Development of Board Game "S.F.Y: Spark, Forge, and Yield!" in Learning Work, Power and Energy on Grade 8 Students

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ABSTRACT

This study addressed the persistent challenge of suboptimal student achievement in science education, particularly in Grade 8 physics, by examining the impact of a novel board game, "S.F.Y: Spark, Forge and Yield," on the acquisition of knowledge related to work, power, and energy. Employing a developmental research design with mixed-methods data collection, the research compared the learning outcomes of an experimental group, utilizing the board game, to a control group receiving conventional lecture-based instruction. The "S.F.Y: Spark, Forge and Yield" board game was developed through an iterative process utilizing the Successive Approximation Model (SAM), with validation provided by expert science educators and postgraduate physics students, ensuring alignment with prescribed curriculum competencies. Quantitative analysis, including normalized gain calculations, was conducted to measure student learning, while qualitative data, derived from teacher and student evaluations, provided insights into the pedagogical efficacy of the intervention. Results indicated that the board game received an "Excellent" rating from both educators and students, signifying its perceived effectiveness and curriculum relevance. Furthermore, quantitative analysis demonstrated a statistically significant improvement in student learning outcomes within the experimental group. Consequently, the study recommends the implementation of "S.F. Y: Spark, Forge and Yield" within Grade 8 physics instruction, accompanied by pre- and post-assessment protocols to evaluate student comprehension.

Keywords: Work, Power and Energy, Student Engagement, Science Education, Game-based learning. Board Game

INTRODUCTION

The persistent challenge of suboptimal science education outcomes within the Philippine educational system, particularly in physics, has been a subject of ongoing concern, as evidenced by consistent underperformance in international assessments (DepEd, 2019; Philstar Global, 2023). This research project was initiated to address this issue by investigating the efficacy of a novel pedagogical intervention, specifically a board game titled "S.F.Y: Spark, Forge and Yield," designed to enhance Grade 8 student comprehension of the challenging physics concepts of work, power, and energy. The use of game-based learning can be an effective strategy for teaching physics topics particularly work, power and energy. Games engage learners at cognitive, emotive, motivational, and social levels, making them effective learning tools (Plass, J.L. et al., 2020). Recognizing that physics, a discipline foundational to technological advancement, is often perceived as challenging by students at the high school level (Wangchuk et al., 2023), this study sought to explore alternative instructional approaches to supplement traditional lecture-based methods. Previous research has indicated that factors such as the abstract nature of the subject matter, reliance on mathematical reasoning, and potential limitations in instructional delivery contribute to this perception (Rao et al., 2021; Almianai et al., 2022). According to Ngema, M.H. (2016), the factors that affect the students' low performance are the absence of resources, the time allocated for each

science topic and the medium of instruction. Specifically, the concepts of work, power, and energy, integral to the Grade 8 physics curriculum, present significant learning difficulties, particularly in the application of problem-solving skills (Fitroh et al., 2020). This manifested in observable student apprehension and a consistent pattern of low scores on assessments pertaining to these topics during preliminary evaluations conducted within the target population. Acknowledging the limitations of traditional didactic methods in addressing the diverse learning styles and cognitive needs of students (Ngema, 2016; Bada & Jita, 2023), this research project explored the potential of game-based learning as a means of enhancing student motivation, engagement, and cognitive development. Drawing upon existing research that suggests games can facilitate the development of strategic thinking and problem-solving skills (Plass et al., 2020; Dvoryatkina & Simonovskaya, 2021; Qader et al., 2022), "S.F.Y: Spark, Forge and Yield" was developed and implemented. This game was designed with specific learning objectives aligned with the Department of Education's (DepEd) curriculum competencies for Grade 8 physics, ensuring its relevance and applicability within the Philippine educational context. The game's development involved iterative refinement based on feedback from experienced science educators and physics education specialists, ensuring both pedagogical soundness and engaging lessons.

This study, therefore, aimed to evaluate the impact of "S.F.Y: Spark, Forge and Yield" on Grade 8 students' comprehension of work, power, and energy concepts. "Spark," "Forge," and "Yield" describe a systematic progression: an initial idea ("spark"), its rigorous development ("forge"), and the resulting outcome ("yield"). This sequence outlines the path from inception to realization. Through a rigorous mixed-methods approach, incorporating both quantitative assessments of student learning gains and qualitative analyses of student and teacher perceptions, this research explored the efficacy of this student-centered intervention. The findings of this research are intended to contribute to the development of evidence-based pedagogical strategies for science education within the Philippine context, specifically addressing persistent challenges in physics education, and to offer practical insights for educators seeking to improve student engagement and learning outcomes in challenging scientific domains.

