Space Travel: Game Development to Promote the Learning of Science Subjects about Solar Systems for 4th-Grade Students

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Abstract—The objectives of this research are to develop a game to promote the learning of the solar system in science subjects of 4th-grade students, to compare the academic results of pre-and posttest of students after learning with the space travel game and to determine the satisfaction level of students with the space travel game. The sample group used in the experiment was 4th-grade students from school T, and classes were randomized using the stratified random sampling method. Students were categorized into two groups: those with average scores and those with high scores in science subjects. The final results were compared between the control group, 27 students learning using the conventional method, and the experimental group, 27 students learning using the space travel game. There were 52 students in total. The tools used in this experiment are a space travel game, an achievement assessment test, a pre-and posttest, and a questionnaire to determine the satisfaction level of students. The statistical tools used are the mean, percentage, standard deviation, paired t-test, and independent t-test. The results of this experiment showed that the experimental group learning from the game obtained a higher score than that of the control group by 1.19, on average. The scores of both groups were shown to have statistically significant differences at a 95% confidence level.

Keywords—4th grade students, education game, solar system

1 Introduction

Applying science to our daily lives and careers and creating equipment and goods that benefit people is crucial—technology development benefits from scientific knowledge. As a result, human growth includes the ability to think logically, creatively, and analytically. It also includes critical research skills and methodical problem-solving abilities. Additionally, it bases conclusions on facts and corroborated testimonies. Science is the modern world's culture, known as a knowledge-based society.

Therefore, everyone should acquire scientific information to understand nature and technology better and be able to apply knowledge. Teachers must employ various instructional strategies and learning tools to encourage pupils to think critically and methodically. However, many things could be improved in Thailand's educational system. The limitations of the teaching methods, particularly those that place a heavy emphasis on textbooks, are to blame for the majority of the issues. Instead of helping students develop their understanding, it emphasizes helping them memorize the material, as was discovered when the researcher spoke with science teachers. For example, some students needed help learning to characterize different types of planets. The planets could not be sorted in the solar system.

Due to these issues, many schools have tried to provide educational resources over the years in various ways. This technique improves science learning outcomes, particularly concerning the solar system issue. This is evident from Kirikkaya, Iseri, & Vurkaya (2010) [16], who studied grade 7 learning in results for the academic areas of space and solar systems. It was discovered that game activity could improve learning motivation.

Due to the use of educational games, other forms of learning materials do not interact with and respond to learners, as well as learning through educational games. By requiring students to play the game following the rules, this process aids learners in learning per their learning objectives. The game will support the traditional method, increasing students' interest in learning, motivation for learning, engagement, and learning going with the flow [1-7].

Playing games can increase students' interest in their studies. This is also evident from a study on creating computer games for students in El Mawas et al.'s (2020) [6] primary school to learn about science concepts related to the solar system. Students demonstrated a high level of satisfaction while learning with games. It was discovered that the experimental group that used the game in their learning activity performed much better than the control group and that the students had a great learning experience when using the Final Frontier game [6]. Games in the classroom will help students learn the material effectively and have fun while studying instead of getting bored. [7],[9]. [15],[23].

The context and substance of games created for educational purposes must be considered with the lesson's content. Adjusting the game's material to the player's proficiency level. [2] To ensure that each learner has a productive learning experience, it focuses on finding solutions to their difficulties.[13] The use of games in the classroom should be encouraged to allow teachers to become familiar with the rules and content of the game before using it with students. Because playing educational games in class will encourage conversation and collaborative learning among all students. [9],[18]. During the COVID-19 pandemic. Since they must study alone and are unhappy, the students are still determining whether they are lonely or just unhappy. It is comparable to taking classes with others [11-12].

To encourage students to use their imaginations while learning, the researcher asked the science teachers at School T about difficulties in teaching and learning about space travel. The researcher created a game to encourage the learning of science subjects after discovering that the school has used many different technological teach-

ing media. However, no game media for teaching science subjects about solar systems to grade 4 students at school.

2 Objective

1. To develop games to promote learning of science subjects about solar systems for students in grade 4.
2. To compare the academic achievement of grade 4 students before and after using the space travel game to promote learning in science subjects about the solar system for students in grade 4.
3. To study the students' satisfaction after learning the space travel game.

3 Theoretical framework

When designing and developing educational games that encourage classroom collaboration among students and boost academic performance, In order to get the participant's brain to wake up and remember the type and shape of the stars in the game, the researcher selected an adventure game. Since the game's genre fits the content's need to describe processes, observations, judgments, and talents. A fluid learning method that uses games as a base is employed. The following components will be present in the game: Interactive, Representation and story, Challenge, Rules, and Fun.

