applied sciences

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Brief Report

The Application of Game-Based Teaching for Water Resources Science Learning

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Abstract: It is essential to encourage scientific understanding of water resources. However, how to achieve this for different objects needs to be researched further. Therefore, the purpose of this study is to analyze the impact of game-based teaching on elementary school students' learning satisfaction in water resources science applications. Students who take the course are asked to complete a learning satisfaction questionnaire at the end. A total of 420 questionnaires were distributed, with 388 being effective, a 92% effective ratio. The questionnaire data was used to conduct the study and analysis. The Cronbach's α for all factors exceeded 0.7, indicating that the questionnaire items are stable and internally consistent. The results of descriptive statistics, factor analysis, independent sample *t*-test, regression analysis, and correlation analysis revealed that students were extremely satisfied with game-based water resources science teaching. According to factor analysis, three key factors influenced learning satisfaction: "learning style," "learning interest," and "learning process." Furthermore, "learning interest" was positively related to "learning style" and "learning process," with both having a significant effect on "learning interest." The findings of this study also show that water resources science applications can be taught and promoted in a variety of ways.

Keywords: water resources science; game-based teaching; learning satisfaction

Citation: Yang, H.-C.; Lee, M.-T.; Lin, L.-C. The Application of Game-Based Teaching for Water Resources Science Learning. *Appl. Sci.* **2022**, *12*, 9920. https://doi.org/10.3390/app12199920

Academic Editor: Ramaraj Boopathy

Received: 3 September 2022
Accepted: 29 September 2022
Published: 2 October 2022

1. Introduction

Reservoirs, river dams, water intake structures, and fishways are all commonplace in daily life. As a result, water resources science should not be regarded solely as a specialized field, and it is critical that the general public comprehends water resources science as it applies to their daily lives [1–3]. Learning about water resources science will help people understand why floods occur and bring people together to help eliminate flood hazards. As a result, popularizing and promoting knowledge of water resources science is essential. The promotion of popular science begins in elementary school, and fostering elementary school students' interest in water resources science will strengthen knowledge in this field [4,5]. Elementary school students may have difficulties such as not recognizing certain nouns, needing to be talked to in an understandable manner, not knowing how water resources science relates to them, and so on. Because water resources science covers a broad variety of topics, the water cycle may be addressed at the elementary level to help students comprehend the source and usage of water resources. This enables students to comprehend the connection between water resources and their lives.

Using scientific games for teaching is a method of converting natural science subjects into games in which students gain knowledge via pleasurable learning. Concern for the teaching setting, exploration, discovery, invention, and introspection are all part of the scientific game teaching process [6]. According to Huang and Lai [7], science games used for education should be coupled with real-life experiences to attract students' interest. Teachers should be concerned about their students' safety; the teacher should first demonstrate the procedure, and then students should try it for themselves. Students should be given greater opportunities for operation. When leading students, the teacher does not need to instantly express the scientific concept; instead, the teacher should allow students to gradually explore for themselves, assisting them in developing the proper scientific techniques and motivating their attitude and creativity in science. Therefore, using science games to teach students involves more than just letting them play games. Science games are activities that contain scientific principles or concepts and allow students to have fun with science [8]. A science game is a game-based learning strategy that integrates scientific principles and hands-on operation with educational objectives under flexible rules [9]. Presentations are the methods of conventional water resources science education [10].

According to the descriptions above, this study proposes integrating game-based teaching to investigate learners' learning satisfaction in order to improve the way they learn. The additional benefit of this research is that it might help instructors understand how to improve the way their students learn and boost learning pleasure. Furthermore, it can improve research participants' comprehension of water resources science and increase the likelihood of it being appreciated. As a result, the purpose of this study is to learn how to increase water resources science learning satisfaction through game-based teaching to entice more students to learn the subject. This study employs water resources science as a subject in popular science promotion activities, allowing students to comprehend its contents and, as a result, identify the factors that influence students' learning satisfaction in game-based teaching. This study also investigates the factors that affect students' learning interest in the subject. Based on the findings, teachers hopefully will incorporate water resources scientific games into the teaching curriculum and utilize science games as a teaching tool to pique students' interest in this subject of science.

