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Game-Based Learning for Groundwater Conservation: Enhancing Student Engagement and Sustainable Practices

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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. Groundwater is one of the most challenging common pool resources to govern, resulting in resource depletion in many areas. We present an innovative use of collective action games to not only measure propensity for cooperation, but to improve local understanding of groundwater interrelationships and stimulate collective governance of groundwater, based on a pilot study in Andhra Pradesh , India. The games simulate crop choice and consequences for the aquifer. These were followed by a community debriefing, which provided an entry point for discussing the interconnection of groundwater use, to affect mental models about groundwater. A slightly modified game was played in the same communities, one year later. Our study finds communication within the game increases the likelihood of groups reaching sustainable extraction levels in the second year of play, but not the first. Individual payments to participants based on how they played in the game had no effect on crop choice.

Either repeated experience with the games or the revised structure of the game evoked more cooperation in the second year, outweighing other factors influencing behavior, such as education, gender, and trust index scores. After the games were played, a significantly higher proportion of communities adopted water registers and rules to govern groundwater, compared to other communities in the same NGO water commons program.

1. INTRODUCTION

1.1 Importance of Water Resources

Common in daily life are fish ways, water intake structures, river dams, and reservoirs. Consequently, water resources research should not be seen only as a specialized discipline; rather, it is essential that the general population understands water supplies research as it relates to their everyday life. People may better understand why floods happen and work cooperatively to reduce flood threats by learning about the science of water resources. Therefore, it is crucial to popularize and spread knowledge about water resources science. Popular scientific education starts in the first grade, and encouraging younger pupils' dedication to water-related technology will only improve our understanding of this area. Several words could be challenging for preschoolers to comprehend, they could require to be spoken to in a comprehensible way, they might struggle to comprehend the connection between water resources science and themselves, and and so forth. Water-based economics includes a wide range of subjects, including the flow of water, which may be covered at a basic level to assist children understand the source and application of the water supply. It assists pupils understand how water-related issues affect how they live everyday. Astronomical activities are a fun way for kids to understand basic biological concepts.

1.2 Game-Based Learning for Water Science Education

Modern instruction with games involves considering the educational environment, exploring, discovering, inventing, and reflecting. Huang and Li recommend combining scientific activities with actual life scenarios to engage pupils. To ensure the security of learners, educators ought to illustrate the method beforehand before they allow children to try the technique on their own skin. Kids have to be provided more possibilities for operations. As opposed to immediately expressing scientific concepts, teachers ought to empower pupils to research independently, establish suitable scientific methodologies, and foster an open mind and inventiveness towards science. Utilizing scientific activities to educate people requires greater than simply playing ones. The success of educational games for environmental responsibility, and specifically for equitable water management, has been the subject of the most recent literature. Starting with the findings that variables like expected goals, the intended audience, and both temporal and spatial scales have a significant impact on both the development of video games approaches and studies developed to evaluate them, a framework has been developed for directing and reflect regarding the conception and evaluation of interactive games strategies.

1.3 Impact of Game-Based Learning on Student

As per the mentioned explanations, this research suggests incorporating game-based instruction to examine students' learning satisfaction and enhance their learning process. Another advantage of this investigation is the reality that it may provide teachers with insights into methods to enhance the educational experience of their pupils and increase their enjoyment of studying. Additionally, it may increase the possibility that water management knowledge will be valued and enhance survey respondents' understanding of it. Therefore, the goal of this project is to determine how to use educational games to improve student achievement in water-related science and encourage additional learners to pursue the field. The availability of water science is used in this study as a topic in common science programs, enabling students to understand its contents and, consequently, determine the elements that affect their educational happiness in instruction through games. The elements influencing the interest of learners to pursue the topic are also examined in the present research. It is hoped that teachers will use science activities as an instructional instrument to spark curiosity among pupils in the environment and integrate them into their courses following the results of the study.

