 Implementation and Evaluation Phase

Alpha testing was conducted with a small group of students who shared similar characteristics with the actual study respondents to identify weaknesses in the game design and task structure. The feedback obtained from this pilot test was used to refine the design and functionality of the ExploreGeo Kit, ensuring greater effectiveness and alignment with the intended learning objectives. Once the refinement process was completed, the kit underwent an expert evaluation, where selected specialists assessed its functionality and design elements before its implementation to ensure its suitability and quality.

Two educational technology experts with more than seven years of experience in teaching educational technology were responsible for validating the game-based learning elements and the principles of Social Constructivism Theory. Meanwhile, two Geography teachers with over ten years of teaching experience evaluated and verified the accuracy of the quiz content related to Wind Directions and Angular Bearings. Upon successful validation, the ExploreGeo Kit was deployed by the actual study respondents as part of the intervention phase**.**

4. Conclusions

This study highlights the significance of game-based learning in improving secondary school students' understanding of fundamental geographical concepts, particularly Wind Directions and

Angular Bearings. The ExploreGeo Kit, developed based on the ADDIE instructional design model and Social Constructivism Theory, aims to provide an interactive and engaging learning experience through game-based activities. While the integration of technology and active learning strategies enhances student motivation and conceptual understanding, some educators may struggle with its implementation due to limited pedagogical and technological skills. To address this challenge, the ExploreGeo Kit is not intended to replace traditional teaching methods entirely but rather to serve as a complementary tool that diversifies instructional approaches. By fostering an immersive learning environment, this tool encourages student participation, critical thinking, and collaborative problem-solving. However, its successful implementation depends on educator readiness, adequate resources, and proper training. This paper only focuses on the design and development of the kit; the implementation and analysis of its effectiveness will be conducted after the kit has been validated. Future research should explore ways to optimize the effectiveness of game-based learning tools in diverse educational settings to further enhance student engagement and academic achievement.

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