2. Literature Review

2.1. Science Games and Teaching

In recent years, many institutes and educators have devoted their efforts to popular science education. Game-based teaching is used to simplify scientific principles and incorporate them into students' daily lives, allowing them to enjoy learning [11,12]. The goal of game-based teaching is for students to learn scientific principles while having fun [13]. In a broad sense, science games can include math games, physics games, chemistry experiments, educational toys, and science toys, among other things [14,15]. Science games are a combination of science activities and games that allow students to learn scientific principles through play [16]. They are both a type of scientific activity and a type of game. Science games are not as strict as science experiments, which emphasize the operation process rather than experiment procedures, but they are also not as relaxed as games [17]. As a result, science games must include scientific principles, and students must apply their scientific knowledge in the process. In a nutshell, science games are a hybrid of "science" and "games." Science toys are excellent teaching instruments for nature, physics, and chemistry, and may be used to operate scientific concepts and investigate fundamental scientific laws while children have fun [18,19].

To summarize, scientific games are entertaining and intriguing, and they pique kids' interest in science. Teachers who employ science toys in conjunction with science concepts not only assist students to gain scientific information and boost their focus but also pique kids' enthusiasm for science [20]. Teaching scientific games entails more than simply allowing students to play games. Teachers must start with students' interests, plan complete contents and instruments, and incorporate scientific knowledge into the games so that students become interested in science and develop scientific concepts while playing the games; students will also gain a sense of accomplishment through future active participation in related activities. Teachers who can use students' prior knowledge as a foundation, support, and guide, and expand their knowledge, create an appropriate learning environment; furthermore, using science toys and games to guide students in learning will allow students to build concepts they are attempting to learn and will aid the process of science teaching activities, effectively elevating students' science literacy [19].

2.2. Learning Satisfaction

The term "satisfaction" is ambiguous since it varies depending on the individual and the circumstance. People's perceptions of the quality of goods, services, jobs, life, and the environment are frequently gauged by their level of satisfaction. The perception of whether the good or service is acceptable given the price paid is known as satisfaction [15]. Each person's demands and expectations for the learning process are unique. The individual will feel content and be eager to participate in the learning activity once more if what they learn fits their requirements or expectations. On the other hand, they will not want to participate in learning activities any longer if their wants or expectations are not met. As a result, learning satisfaction is a crucial learning result [21]. Studies on learning satisfaction can point out course flaws and suggest fixes, which benefits learners and directs progress [22,23]. High learning satisfaction provides a lot of advantages, such as boosting learning motivation, lowering learning institutions' dropout rates, addressing course-related problems, enhancing services, and increasing the number of learners. It also strengthens learners' will to continue studying [22,24]. Learners' perceptions of their learning outcomes are determined based on the discrepancy between what they learn and what they anticipated learning. Learners will be satisfied when this discrepancy is lower, but when it is more significant, learners will be less satisfied [25,26]. In summary, learning satisfaction may be utilized to determine whether or not students' learning outcomes in educational activities match their requirements and expectations.

3. Research Methodology

The course program is designed based on the research team's discussion, taking into account the learning level of the participants and selecting the course theme (water cycle) that best matches them. Following the establishment of a half-day course schedule, the content of the activity execution is finished in accordance with this schedule. For the purposes of this study, primary school students were given a game-based teaching course and then a questionnaire survey was conducted after the course. A total of 420 questionnaires were issued, of which 388 questionnaires were effective, with an effective ratio of 92%. The satisfaction assessment questionnaire used in this study was produced by combining and summarizing relevant research (i.e., [27,28]), which serves as the fundamental framework of the questionnaire, and then producing the questions and completing the reliability and validity analysis. The following list represents the learning satisfaction questionnaire's items: (1) You like this activity; (2) You like the contents taught in class; (3) You like game-based teaching; (4) You like hands-on experience; (5) You concentrate on the lecture in class; (6) You are eager to answer questions in class; (7) You work hard with members of your group in class; (8) You understand the contents taught in class; (9) Game-based teaching makes it easier for you to understand the contents; (10) Hands-on experience makes it easier for you to understand the contents; (11) Understanding what the teacher is teaching gives you a sense of achievement; (12) Playing games gives you a sense of achievement; (13) Knowing how to operate the teaching tools gives you a sense of achievement; (14) You will participate in the next science related activity; (15) You will recommend that friends participate in related science activities. The responses were recorded on a five-point Likert scale [29].