2.PROBLEM STATEMENT

2.1 Insufficient Knowledge Regarding Ground water Conservation

A major global concern , water shortage is made worse by unsustainable consumption patterns, climate change, and rising demand. Even though conservation is desperately needed, it is still difficult to get young people to adopt water-saving habits. It is frequently the case that traditional teaching methods are unable to hold their attention or promote sustained behavioral change. In order to promote proactive involvement and raise environmental awareness, game-based learning has become a viable technique. Through games people learn about conservation methods such as crop irrigation diversification , artificial recharge of ground water.

2.2 Inept Water Conservation Training Methods

Present ground water conservation is all theoretical and do not provide any practical information . Conventional methods such as textbooks , rarely occurring awareness camps, lecture based lessons make it harder for students to adapt them to real life scenarios. A gamified strategy is capable of handling this by letting users test out various conservation strategies in virtual settings that replicate actual circumstances like pollution and droughts. Students will be able to get deeper understanding of the issue and the actions to taken to use water resources more conservatively also their actions which may directly affect the resource.

2.3 Lack of Participation in Environmental Knowledge

The subject of ecology is unappealing for numerous youngsters, which results in inadequate information recall and little practical use. An educational game about freshwater preservation can keep players interested by including game features like rankings, prizes, and social sharing. This participatory method will boost motivation and guarantee that conservation information is successfully retained and used.

3.OBJECTIVES & SCOPE

3.1 Objectives

3.1.1 Educate on Groundwater Conservation

Conventional approaches to teaching freshwater preservation can occasionally be difficult and uninteresting, particularly for children and adolescents. Utilizing an entertaining and engaging system, this app seeks to make these ideas easier to understand while allowing users to gain knowledge as they participate. Through the use of illustrations, modeling, and resolving issues components, users are going to be enabled to understand the significance of freshwater management in an engaging and easy-to-understand manner. Users will be encouraged to develop ethical water usage behaviors by the game's integration of real-life water management tactics, challenges, and prizes.

3.1.2 Encourage Sustainable Water Practices

Introducing and promoting the use of efficient water-saving techniques is a major component of the challenge. The actions that follow will be covered for participants: Synthetic Refill: This is the procedure of recharging freshwater through refuel boreholes, rainfall collection, and additional techniques. The use of micro-: Effective techniques for watering that reduce the use of water in farming, including spray and trickle networks. Choosing water-efficient plants that minimize excess utilization of groundwater is known as diversifying the crops. The effects associated with these actions on the condition of groundwater and their contribution to sustainable development over time will be demonstrated to participants during interactive games.

3.1.3 Simulate Real-Life Scenarios and Challenges

In an effort to enhance the realism of the process of education, the simulation will include numerous situations that replicate practical difficulties. They might consist of: Dry conditions: When there is very little precipitation, users will need to take calculated choices about how much water they want to utilize. Overwhelming Storms: Properly handling excessive precipitation to avoid disaster and replenish aquifer. Managing pollutants through home waste-water, runoff from farms, and manufacturing waste that degrades the integrity of groundwater is known as soil contamination. Excessive harvesting: Recognizing how unsustainable consumption of groundwater can result in degradation and collapse of land. Through overcoming these obstacles in a virtual setting, players will hone their capacity to solve issues and gain the ability to adjust to actual dealing with water problems.

3.1.4 Encourage Learning Through Gamification and Reward Systems

The application of gamification strategies to increase player engagement is one of the game's fundamental components. Marks or digital currency will be awarded to players who make sustainable decisions. The value of the coins or points will depend on how well the players manage their water resources. Unlock-able Features: Players can advance by unlocking additional tools, strategies, or game stages, which encourages them to keep studying. The game will include a number of missions that require players to do groundwater conservation-related tasks in order to proceed to the next level. Players that regularly make wise choices about water management can obtain digital badges and titles like "Water Guardian" or "Sustainability Champion." These components are used in the game to keep players interested while reiterating important groundwater conservation ideas.

