Development of Criss-Cross Scrabble Game as Supplementary Material to Enhance Student Literacy on Intellectual Revolutions

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ABSTRACT

This study seeks to enhance students' literacy in the field of Science, Technology, and Society, with a particular focus on Intellectual Revolutions, by designing and implementing the Criss-Cross Scrabble Game as a supplementary educational resource. Utilizing a mixed-method research design, the study employed a pretest-posttest methodology to evaluate the impact of the game on students' understanding and engagement with Intellectual Revolutions. Conducted at North Eastern Mindanao State University – Cantilan Campus, the research adhered to ethical protocols by obtaining permissions from institutional authorities and securing informed consent from participants. Initially, a pretest was administered to establish a baseline of students' knowledge. The Criss-Cross Scrabble Game was then integrated into regular classroom activities over a predetermined period, serving as an interactive tool to reinforce learning. Following the intervention, a posttest was conducted to assess any shifts in students' comprehension and engagement levels. Quantitative analysis, including paired t-tests, was employed to compare pretest and posttest results, which revealed a statistically significant increase in mean scores, indicating measurable improvements in student literacy. To complement the quantitative findings, qualitative data were collected through focus group discussions and semi-structured interviews, providing deeper insights into students' experiences and perceptions of the game. The findings underscore the effectiveness of game-based learning as an educational strategy, demonstrating its ability to deepen understanding of Intellectual Revolutions. Furthermore, the study highlights the potential of this interactive learning tool to cultivate critical thinking, bridging the gap between theoretical inquiry and practical application showcasing its capacity to encourage innovation, adaptability, and the application of analytical skills in the real-world context.

Keyword: *Criss-Cross Scrabble, Game-Based Learning, Student Literacy, Normalized Gain, Educational Intervention.*

1. INTRODUCTION

Intellectual revolutions have long served as pivotal moments in human history, driving transformative changes in science, technology, and society. These revolutions—marked by paradigm-shifting ideas and groundbreaking discoveries—challenge conventional thinking, fuel intellectual curiosity, and foster innovation. From the Scientific Revolution of the 16th and 17th centuries to the Digital Revolution of the 20th and 21st centuries, each epoch has profoundly influenced humanity's understanding of the world and its capacity to shape it.

The importance of intellectual revolutions lies in their ability to bridge the gap between theoretical inquiry and practical application. The Scientific Revolution, for example, introduced empirical methodologies that revolutionized science, enabling discoveries in physics, biology, and astronomy that laid the groundwork for modern technology (Kuhn, 1962). Further, recent studies on the Fourth Industrial Revolution highlight how advancements in

artificial intelligence, biotechnology, and robotics are transforming science and technology, reshaping industries, and influencing global society (Schwab, 2017). Similarly, contemporary analyses underscore the role of digitalization and data-driven decision-making in fostering innovation and societal progress (Fleming et al., 2020).

However, students often face challenges in understanding Intellectual Revolutions due to their abstract and multidisciplinary nature. Another significant factor is the lack of relatable or practical applications presented in traditional teaching methods. Intellectual revolutions are often taught as historical events, focusing on dates, figures, and outcomes rather than their ongoing impact on contemporary society. This approach can make the material seem detached from students' lived experiences, reducing engagement and curiosity. To overcome these difficulties, educators must employ interdisciplinary and gamification teaching strategies and real-world examples to help students see the enduring relevance of intellectual revolutions in shaping science, technology, and society (Plass et al., 2020; Hwang et al., 2018).

Criss-cross Scrabble can serve as an effective tool to bridge the gap in students' understanding of intellectual revolutions by promoting active engagement and interdisciplinary learning. This educational game requires players to connect terms and concepts, fostering a deeper understanding of the relationships between key ideas, figures, and events. This process encourages critical thinking and reinforces the interconnectedness of concepts, making abstract ideas more tangible. Studies show that game-based learning enhances student engagement and retention by providing a dynamic and interactive approach to complex subjects (Plass et al., 2020).

Criss-cross Scrabble allows for collaborative learning, which is crucial for grasping multidisciplinary topics such as intellectual revolutions. By working together to build word grids, students share knowledge and perspectives, creating opportunities for peer teaching and discussion. This collaborative environment helps clarify misconceptions and encourages curiosity, as players actively seek connections and explore how historical ideas influence modern science and technology. Research highlights the role of collaborative games in improving communication and problem-solving skills, making them particularly effective in addressing challenges associated with abstract and historical content (Hwang et al., 2018). By integrating Criss-cross Scrabble into the curriculum, educators can make intellectual revolutions more engaging and accessible to students.