In order to satisfy the demands of guiding students to learn through scientific toys and science games (Lai and Wang, 2010), water resources science teaching materials were divided into two parts; one is a monopoly game, and the other is a jigsaw puzzle. Monopoly uses a water world map (as illustrated in Figure 1) designed by this study for students to learn about the water cycle and water resources science concepts. When playing monopoly, students are separated into groups and move by rolling dice. At each step, there are a number of cards containing water resource related knowledge. Students who answer correctly can move forward. The card's contents comprise knowledge about each facility. Students that play the game will not only have a good time, but they will also obtain knowledge about water resources science. The jigsaw puzzle is cut at the red line and folded at the black line (as illustrated in Figure 2). Students have to figure out how to fold the puzzle into four different pictures, including a "water world map," "Taiwan's 25 main rivers," and a "Taiwan reservoir distribution map."

Figure 1. Water world map. Reproduced with permission from Han-Chung Yang, Water Resources Primary School; published by Shu-Chuan Publishing House, 2015 [30].

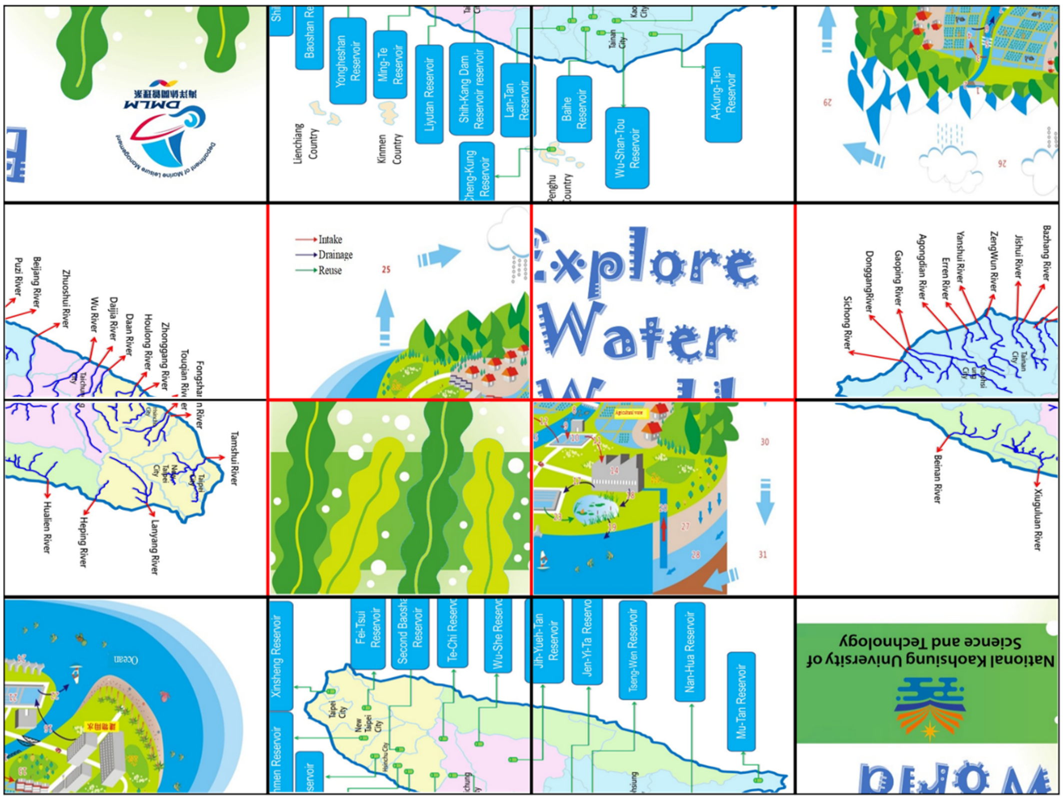

Figure 2. Jigsaw puzzle.