3.2 Scope

3.2.1 Target Audience

Teens, kids in school, including anyone with a passion in environmental preservation are the main target audience for the application. Children and teens are encouraged to actively participate in conserving water initiatives by offering easy-to-understand explanations of watershed management principles. The activity can also be used by landowners, lawmakers, and business people to learn about effective water preservation techniques.

3.2.2 Multi - platform Accessibility

The app is expected to be made on a variety of systems in order to guarantee its release achieves an extensive demographic, involving: Smart-phones (SOS & Android): enabling customers to enjoy games on iPad and cellphones for convenience. Web-Based Version: This version eliminates the need for installations by allowing participants to utilize the application via a computer's browser. In order to provide availability in places with poor communication, the offline experience enables playing despite having to be online. The app can effectively raise knowledge about freshwater preservation worldwide if it is made freely available.

3.2.3 Simulate Real-Life Scenarios

A variety of digital elements will be included in the game to create an engaging educational experience, such as: Simulation-Based Instruction: To comprehend the effects of various water-related choices, players might control digital landowners, cities distribution structures, or manufacturing areas. Participants need to employ scenario-based thinking to adapt to actual events, including prolonged shortages or contaminated the soil, by putting appropriate environmental mechanisms in place. Visually Content Portrayal: Players may see the amount of groundwater and the effects of their choices thanks to diagrams, visuals, plus slides-hows. With the help of each of these elements, users will be able to learn aquifer management in a fun and useful manner.

3.2.4 Scenario-Based Decision Making

Adaptive difficulties that alter according to the actual situation at hand will be incorporated into the course of play. A character may encounter diminished groundwater supplies and need to figure out how to bring everything back into harmony if they neglect the supply of water, for instance. Future advantages will result from environmentally conscious choices like employing efficient drainage or safeguarding waterways against pollution. In order to assist them comprehend the interconnected links of various drainage systems, gamer are going to get comments regarding their decisions. This strategy will support learning and get players ready for making water-saving decisions in the real world.

3.2.5 Leaderboard & Certification

Players' development will be monitored in the course of the game, and players who master methods for dealing with water will receive rewards. Features will consist of: Leader board Rankings: By comparing their scores to those of other players, players can encourage competition that is beneficial and drive to get better. Accreditation for Proficient Performers: Certificates acknowledging their expertise in groundwater conservation might be given to top-performing athletes, which might aid them advance academically or professionally. Participation in the community: In order to foster cooperative learning, players can take part in discussions, exchange tactics, and work together on tasks. Through the incorporation of accreditation and acknowledgment, the activity can function as an environment for preserving water education as well as an educational tool.

4.LITERATURE REVIEW

4.1 Science-Based Games and Education

More and more of institutes and teachers are now focusing on teaching through science and fun activities. Students might enjoy studying when scientific concepts are made simple and applied to their everyday lives through game-based learning. With game-based learning, students are supposed to enjoy themselves while learning scientific concepts. Science games include characters , experiments , arithmetic science games and more. Involving different science activities in games can attract students play them while gaining scientific knowledge. In summary, games do catch children’s interest and are both engaging and fascinating in a way. In addition to helping children learn science ideas and improve their concentration, teachers who use science toys with their students that also increases their passion for science. Science games must therefore incorporate scientific concepts, and students must use what they have learned about science. While, Science games is build by combination of “science” and “games”. Children can use science toys to explore basic scientific laws and operate on scientific concepts while having fun. They are make good aspects for teaching chemistry, nature alarming issues.