METHODS

Research Design

This study utilized a Research and Development (R&D) design, incorporating both qualitative and quantitative methods, to develop and evaluate a board game, "S.F.Y: Spark, Forge and Yield," for enhancing Grade 8 physics education on the topics of work, power, and energy. The development process was guided by R&D principles, specifically the Successive Approximation Model (SAM), ensuring iterative refinement based on expert feedback. This model facilitated the creation of a game aligned with the Department of Education's curriculum competencies. The mixed-methods approach allowed for a comprehensive assessment of the game's effectiveness by capturing both subjective experiences and objective learning outcomes. Qualitative data, gathered through post-game surveys administered to both students in the experimental group and participating science teachers, provided insights into student perceptions of engagement, enjoyment, and perceived learning, as well as teacher observations on the game's pedagogical value and implementation challenges. The surveys included open-ended questions designed to elicit detailed feedback on game mechanics, content clarity, and motivational aspects. Quantitatively, a quasi-experimental design was employed, comparing an experimental group (using the "S.F.Y: Spark, Forge and Yield" board game as a primary instructional tool) to a control group (receiving traditional lecture-based instruction) through pre- and post-achievement tests. These tests were specifically designed to assess student understanding of work, power, and energy concepts, with items aligned with the curriculum competencies. The pre-tests established baseline knowledge, while the post-tests measured learning gains. This enabled the researchers to determine the impact of the board game on student learning gains, using statistical analysis such as normalized gain calculations and t-tests to compare mean scores between the groups and within each group's pre- and post-test results. Furthermore, the analysis of gain scores between the control and experimental groups provided a clearer understanding of the relative effectiveness of the board game intervention.

Research Subjects and Participants

The study involved two Grade 8 sections from Abdul Azis Liwalug National High School. Participants were

selected based on: active Grade 8 enrollment, documented parental/guardian consent, and the absence of medical conditions that could interfere with their learning. Prior to implementation, the "S.F.Y: Spark, Forge and Yield" board game underwent a thorough validation process. This included a review by eight experienced physics educators and science teachers, who assessed the game's content accuracy and pedagogical effectiveness. Additionally, a group of physics education graduate students participated in pilot testing, providing feedback on the game's usability and engagement. Feedback from both groups was used to refine the board game packet, ensuring its alignment with curriculum competencies and its suitability for the target student population.

Data Gathering Procedure (Successive Approximation Model)

The data gathering process was systematically structured. It began with an assessment analysis using the SAM model, involving eight teachers and ten physics education postgraduate students to identify challenging Grade 8 physics topics. This informed the design and development of the board game packet, which was then validated by the same experts. Finally, the game was implemented and evaluated in a quasi-experimental setting, using pre- and post-tests for quantitative data, and post-game surveys for qualitative insights from students and teachers.

Preparation Phase

The information gathering process, crucial for the foundational design of the physics board game, commenced with an online survey administered to eight experienced science teachers. These teachers were tasked with ranking the Grade 8 physics topics, as outlined in the Department of Education's (DepEd) Most Essential Learning Competencies (MELCs), from the most challenging to the least challenging to teach. This provided insight into pedagogical difficulties encountered by educators. Complementing this, a separate online survey was conducted with 78 Grade 9 students, who, having recently completed the Grade 8 curriculum, were asked to rank the same physics topics based on their perceived difficulty to learn. This student perspective offered a valuable counterpoint to the teachers' insights, highlighting areas where students struggled with comprehension. The resulting rankings from both teacher and student surveys were meticulously analyzed. This analysis aimed to identify areas of significant overlap, indicating topics that were both difficult to teach and difficult to learn. These identified topics, which included 'Work, Power, and Energy', were then prioritized for inclusion in the board game and subsequent achievement tests. This strategic selection ensured that the board game addressed the most pertinent and challenging aspects of the Grade 8 physics curriculum, thereby maximizing its potential impact on student learning.

Iterative Design, Development and Validation of S.F.Y: Spark, Forge and Yield Board Game

The design process involved creating game content and mechanics, integrating the game Dama with a manual to guide its adaptation for educational purposes. The game aligned with the K-12 Science Curriculum, using MELCs, DepEd Science Modules, and Learners' Materials to ensure it met academic standards and specific learning objectives. A game mechanics manual was developed, outlining rules, objectives, and interactions, and tested with educators or game testers for feedback. Thesis advisers, Science teachers and graduate students from MSU-IIT reviewed the board game's design, focusing on learning competencies, game elements, engagement, and feedback. Revisions were made based on their input. The board game was evaluated using a rating scale adapted from Gutierrez (2013) and a Comments and Suggestions Sheet based on Malicoban et al. (2021). All feedback and recommendations received were integrated into the board game to enhance its design.