4. Analysis Results

Quantitative statistical analysis methods used in this study include Cronbach's α reliability analysis, descriptive statistics, factor analysis, independent sample t-test, regression analysis, and correlation analysis. Cronbach's α is used to test the internal consistency of items. A higher Cronbach's α value indicates stronger reliability; a value greater than 0.7 indicates high reliability, 0.7~0.35 indicates moderate reliability, and lower than 0.35 indicates low reliability [31]. Cronbach's α can be used to measure the reliability of research variables and learn the consistency of constructs [31].

Of the 388 effective samples, 188 or 48.5% were "male," and 200 or 51.5% were "female"; the number of female respondents was 3% more than male respondents. In terms of the grade that respondents were in, 39 or 10.1% were in the first grade, 40 or 10.3% were in the second grade, 74 or 19.1% were in the third grade, 84 or 21.6% were in the fourth grade, 82 or 21.1% were in the fifth grade, and 69 or 17.8% were in the sixth grade.

Factor analysis is used to extract factors that affect learning satisfaction. Factors with a KMO value that reaches 0.9 are an extremely good fit; the chi-square value of the Bartlett test of sphericity was 2473.592 *** ($p < 0.001$), indicating that it is appropriate for factor analysis. Three factors were extracted based on the analysis results; one was named "learning style" because the items are related to the contents of interactive teaching and actual operation [32]; the second was named "learning interest" because the items are related to liking science courses and the intention to recommend and participate in the course [33]; and the third was named "learning process" because the items are related to students' learning process in class [34]. The Cronbach's α of all factors exceeded 0.7, showing that the items on the questionnaire are stable and internally consistent; the total variance explained is 58.005%, as shown in Table 1.

Table 1. Factor analysis.

	Learning Style	Learning Interest	Learning Process
Knowing how to operate the teaching tools gives you a sense of achievement.	0.744		
Hands-on experience makes it easier for you to understand the contents.	0.731		
Playing games gives you a sense of achievement.	0.720		
Game-based teaching makes it easier for you to understand the contents.	0.708		
Understanding what the teacher is teaching gives you a sense of achievement.	0.675		
You like hands-on experience.	0.610		
You like game-based teaching.	0.548		
You understand the contents taught in class.	0.490		
You like this activity.		0.774	
You like the contents taught in class.		0.697	
You will participate in the next science related activity.		0.729	
You will recommend that friends participate in related science activities.		0.480	
You concentrate on the lecture in class.			0.754
You are eager to answer questions in class.			0.699
You work hard with members of your group in class.			0.703
Eigenvalue	6.312	10348	1.040
Variance (%)	42.083	8.986	6.936
Cumulative variance (%)	42.083	51.069	58.005
KMO value: 0.897, Bartlett ball test chi-square value: 2473.592, significance: 0.000			

To see the difference in learning satisfaction of students by background variables (gender), an independent sample t-test is used for analysis to further understand differences in each aspect (learning style, learning interest, and learning process). Analysis results are shown in Table 2. There was no significant difference in each aspect of learning satisfaction between respondents of different gender ($p > 0.05$). The results show that male and female students have the same high level of satisfaction with the contents of the activity. As a result, it is possible to conclude that the game-based teaching approach developed by this study may make students of different genders feel extremely satisfied when participating in this activity course.

Table 2. The difference in learning satisfaction of students by gender variable.