No.	Aspect	Measured Factor	Estimated Value	Unit	Notes
1	Student Engagement	Increase in engagement	75	%	Engagement rise due to game-based activities.
2	Learning Improvement	Improvement in science test scores	20	%	Based on pre- and post-game assessments.
3	Fun Factor	Student enjoyment rating	4.5/5	Scale	Based on student feedback surveys.
4	Concept Retention	Concept recall after 1 month	80	%	Higher retention through interactive play.
5	Concentration Boost	Attention span increase during sessions	30	%	Relative to traditional teaching methods.
6	Passion for Science	Students showing increased interest	65	%	Measured via surveys and participation in science activities.
7	Game Variety	Types of science games used	6	Categories	Includes chemistry, nature, arithmetic, experiments, etc.
8	Daily Usage	Average game-based learning time	35	Minutes/day	Time spent on science games per student.
9	Teacher Adoption Rate	Teachers using science-based games	60	%	Adoption rate in a sample group of schools.
10	Cost-Effectiveness	Average cost per student for materials	12	USD/month	Estimated cost of science toys and game tools per student.

Table 4.1: Impact Metrics of Science-Based Games in Education

4.2 Finding Contentment in Learning

Expectations for learning processes differ from person to person and depend on individual interests. If a persons' expectations and needs meet the learning process they might get eager and may want to enroll in more learning programs in future. However, if their desires or expectations are not satisfied, they won't enroll in such educational activities. Thus, one of the most important learning outcomes is learning contentment. While learning satisfaction can result in increasing the percentage of learners , a boost in motivation and understanding and solving the problems associated with it. Based on the difference between what students learn and what they expected to learn, their assessments of their learning outcomes are established. To summarize , contentment in learning can be a factor determining if learning outcomes in educational programs match the expectations and requirements of the learns' if they do it will directly increase their progress.

No.	Metric	Before	After	Change	Unit
1	Learner Satisfaction	40	68	+28	%
2	Motivation Level	55	88	+33	%
3	Re-enrollment Rate	30	62	+32	%
4	Learning Progress	60	75	+15	Score/100
5	Dropout Rate	22	13	–9	%
6	Problem-Solving Skill	50	65	+15	Score/100
7	Interest Alignment	48	78	+30	%
8	Assessment Satisfaction	52	82	+30	%
9	Learning Program Appeal	40	70	+30	%
10	Overall Contentment Index	45	74	+29	%

Table 4.2: Quantitative Impact of Learning Contentment on Educational Outcomes

An independent sample t-test is utilized for analysis to further understand variances in each component (learning style, learning interest, and learning process) and to determine how students' learning pleasure varies by background variables (gender). Table 1 displays the findings of the analysis. Every component of learning satisfaction did not significantly differ between respondents of various genders ($p > 0.05$). The findings indicate that both male and female students are very satisfied with the activity's contents. Therefore, it is feasible to draw the conclusion that students of all genders may feel quite content when doing this activity course thanks to the game-based teaching approach created by this study.

5.METHODOLOGY

5.1 Research Design

The assessment of the chosen video game sample was conducted using a mixed methodological research, qualitative and quantitative, based on the classification of the games based on a set of scores assigned to their gameplay, narrative, and educational qualities, as well as the evaluation of pairings. While they incorporate important aspects of the video game's internal character, such the story play and narrative framework, the dimensions place more emphasis on elements outside of the technological and architectural quality of the game design. In accordance with a Delphi consultation, which is a methodical, iterative, and collaborative procedure designed to gather expert perspectives and analyze consensus following multiple consultation rounds. Following the consultation phase, a matrix of quality standards for video game evaluation has been confirmed. After reviewing and reaching a consensus on the differences, three separate evaluators applied this matrix to each of the games. A ranking of excellence by quartile was then attainable thanks to the implementation of a hierarchical

classification. As modes of subjective peer evaluation, this process is comparable to that employed in other honorable mention and merit award procedures.