To get players to focus on the lesson's material, the game must be engaging and appealing till the kids perceive that playing games while learning is enjoyable and not dull. The game's fluidity design must account for the student's degree of playability and topic knowledge. The learners will become bored if the game's content and difficulty are too challenging. On the other side, if the game's substance and difficulty are too easy, the players would get bored [1-10], [14-5], [18-20].

4 Literature review

Research on using games to raise student achievement has been undertaken recently. Most of them include space, Objects, Attributes and states, Actions, Rules and goals, Skill, and chance [28]. The creation and development of instructional games were done using the fluidity idea. By keeping a balance between the game's challenge and difficulty. Until it causes the pupils to get fun and go with the flow. The game must also continue to be entertaining and engaging to draw players and encourage them to learn more; this is called EGameflow [7], [15], [20-24], [27], [30].

5 Research conceptual framework

So, Figure 1 shows the conceptual model of this study. Our interests are to investigate the relationship between learning development variables with the space travel

game and students' attitudes. The independent variables are 1) student information, 2) game elements, 3) game design, and 4) solar system lessons. The dependent variables are: 1) game-based learning with EGameflow, 2) student satisfaction, and 3) academic achievement.

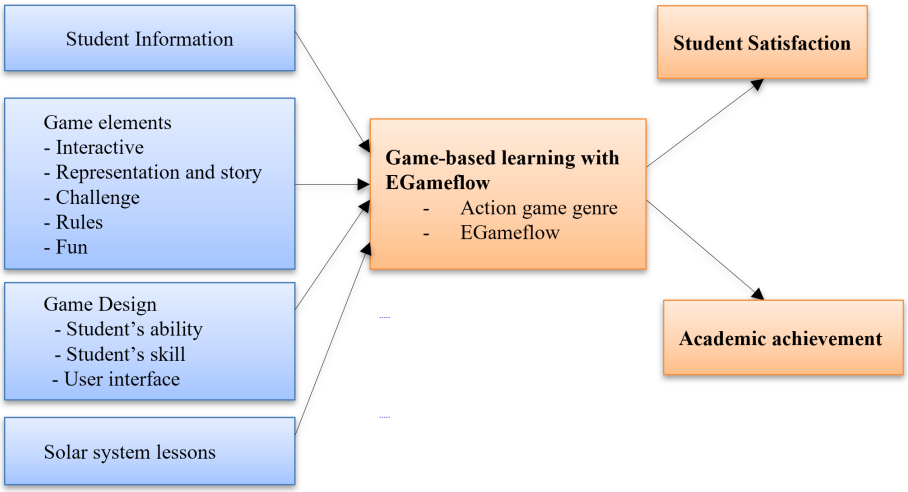

Fig. 1. Research conceptual framework for developing learning with the space travel game

6 Hypothesis

Students who learned using space travel games and those who studied with a traditional learning method had statistically significant differences in academic achievement at the 95% confidence level.

7 Research methodology

7.1 Sample group

In this research, an experiment was conducted on 54 grade 4 students from T School, all of whom achieved intermediate academic results. In this experiment, the sample groups were separated into two groups: the experimental group and the control group.

7.2 Data collection

Experimental data were collected from the sample group.

1. Students in the sample group were to perform a pretest to obtain academic achievement.

2. Conducting experiments:
3. Describe the directive by encouraging the experimental group's students to play games that teach science concepts related to space travel. Advice on how to play the game was continuously given to the students.
4. A posttest was taken to determine achievement after learning with the game.
5. Students in grade 4 take a test to assess their learning after playing space travel games using the same format as the preschool achievement test.

Experimental data were collected from the control group.

1. Students in the control group performed the pretest to obtain academic achievement.
2. Students learn about space travel in science subjects in a conventional way.
3. A posttest was taken to determine the achievement after learning the lesson typically.

7.3 Materials

Space travel game. The design and development of this game is a digital game that consists of various elements [10], which are fun, gameplay, rules, goals, interactive, adaptive, outcomes, feedback, challenge, problem-solving, interaction, representation, and story [1], [4], [7-10], [15], [18-20]. These elements are elaborated in Table 1, and Table 2 shows some main screens of the game.

Space travel is an educational game to promote the learning of science subjects about solar systems for 4th-grade students. This type of game is an action game. The balance of the game's difficulty levels and elements is based on the EGameflow model as they construct and develop the game. Storytelling, entertainment, educational material, drawings, and character design [4],[6],[8-10],[15-17]. The details of the game designs in space travel are described below [18-25],[27],[30].