2. RESEARCH QUESTIONS

1. What level of intellectual revolution literacy is observed among second-year students at North Eastern Mindanao State University – Cantilan Campus, as determined by their pre-test and post-test performance?
2. What level of improvement in intellectual revolution literacy is observed among the students, as indicated by the normalized gain scores?
3. Is there a statistically significant difference between the pre-test and post-test mean scores in intellectual revolution literacy?
4. Based on the results, what targeted interventions can be proposed to further enhance the intellectual revolution literacy among students?

3. RESEARCH METHODOLOGY

3.1 RESEARCH DESIGN

This research utilized a mixed-method design to develop and evaluate the Criss-cross Scrabble game as a supplementary learning tool aimed at enhancing students' literacy on intellectual revolutions. The quantitative component, implemented through pretests and posttests, measured changes in students' understanding of intellectual revolutions, providing insights into their cognitive progress. Meanwhile, qualitative data were collected through focus group discussions (FGDs) and interviews to explore students' engagement with the game and their perceptions of its effectiveness. By integrating these approaches, the study offers a holistic evaluation of the Criss-cross Scrabble game, examining its impact on both the academic performance and the interactive learning experience of second-year students at North Eastern Mindanao State University – Cantilan Campus.

3.1 RESEARCH LOCALE

The study was conducted at North Eastern Mindanao State University – Cantilan Campus, located in Surigao del Sur, Philippines. As a central institution for higher education in the region, the university serves a diverse student

body comprising individuals from both urban and rural communities. This site was selected due to its alignment with the study's objective of enhancing intellectual revolution literacy among 30 second-year students, who represent the target population for the proposed intervention.

3.2 RESEARCH PARTICIPANTS

The participants in this study consisted of 30 second-year students from North Eastern Mindanao State University – Cantilan Campus. They were selected because they are currently enrolled in the Science, Technology, and Society course, which covers topics related to intellectual revolutions. This course aligns with the focus of the study, making these students an appropriate group for the intervention.

3.3 RESEARCH INSTRUMENT

The researchers developed research instruments designed to assess student engagement and intellectual revolution literacy. To measure literacy in intellectual revolutions, a 40-item test was created for both the pretest and posttest. These instruments were validated by experienced science master teachers in education to ensure their accuracy and relevance. The reliability of the tools was confirmed, with a Cronbach's alpha score of 91%, demonstrating their high internal consistency.

3.4 DATA GATHERING PROCEDURE

The data collection process was conducted in several phases. First, approval was obtained from the university administration to facilitate the study. Following this, a pretest was administered to establish baseline levels of student engagement and intellectual revolution literacy. The Criss-Cross Scrabble Game was then integrated into the classroom for a specified period. Upon completion of the activities, a post-test was conducted, and feedback from participants was collected. The data from both the pre-test and post-test were carefully analyzed to assess the effectiveness of the Criss-Cross Scrabble Game. In addition, focus group discussions (FGDs) and interviews were held to capture qualitative insights regarding student engagement and their perceptions of the game.

3.5 ETHICAL CONSIDERATIONS

The study followed ethical guidelines to ensure the protection of participants' rights and well-being. Prior approval was obtained from the university administration, as well as consent from the students' parents or guardians. Participants were fully informed about the study's objectives and were made aware of their right to withdraw at any time without facing any negative consequences. Additionally, the study maintained strict confidentiality and anonymity regarding the participants' information throughout the research process.

3.6 SCOPE AND LIMITATION

The scope of the study centered on the implementation of the Criss-Cross Scrabble Game to enhance intellectual revolution literacy, which limits the generalizability of the findings to similar educational contexts. The study's limitations included variability in student engagement, which was influenced by differences in their prior knowledge of technology and intellectual revolutions. Additional factors that generated impact on the results included the amount of time allocated for the intervention and the demographic characteristics of the students in the sample.