5.2 Sample Study

Internet-based video games are also referred to as online games. Our study's sample was chosen by concentrating on those online instructional video games about water. The terms "video game" or "online game" and "water" or "water cycle" were the web searches we used. Since this age group is essential for establishing sustainable behaviors that last a lifetime, the study focuses on pupils between the ages of 10 and 18 years of age. Purposive and random sampling are used to select participants from nearby community centers and schools. With a sample size of 100–150 students, variety in learning styles and demographics is guaranteed. Prior to data collection, participant and parental consent are acquired. Simulation games have the potential to motivate learners and overcome some of the drawbacks associated with more conventional learning methods (Ruben, 1999). Because "individuals assume roles, act out their characters, experience the interaction and see the outcome," activation is a fundamental component of simulation games (Oblinger, 2004). Through simulations, learned material may be put to the test in a real-world environment.

5.3 Game Based Learning

The game combines scenario-based problem-solving, where students make choices to lessen water waste in their communities and at home, with simulated water management difficulties, which demand that players allocate resources effectively. With the knowledge that their games and interactions with other players could lead to success or failure, the players voluntarily submit to the rules of this fictional aim, which is constructed in an artificial environment. Points, leader boards, and awards are examples of gamification components that increase engagement and motivation. Two components made up the teaching materials for water resources science: a jigsaw puzzle and a monopoly game. This work created a water world map that is used in Monopoly to teach kids about the water cycle and water resources scientific issues. Students are divided into groups and move by rolling dice when playing monopoly. There are several cards with information about water resources at every stage. Pupils who provide the right response can proceed. Cutting at the red line and folding at the black line completes the jigsaw puzzle. Students must find out how to fold the jigsaw into four different drawings, such as a "reservoir distribution map," a "water world map," and a "main rivers."