Table 1. Space travel game design

Game element	Question	Objective of measurement
Interactive	The in-game illustrations were beautiful and clear.	To study the students' academic achievement and satisfaction after learning with the space travel game.
	Are the in-game illustrations attractive and exciting?	
	The in-game font character was suitable for playing the game?	
	The in-game font size was suitable for playing the game?	
	The in-game font colour was appropriate for the gameplay?	
	The sound effects in the game were crisp and clear.	
Representation and story	The game story was interesting and appropriate?	
Challenge	The game level was suitable for players?	
Rules	The game sections have instructions and explain in detail how to play, which is easy to understand.	
Fun	The game is fun and attractive.	

Table 2. Description of the space travel game

Figure	Description
	The game's narrative.
	In each level, players must shoot stars that resemble stars; for instance, in the Mercury stage, they must shoot Mercury. This will help the gamers recall the stars [8].

Narratives in the game are as follows.

Lesson 1: Neptune
- The shape of the planet
- Characteristics of the planet
- Planetary elements

Lesson 2: Uranus
- The shape of the planet
- Characteristics of the planet
- Planetary elements

Lesson 3: Saturn
- The shape of the planet
- Characteristics of the planet
- Planetary elements

Lesson 4: Jupiter
- The shape of the planet
- Characteristics of the planet
- Planetary elements

Lesson 5: Mars
- The shape of the planet
- Characteristics of the planet
- Planetary elements

Lesson 6: Earth
- The shape of the planet
- Characteristics of the planet

Planetary elements
Lesson 7: Venus
The shape of the planet
Characteristics of the planet
Planetary elements
Lesson 8: Mercury
The shape of the planet
Characteristics of the planet
Planetary elements

Learning achievement tests. The pretest exam measures the learner's knowledge before starting the experiment, and the posttest exam measures the learner's knowledge after the experiment.

Satisfaction questionnaire. Since the space travel game learning satisfaction questionnaire was based on the Likert scale, with one meaning "very dissatisfied" to 5 meaning "very satisfied". The interpretation of each level is listed below so that the analysis of student satisfaction can be performed [24-25]:

1.00 – 1.80 = very dissatisfied
1.81 – 2.60 = moderately dissatisfied
2.61 – 3.40 = neither satisfied nor dissatisfied
3.41 – 4.20 = moderately satisfied
4.21 – 5.00 = very satisfied

7.4 Quality assessment of the tools

Experts in multimedia have assessed the tools used in this research technology field using an estimation scale according to the Likert method [15],[16]. Space travel received an excellent overall score on the quality assessment used to evaluate the calibre of science educational materials (x = 3.98, S.D. = 0.91). Three experts evaluated the content validity of the grade 4 students' pre- and post-science tests on space travel to determine each item's consistency index (IOC) on the learning achievement test. The IOC value was found to be 0.7798. The test was modified as needed by the researchers using the tools. It was also tested on no population groups, such as grade 5 students, to evaluate the test's difficulty (P) and discriminant power (R) using a criteria-based summary of each item. Low-weighted reliability was 0.7667 overall. The content validity of the survey regarding gamers' satisfaction with space travel games was examined by three experts. As a result, each item's index of conformity (IOC) was determined to be 0.934, indicating that the questions were consistent with the learning objectives.

7.5 Data analysis

The researcher analyzed the data and processed it with a computer using a packaged program.

- The pretest and posttest achievement of the control and experimental groups were compared using the statistical values used to compare the population that were not independent of each other (paired t-test).
- Mean and standard deviation was used to study satisfaction with space travel game.

8 Results and discussions

The learning achievement test is based on the pretest and posttest to compare the students' knowledge before and after learning between the control and experimental groups. The paired t-test and t-test independent are the analysis to answer this hypothesis. All results are shown in Tables 3, 4, and 5.

Table 3. Paired samples t-test of posttest – pretest in the control group

	Number (N)	**Mean ($\bar{x}$)**	**S.D.**	**t**	**Sig.**
Post–Pre	27	3.15	1.875	8.724	.000

Between the pretest and posttest, it was found that the control group had prior learning achievement. The differences in means from both tests are highly significant at a 95% confidence level ($p < 0.05$).

Table 4. Paired samples t-test of posttest – pretest in the experimental group

	Number (N)	**Mean ($\bar{x}$)**	**S.D.**	***t***	**Sig.**
Post – Pre	27	4.04	1.911	10.976	.000

Between the pretest and posttest, it was found that the experimental group had prior learning achievement. The differences in means from both tests are highly significant at a 95% confidence level ($p < 0.05$).