Factor	Variable	Number	Mean	Standard Deviation	f Value	*p* Value
learning style	male female	188 200	4.65 4.71	0.46 0.46	−1.24	0.346
learning interest	male female	188 200	4.66 4.61	0.45 0.56	1.04	0.159
learning process	male female	188 200	4.38 4.39	0.62 0.68	−0.34	0.395

Table 3 shows that "learning interest" is positively related to "learning style" and "learning process," with the correlation coefficient reaching the level of significance at $p < 0.01$ and R between 0.4 and 0.6, indicating moderate correlation. Finally, regression analysis is used to understand the interplay between "learning interest," "learning style," and "learning process." Table 4 shows that the Beta value of "learning style" is 0.736 (t = 6.007, $p < 0.000$), and the Beta value of "learning process" is 0.352 (t = 9.833, $p < 0.000$), showing that learning style and learning process both have a significant effect on learning interest.

Table 3. Correlation Analysis.

	Learning Interest	Learning Style	Learning Process
learning interest	—	0.666 (**)	0.448 (**)
learning style	0.666 (**)	—	—
learning process	0.448 (**)	—	—

** $p < 0.01$.

Table 4. Regression analysis.

	Original Regression Coefficient (B)	Standard Deviation	Standardized Regression Coefficient (Beta)	t Value	Sig.
learning style	0.736	0.042	0.666	6.007	0.000
R = 0.666; R2 = 0.444; Adjusted R2 = 0.442; F = 308.082					
learning process	0.352	0.036	0.448	9.833	0.000
R = 0.448; R2 = 0.200; Adjusted R2 = 0.198; F = 96.692					

According to the findings of this study, students prefer game-based teaching. Instead of reading materials, students use their hands to perform tasks and help each other while playing games, increasing their opportunity to interact. Changes in learning style or process are thus all related to students' learning interests. As a result, both "learning style" and "learning process" had a significant influence on "learning interest" in the activity. This research also demonstrates that learning style and learning process satisfaction can predict learning interests; that is, when learning style and learning process satisfaction are high, learning interest is also high. This indicates that to improve overall learning satisfaction, we must first focus on designing the learning style and learning process of game-based teaching and then arouse students' interest in learning.

5. Conclusions

According to the study's findings, using science games to teach primary school pupils about water resources has been quite successful. Since textbook information is turned into engaging games as part of science-based instruction, students can learn important scientific concepts while having fun. According to this study, it was this procedure that contributed to students' high levels of general satisfaction. Students of different genders showed no discernible variation in their satisfaction with their learning. Additionally, the educational activity's learning process and learning style have a significant impact on students' interest in learning about water resources science. Based on the above results, game-based teaching should differ in the design of course activities as well as the contents of the teaching plan. The design of course activities, regardless of gender, should be built on interaction and practical operation. The design of lesson plan contents should encourage and give chances for students to participate in course activities. Game-based teaching can also attempt to designate corresponding levels of difficulty, or use a challenge level system, which may allow students to gain a sense of accomplishment in the process of achieving complex challenges, arouse interest, and then have the opportunity to improve overall satisfaction. Based on this finding, it is advised that teachers create curricula that combine science games related to water resources to engage students in the subject matter. This will enable the field's abilities to develop and an understanding of water resources science to take root at an early age. The findings of this study also suggest that water resources science applications can be promoted and taught using a variety of methods.

Author Contributions: Conceptualization, M.-T.L., L.-C.L. and H.-C.Y.; methodology, H.-C.Y.; formal analysis, H.-C.Y.; writing—original draft preparation, H.-C.Y.; review and editing, M.-T.L., L.-C.L. and H.-C.Y. All authors have read and agreed to the published version of the manuscript.

Funding: The APC was funded by National Kaohsiung University of Science and Technology.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: All data will be available on reasonable request.

Acknowledgments: The authors would like to thank the National Science and Technology Council, Taiwan, for their financial support of this research under Contract NSC 102 -2515 -S-366 -001.

Conflicts of Interest: The authors declare that they have no conflict of interest.

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