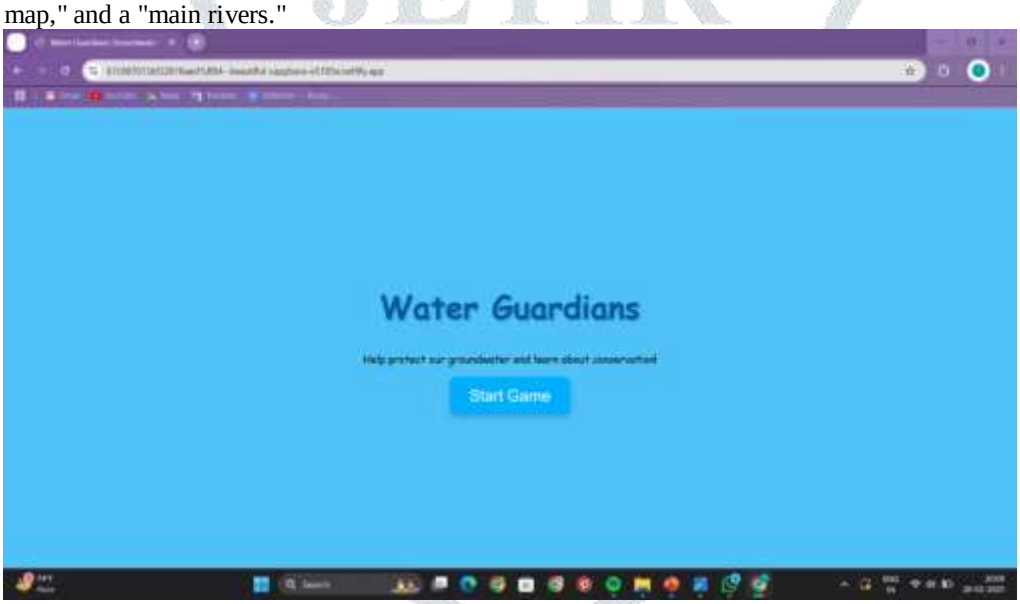

Figure 5.3.1: Water Guardians: Interactive Groundwater Conservation Game

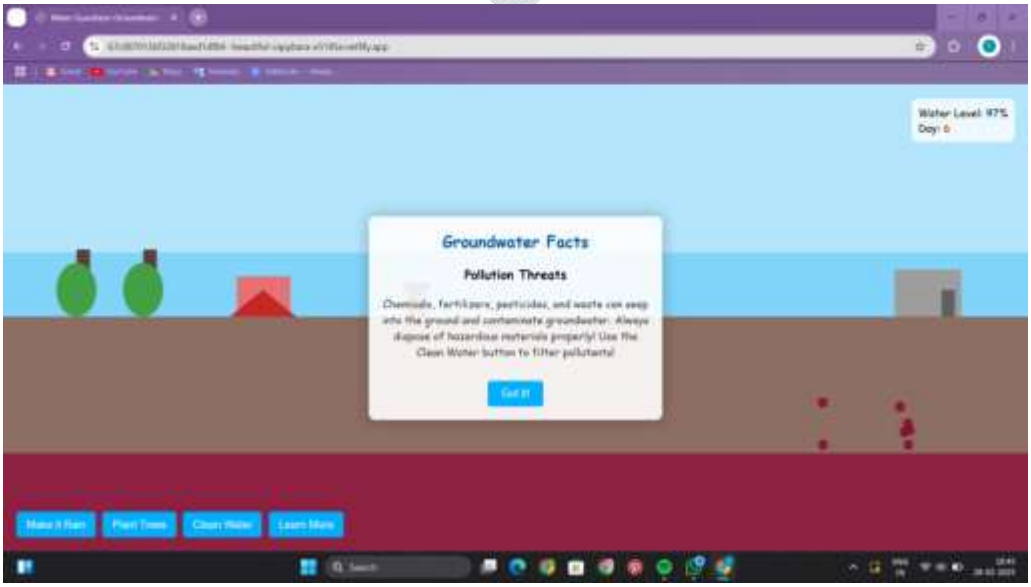

Figure 5.3.2: Pollution Threats to Groundwater in the Water Guardians Game

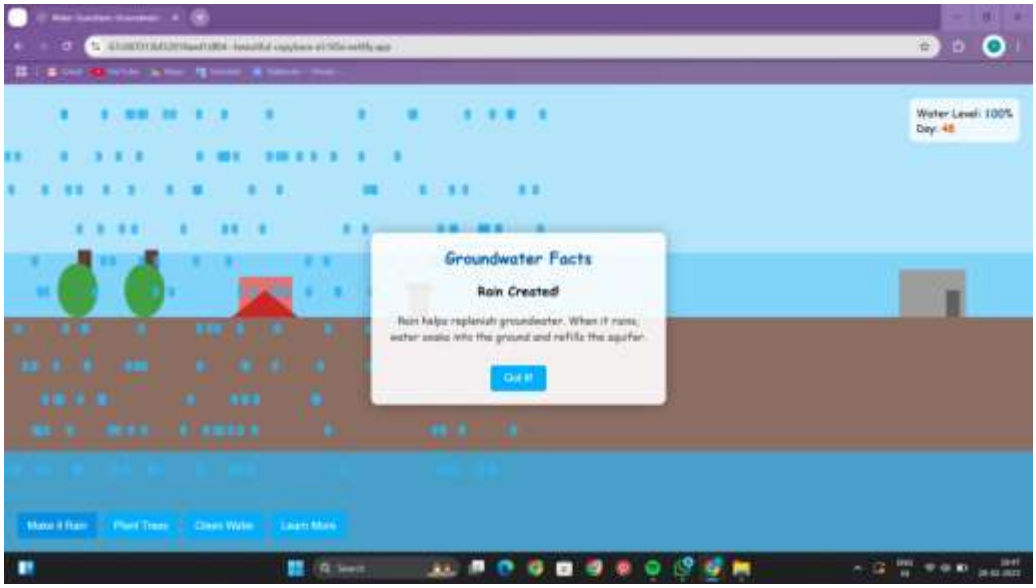

Figure 5.3.3: Impact of Rain on Groundwater Replenishment in the Water Guardians Simulation