Table 5. T-test independent of posttest–pretest between the control group and experimental group

	Number (N)	**Mean ($\bar{x}$)**	**S.D.**	***t***	**Sig.**
Con–Exp	52	4.04	1.911	10.976	.017

The control group consisted of students who learned through traditional lectures, and the experimental group consisted of students who learned through games that promoted science topics related to space travel. It was discovered that the experimental group had accomplished more, with a mean score difference of 1.19 between it and the control group. It was concluded that the control and experimental groups had

a statistically significant difference in learning achievement at a 95% confidence level ($p < 0.05$).

Table 6 shows that the satisfaction survey results revealed that space travel had the highest level of satisfaction, with a mean score of 4.55 and a standard deviation of 0.36. When examining each component, it was discovered that the game's illustrations also had a high level of satisfaction are beautiful on a very high level.

Table 6. Student's satisfaction after learning about space travel

No	Question	Mean	S.D.	Interpreted
1	The in-game illustrations were beautiful and clear.	4.74	0.53	very satisfied
2	Are the in-game illustrations attractive and exciting?	4.67	0.55	very satisfied
3	The in-game font character was suitable for playing the game?	4.56	0.70	very satisfied
4	The in-game font size was suitable for playing the game?	4.56	0.64	very satisfied
5	The in-game font colour was appropriate for the gameplay?	4.56	0.75	very satisfied
6	The sound effects in the game were crisp and clear.	4.48	0.70	very satisfied
7	The game story was interesting and appropriate?	4.41	0.75	very satisfied
8	The game level was suitable for players?	4.63	0.63	very satisfied
9	The game sections have instructions and explain in detail how to play, which is easy to understand.	4.26	0.71	very satisfied
10	Is the game fun and attractive?	4.63	0.69	very satisfied
	Total	4.55	0.36	very satisfied

The satisfaction level was at the highest level. The in-game illustrations were beautiful and clear ($\bar{x} = 4.74$, S. D = 0.53). The in-game illustrations were attractive and interesting at the highest level of satisfaction ($\bar{x} = 4.67$, S. D = 0.55). Respectively, sections have instructions that explain in detail how to play and are easy to understand. ($\bar{x} = 4.26$, S. D = 0.71).

Because a researcher created the game, it is an action game with content that can be used to test each planet's shape memory while playing. Students must retain each planet's colour and shape in the game [17] and fire appropriately following that shape to receive points; if the student fires the incorrect planet, it will receive fewer points. For the kids, shooting planets in the allotted time is challenging. Students are required to attempt to memorize the form of the globe. Once all ten stars have been hit, continue shooting. After that, they will be able to continue and play the quiz game. Playing shooting games with planets with students to inspire students to be aware and get ready for learning. When students move to play quiz games, they will feel motivated to provide the most exact answers in order to advance to the next stage [6-9],[15-16],[19],[23-24],[29-30]. As a result, when the posttest results were taken into account, it was discovered that the learning achievement of the students who learnt through games was higher than that of traditional learning.

Games are used to manage learning in the classroom, allowing students to ask questions at any moment and learn alongside classmates. Make the learning environment joyful and enjoyable. Accordingly, considering the questionnaire's findings, it was discovered that both the learners' ability to learn through games and their satisfac-

tion with doing so were at the highest levels. Additionally, this outcome can show that students are pleased with how space flight is illustrated—they find it beautiful, understandable, eye-catching, and fascinating. The game's difficulty is appropriate for learning while also being enjoyable and beautiful, in keeping with EGameflow[7].

9 Conclusions

This study aimed to compare the science learning outcomes of fourth-grade students who attended regular lectures and the results with those of students in the control group who studied using a game. The researcher requests that the results be discussed, considering the analysis as follows.

1. Students in the sample group obtained slightly higher results than students in the control group, with a difference of 1.19.
2. Students' satisfaction level with the space travel game is high.
3. Students enjoy the gameplay and user interface of the game, which is under the game flow and elements.

The results of this experiment showed that the experimental group learning from the game obtained a higher score than that of the control group by 1.19, on average. The scores of both groups were shown to have statistically significant differences at a 95% confidence level.

Utilizing EGameFlow to create instructional games enables students to get into the flow. Engaging with the material for extended periods and having fun will improve learning outcomes.

Cooperative and participatory learning should be the foundation of game-based learning because their peers will motivate them to want to study more. Due to the competitive nature of game-based learning, game-based learning may combine team or group learning approaches to aid in developing learners' social and interpersonal communication skills [22].

For future research, the study should be done on the relationship between learning styles and group or team games that can boost the level of learning flow of individual learners or the study of the proportion of challenging within the game with the learning flow of individual learners and studying the type of game to be developed in order to develop an educational game suitable for the skills of the learners. Including the learners' educational background

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