Data Analysis

To gain insights from the collected data, various statistical tools were used during the analysis. Thematic analysis was employed to evaluate qualitative data gathered from the comments and suggestions section of the rating scale, as well as from survey feedback. Quantitative data from the rating scale and intrinsic motivation questionnaire were analyzed using mean calculations, providing a numerical perspective on the board game. Furthermore, normalized gain was applied to measure the improvement in participants' scores after the implementation.

RESULTS AND DISCUSSIONS

Preparation Phase

The researcher conducted a survey to determine which topic in Grade 8 science aligned with the DepEd's learning competency was the most challenging for students. The results of the survey indicated that Work, Power, and Energy is the most difficult for Grade 8 students. This finding provided valuable insights into the specific areas where students having a hard time the most. To address this issue, the researcher gathered information on effective teaching strategies and resources that could help improve students' understanding of Work, Power and Energy.

Table 1. Aligning the Board Game Packet with the DepEd K-12 Identified Standards and Competencies

Content Standard	Performance Standard	Most Essential Learning Competencies & K-12 CG Code	Duration	Board Game Packet Objectives
The learners demonstrate understanding of work using constant force, power, gravitational potential energy, kinetic energy, and elastic potential energy.	The learners should be able to identify and explain the factors that affect potential and kinetic energy.	- Identify situations in which work is done and in which no work is done; - Describe how work is related to power and energy; - Differentiate potential and kinetic energy; - Relate speed and position of an object to the amount of energy possessed by a body	Week 2-3	Identify situations in which work is done and in which no work is done; Describe how work is related to power and energy; Differentiate potential and kinetic energy; Relate speed and position of object to the amount of energy possessed by a body.

Iterative Design, Development and Validation of the S.F.Y: Spark, Forge and Yield

The board game was intentionally designed to maximize student engagement and learning. To achieve this, it incorporated cognitive, social, and immersion elements. Cognitive elements, such as memorization cards, aimed to enhance recall of physics concepts. Social elements, including action cards and tiles, facilitated interaction between players. Immersion elements, like timed gameplay and unique game pieces, increased student involvement. These elements were integrated to create a compelling and engaging learning experience.

Table 2. Game Elements Incorporated

Game Elements	Design/Implementation strategies
Wild Cards	Players draw a wild card when no other move is possible. This card contains commands that allow players to manipulate specific game chips, effectively changing the game state.
Game Chips Hints	Background pictures contained hidden hints for matching questions and answers, requiring players to actively observe and discover these clues.
Rock-paper-scissors match	To begin the game, a rock-paper-scissors match is held. The winner of this match has the advantage of choosing which color tiles they will use and which set of chips (questions or answers) they will play with.
Game Chips	The primary interactive elements facilitate player actions and competitive gameplay.
Rules	It is set to ensure the smooth flow or experience of the board game.
Time logistics	Players are given a fixed time limit to draw cards, or to win the game.

A 64-tile board, divided into alternating yellow and red sections, provides a structured playing field. A rock-paper-scissors match determines initial player advantage, allowing the winner to select tile color and chip type, introducing an element of chance and strategy. The game adapts the familiar mechanics of 'Dama' to teach Grade 8 physics concepts, replacing pawns with question-and-answer chips that require matching for capture, actively engaging players with the subject matter. Hidden hints on each chip provide scaffolding for learning. Wild card activities are flexible, performance-based assessments within a curriculum that reveal a student's true capabilities

beyond standard metrics. It assesses a student's performance standard by requiring to apply skills in dynamic situations, and successful completion directly impacts their progress, emphasizing the link between demonstrated ability and agency. A 20-minute time limit maintains focus, while a scoring system based on captured and remaining chips provides a quantifiable measure of performance. The total score functions as a quiz, divided into short and longer halves, integrating assessment into gameplay and allowing for progressive learning. Each component is designed to enhance engagement and facilitate a deeper understanding of 'Work, Power, and Energy' concepts.