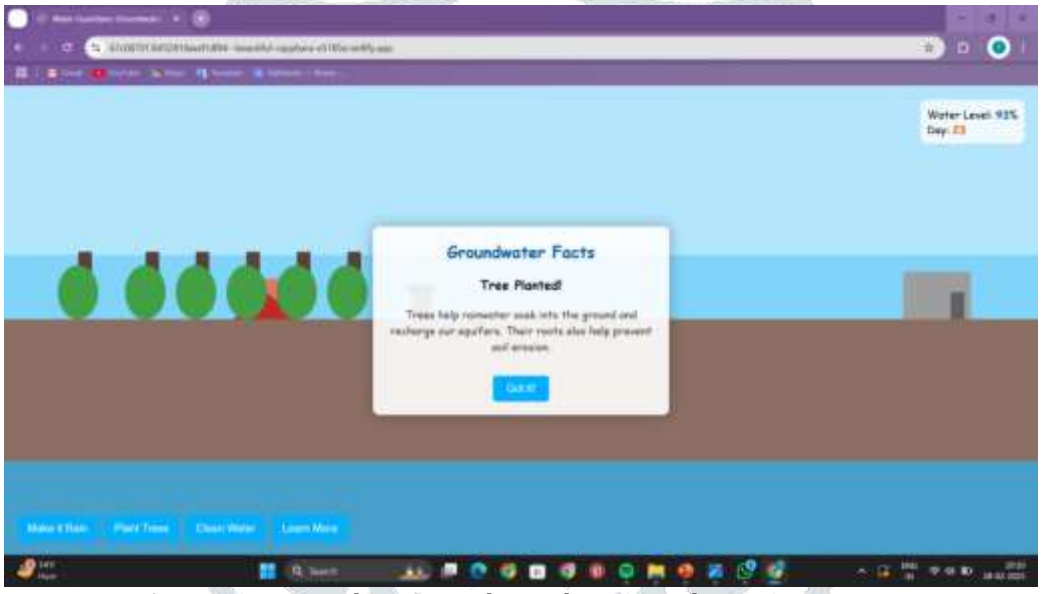

Figure 5.3.4: Tree Plantation and Its Role in Groundwater Conservation

5.4 Data Analysis

We applied the established criteria to assess the water-related video game sample and gain a better grasp of their educational and communicative aspects. Experts were selected based on their background in theory and practice, willingness to take part in the study, and viability of communication. In order to build a set of indicators to analyse the communicative and educational qualities of online games on water-related topics, the study uses the Delphi method, a systematic and participatory approach to gather opinions that establish consensus based on specialist judgments and experiences. In order to determine the relevance and utility of preliminary dimensions (categories of evaluation) and criteria (indicators of evaluation), which were identified through a thorough literature review and pre-selected for their potential to provide useful information from a narrative by drawing inspiration from Pérez-Latorre's "Social Discourse of Video games Analysis Model," which integrates both analysis perspectives, an open-ended question was sent to the experts in the first round of the technique. Using a questionnaire, experts evaluated the assessment criteria relevance and usefulness in three ordinal categories (high, medium, and low) during the second round of consultation. The criteria that received a 90% consensus (high + medium) were chosen. The criteria that failed the second phase were reassessed in the third and final round to determine whether or not they should be excluded from the final set of criteria.

6.RESULTS

6.1 Increased Awareness and Knowledge

The majority of learners only knew the very basics of water conservation before the game-based learning experience, which was frequently restricted to everyday actions like shutting off the faucet. But after that they showed greater understanding of concerns related to water conservation and management and got exposure to use of water resource worldwide. Students also demonstrated more awareness of their own water consumption, with many reporting behavioral changes including cutting back on wasteful water use, motivating family members to practice conservation, and actively looking for more sustainable water solutions in their everyday lives such as rain water harvesting for increasing the water level. The use of games as a teaching tool has the ability to accommodate complicated material by decomposing it into game parts, presenting the knowledge as a storyline, and having players complete difficult tasks and earn rewards for the efforts they made. Students have been found to

benefit from game-based learning not only in terms of learning but also in terms of developing critical abilities and dispositions like taking risks, accepting failure, healthy competition, facing uncertainty, and problem-solving.