4. RESULTS

Table 1. Mean Percentage Scores and Mastery Levels in Pretest and Posttest Assessments

Assessment	Percentage (%)	Mastery Level
Pre-test	55. 25%	Near Mastery
Post-test	83.75%	Mastery

Table 1 presents a comparison of the pre-test and post-test results, clearly demonstrating a significant improvement in students' literacy on intellectual revolutions following the implementation of the Criss-Cross Scrabble Game. Initially, students displayed a moderate level of understanding, as evidenced by a pretest mean percentage score of 55.25%, which was categorized as "Near Mastery." This suggests a foundational understanding with some gaps in knowledge. However, after participating in the game-based intervention, the post-test mean percentage score

increased to 83.75%, reflecting a shift to a "Mastery" level of comprehension. This improvement highlights the effectiveness of the Criss-Cross Scrabble Game in enhancing students' understanding and retention of intellectual revolution concepts. The results underscore the positive impact of interactive learning methods, such as gamification, in teaching complex scientific topics. Further supporting this, research by Hamari et al. (2014) affirms the advantages of gamification in boosting student engagement and academic performance in various educational contexts, underscoring the value of innovative educational tools in addressing knowledge gaps and fostering deeper learning engagement.

Table 2. Normalized Gain Results

Assessment	Percentage (%)	Normalized Gain (g)
Pre-test	55. 25%	0.64
Post-test	83.75%	

Table 2 presents the normalized gain calculated from the pre-test and post-test scores, yielding a value of approximately 0.64. This result indicates a medium level of improvement in students' understanding of intellectual revolutions, aligning with the moderate gain range (0.3 to 0.7) established by Hake (1998). The findings suggest that the Criss-Cross Scrabble Game effectively facilitated learning, allowing students to significantly enhance their knowledge during the intervention period. This outcome highlights the potential of interactive and gamified educational tools in driving meaningful academic progress and reinforcing complex subject matter comprehension.

Table 3. Statistical Analysis of Intellectual Revolution Literacy: Pre-test vs. Post-test Results

	Pre-test	***Post-test***
Mean	21.83333	33.43333
Variance	18.55747	9.426437
Observations	30	30
Pearson Correlation	0.089078	
Hypothesized Mean Difference	0	
Df	29	
t Stat	-12.5506	
P(T<=t) one-tail	1.51E-13	
t Critical one-tail	1.699127	
P(T<=t) two-tail	3.02E-13	
t Critical two-tail	2.04523	

Table 3, reveals the analysis of pre-test and post-test, which explicitly indicates that there is a significant increase in intellectual revolution literacy among second-year students at North Eastern Mindanao State University. The paired t-test results show a significant improvement in students' scores from the pre-test (M = 21.83, SD = 4.30) to the post-test (M = 33.43, SD = 3.07), with a t-statistic of -12.55 and degrees of freedom (df) = 29. The small p-values for both one-tailed ($p = 1.51 \times 10^{-13}$) and two-tailed ($p = 3.02 \times 10^{-13}$) tests strongly reject the null hypothesis, indicating a statistically significant increase in scores following the intervention. The Pearson correlation of 0.089 suggests a weak linear relationship between pre-test and post-test scores, further emphasizing that the improvement was likely due to the intervention rather than the students' initial performance.

The variance was higher in the pre-test (18.56) compared to the post-test (9.43), suggesting a more consistent improvement across students after the intervention. The t-statistic's large magnitude and the comparison with critical values (one-tailed = 1.70, two-tailed = 2.05) confirm that the observed difference is well beyond the expected range

due to chance. These results provide evidence that the intervention of the Criss-Cross Scrabble Game significantly enhanced students' understanding, demonstrating its effectiveness as a tool for improving intellectual revolution literacy.