Table 3. Evaluation Rating Result

Category	Mean Rating	Description
Goals and Objectives		
The purpose of the game was fully explained.	4.81	Excellent
The goals and objectives of the game are clearly defined.	4.74	Excellent
The game is thought provoking.	4.77	Excellent
The game covers key concepts of the topic.	4.74	Excellent
The game encourages students' interaction.	4.62	Excellent
The board game helps with recalling concepts or terms.	4.75	Excellent
Board Game Design		
The size of the board game is appropriate.	4.80	Excellent
The features of the board game are attractive.	4.93	Excellent
The materials used in the board game are durable.	4.97	Excellent
The board game is easy to use.	4.70	Excellent
Components and Organization		
The mechanics of the game are clear and easily understood.	4.83	Excellent
The terms used are appropriate to my level of understanding.	4.90	Excellent
The game pieces such as the characters, dice and questions are appropriate and well-aligned.	4.72	Excellent
The length of time to play is reasonable.	4.84	Excellent
Playability and Playfulness		
The game promotes healthy competition and cooperation.	4.81	Excellent
The rules and mechanics of the game provide players with equal conditions of fair play.	4.67	Excellent
The rules of the game make it fun to play.	4.82	Excellent
The storyline is appropriate for the topic.	4.79	Excellent
Usefulness		
The game is effective in introducing the topic.	4.71	Excellent
The game encourages the students to dig deeper into the subject matter.	4.77	Excellent
Playing the game is a productive use of time.	4.71	Excellent
Playing the game helps to understand the lesson.	4.74	Excellent
I recommend this to others	4.93	Excellent
OVERALL MEAN	**4.79**	Excellent

Legend*:* Excellent 5.00-4.50; Good 4.49-3.50; Neutral 3.49-2.50; Fair 2.49-1.50; Poor 1.49-0.00

Table 3 presents the evaluation of the "S.F.Y" board game by 8 science educators and 10 physics education graduate students. The overall average rating (M=4.79) indicates strong validity and acceptance. Evaluators praised the game's innovation and engagement, and their recommendations were used to refine the game materials

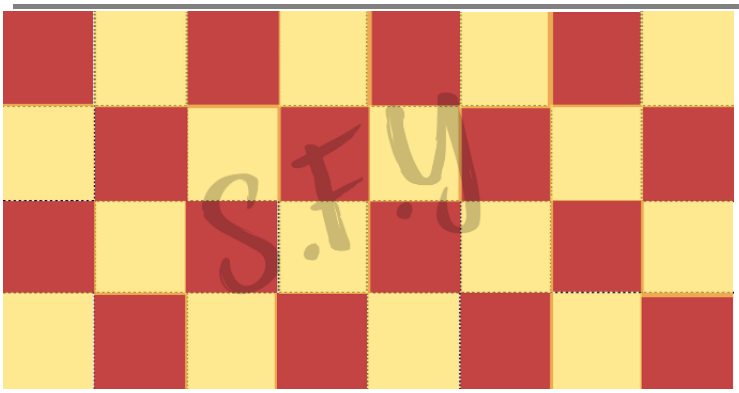

Figure 1

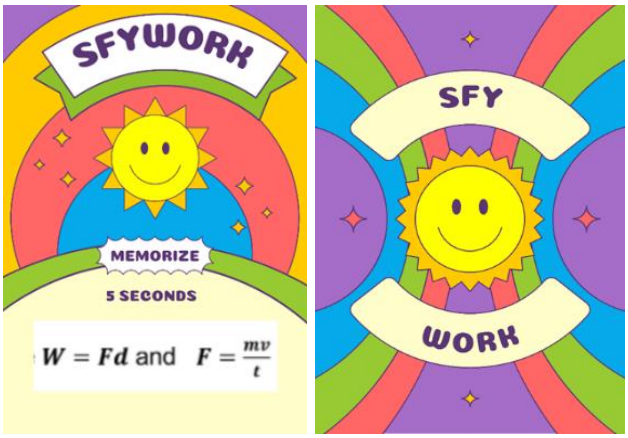

Figure 2

Figure 3

Figure 1 shows the game board tiles, arranged in an alternating color pattern to form the playing field. Figure 2 displays the "SFY Work" wild card, which offers various commands that players can use to strategically alter the game state. Figure 3 illustrates the game chips, each containing either a question or an answer, which players move diagonally or horizontally, similar to the traditional game of "Dama," to capture opponents' chips.

CONCLUSION AND RECOMMENDATION

Important challenges and issues pertaining to teaching and learning work, power, and energy were revealed by the survey conducted as part of this study's topic selection process to determine the comprehensive need of strategic aid among grade 8 students and science teachers. The insights gained from this research significantly influenced the design and evaluation of the S.F.Y. board game. The game underwent rigorous evaluation by a panel of experts, including eight physics specialists/science teachers, and ten physics education graduate students, receiving an "Excellent" rating for its acceptability and potential effectiveness. This study provides a strong foundation for evaluating the effectiveness of the S.F.Y board game in improving Grade 8 students' understanding of work, power, and energy at Abdul Aziz Liwalug National High School. This data informed the development of the educational board game "S.F.Y: Spark, Forge and Yield." These results suggest that the

"S.F.Y" board game can be a valuable tool for improving student understanding of these key physics concepts. The study recommends integrating the game into classroom instruction and using pre- and post-tests to assess its impact on student learning.

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