6.2 Greater Motivation and Involvement

Students were asked to play the game with little assistance. In addition to the game's regulations, they were told that the game was based on their environment and water usage. The fact that they loved playing the game together was noted. They enjoyed playing the game as well as learning valuable facts. Compared to old teaching techniques, the interactive and competitive aspect of these games made the experience more engaging, play full and participants demonstrated heightened excitement for learning. While planning to make the most of their in-game resources, students were encouraged to consider water conservation seriously by the Monopoly-based game that mimicked the management and decision-making of water resources. In their negotiations, trades, and financial decisions involving sustainable water usage, players showed increased cognitive activities as they engaged in active discussions about water-saving strategies. while the Jigsaw Puzzle game made them learn about teamwork and problem-solving together, which increased student involvement. As the students continued to play they realized the importance of water conservation.

7. DISCUSSION

7.1 Game – Based Learning's Efficiency in Water Conservation

Game-based learning and the process of designing games based on successful learning-play integration were covered in this study. The straightforward game was on water use in daily life. The goal of the game is to draw attention to the little things people do that either waste water or save it. As we know, there are a number of factors that influence water usage, and conserving water is not always that easy. Because game has a simple interface it makes easier for the kids to acquire values and information. In this cooperative game, the emphasis moves from individual acts to teamwork in pursuit of the common objective of ensuring water sufficiency and dealing with the fallout from collective decisions. Notably, the game provided more opportunities as compared to other ways. Rather, the structured activities were made to keep children interested in particular contexts (at home, at school, or when spending time with their families), and this was appropriately rewarded with game awards that appeared over a considerable amount of time.

7.2 Long-Term Engagement and Behavioral Effects

These games aim to raise students' awareness of the daily struggles small homes and communities face when it comes to water usage. It will be interesting to analyze hoe these programs will change their perspective and lead to behavioral shift in them. It is believed that these games enable longer-term and more thorough learning. A well-designed simulation game can provide a valuable opportunity to experience a trans disciplinary scenario in a controlled and "protected" setting. According to the research, the program has primarily improved two areas: conversation with parents about water (where it comes from and how to avoid wasting it) and habits and behaviour that involve large or frequent water use (full body washing, hand washing, drinking).

8.CONCLUSION

8.1 Effects on Teaching Methods

The study found that teaching primary school students about water resources through science games has been a rather effective approach. Students can enjoy themselves while learning key scientific topics because science-based instruction transforms textbook material into entertaining activities. In order to conduct a quality assessment based on evidence from narrative, gameplay, and education, this study offers educators and serious game creators a helpful tool. Choosing the resources to be used in teaching scientific-ecological content about topics like water requires methodological rigor, which is provided by the validation process by consensus and traits evaluated in each of the dimensions through a triple round cycle with a panel of experts. There was no appreciable difference in the degree of learning satisfaction between male and female students. Students' motivation in studying water resources science is also greatly influenced by the educational activity's learning methodology and learning style.

8.2 Influence on Student Attitudes and Behaviour

Beyond knowledge acquisition , students were more interested and satisfied with game based learning approach. This activity significantly impacted on students interest in learning about ground water resource management. According to the research teachers should incorporate curriculum with games related to matters of concern and water conservation. Beyond knowledge acquisition , students were more interested and satisfied with game based learning approach. This activity significantly impacted on students interest in learning about ground water resource management. According to the research teachers should incorporate curriculum with games related to matters of concern and water conservation .Students even exhibited more behavioral changes in their day - to - day life and water usage. Many participants were seen making effort by promoting water conservation habits in their households , fixing leaking taps and turning off running taps in their vicinity, etc. Students were seen depicting more responsible behaviour towards the issue.

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