Table 4. Thematic Analysis Based on Focus Group Discussions

Theme	Description	Key Findings
Engagement and Motivation	Students reported high engagement and motivation due to the interactive nature of the game.	The game increased student participation and enthusiasm in learning, leading to higher levels of engagement compared to traditional methods.
Understanding and Retention	The game helped in improving the retention and understanding of complex concepts related to intellectual revolutions.	Students showed better comprehension and recall of key concepts like the Scientific Revolution and technological advancements after playing the game.
Collaboration and Social Learning	Focus on teamwork and collaboration during the game helped students learn from each other.	Students reported that collaborative gameplay encouraged discussions and sharing of knowledge, improving overall understanding.
Critical Thinking and Problem-Solving	The game's design required students to think critically and solve problems to make connections between concepts.	Students developed stronger problem-solving skills and critical thinking abilities, particularly in relating historical events to modern advancements.
Fun and Enjoyable Learning Experience	Students highlighted the enjoyment factor, which made learning more fun and less stressful.	The competitive and playful nature of the game made learning enjoyable, reducing anxiety about the subject matter.
Time Management and Focus	Students noted the challenge of managing time during the game, which required sustained focus and efficiency.	While engaging, the game required students to stay focused for extended periods, improving their ability to manage time and attention during tasks.
Improved Retention Through Repetition	Repeated exposure to concepts through the game helped reinforce learning.	The repetitive nature of the game facilitated deeper retention of terms, historical events, and their relevance in modern contexts.
Game Design and Educational Value	Students provided feedback on the game's format, suggesting improvements for better educational outcomes.	Suggestions for improvement included more detailed explanations of the rules and a stronger focus on application of concepts in the questions.

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The thematic analysis based on the Focus Group Discussions (FGDs) highlights key insights into the impact of the Criss-Cross Scrabble Game as a supplementary learning tool. One of the prominent themes, Engagement and Motivation, underscores the game's ability to captivate students, significantly enhancing their participation in the learning process. The interactive nature of the game fosters a lively learning environment, leading to increased enthusiasm among students. This aligns with research on game-based learning, which shows that such educational

tools improve student engagement and motivation by making learning more enjoyable and less formal (Hamari et al., 2014).

Understanding and Retention emerged as another crucial theme, demonstrating the game's effectiveness in deepening students' comprehension of complex intellectual revolution concepts. By involving students in active problem-solving, the game reinforces key historical and scientific concepts, aiding long-term retention (Gee, 2003). Collaboration and Social Learning were also highlighted in the discussions, where students emphasized the benefits of working together. Cooperative play, as evidenced in the findings, encourages peer-to-peer learning, which has been shown to enhance knowledge acquisition and foster critical discussions (Johnson & Johnson, 2009).

The game's ability to foster Critical Thinking and Problem-Solving was another significant outcome noted by students. The requirement to apply historical and scientific knowledge to solve puzzles and make connections between concepts strengthened students' analytical skills. This mirrors research by Gee (2003), which suggests that game-based learning environments promote higher-order thinking and problem-solving abilities. Additionally, the Fun and Enjoyable Learning Experience theme points to how the Criss-Cross Scrabble Game makes learning enjoyable, effectively reducing the stress often associated with academic subjects. Gamification has been found to increase student engagement and reduce anxiety (Hamari et al., 2014), a result echoed in the findings.

Time Management and Focus emerged as a more nuanced theme, where students indicated that while the game was engaging, it required significant focus and effective time management. The need for sustained concentration during gameplay improved students' ability to stay focused over long periods, as suggested by research on cognitive load and time management in educational settings (Sweller et al., 2011). The theme Improved Retention Through Repetition reflects the game's ability to reinforce concepts through repeated exposure, a strategy known to improve learning outcomes by facilitating deeper understanding (Rohrer & Pashler, 2012).

Finally, the theme of Game Design and Educational Value sheds light on students' reflections about the game's format, with suggestions for enhancing the educational experience. This is a common aspect of educational game research, where iterative design and user feedback play critical roles in improving the effectiveness of game-based learning tools (Gee, 2003). These findings collectively suggest that the Criss-Cross Scrabble Game is a valuable educational tool that not only enhances engagement and retention but also promotes critical thinking, collaboration, and enjoyment in the learning process.

5. CONCLUSIONS

The Criss-Cross Scrabble Game has proven to be a highly effective educational tool in enhancing students' understanding and engagement with complex intellectual revolution concepts. Through the incorporation of interactive and collaborative gameplay, the game significantly increased student motivation, improved retention, and fostered critical thinking skills. The positive feedback from students regarding the game's ability to make learning enjoyable and less stressful further supports its success. Additionally, the game's ability to promote social learning and collaborative problem-solving highlighted its potential to foster a deeper, more meaningful connection to the material. Overall, the Criss-Cross Scrabble Game not only met but exceeded expectations in contributing to students' intellectual revolution literacy, providing a valuable supplement to traditional teaching methods.

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