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Gamification of Education using Multi-Armed Bandit Algorithm

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ABSTRACT

The integration of AI in education has expanded beyond its conventional boundaries by incorporating adaptive algorithms and gamification techniques. The purpose of this study is to explore how the Decision Tree Thompson Sampling (DTTS) algorithm can enhance student engagement and performance in algebra through a web-based game, ALGE-BRUH. Specifically, it examines the implementation of the DTTS algorithm in the gamified educational content aimed at Grade 10 students. The tools and technologies utilized include HTML, CSS, and JavaScript for the front-end, Firebase for backend support, and the DTTS algorithm for adaptive learning. The system delivers tailored questions and feedback to optimize individual learning outcomes. The findings indicate that this approach significantly improves student understanding and retention of algebraic concepts. To further enhance the effectiveness of the gamified educational tool, it is recommended to expand the range of topics covered, incorporate more sophisticated adaptive algorithms, and continually update the content based on user interaction data.

Keywords: Decision Tree Thompson Sampling Algorithm, Web-game, Education

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Chapter 1

THE PROBLEM AND ITS BACKGROUND

In this chapter the background, problem statement and significance of the study are discussed. The general and specific objectives are listed, as well as the scope and limitations. This chapter will provide an overview of the research, its social and personal impacts, and a brief description of the concepts discussed in the study.

Introduction

In today's educational landscape, schools, universities, and educators confront various issues in traditional classrooms and online platforms. Common problems include low student engagement, limited personalization, difficulty tracking progress, and unequal access to quality education (Pappas, C. 2022, Al-Jarf and Reima 2019). These challenges persist due to outdated teaching methods and the struggle to adapt to diverse student needs. Traditional lectures often fail to sustain student interest, making it crucial to explore alternative approaches that can enhance learning experiences.

Enter gamified education, a transformative solution that utilizes Multi-Armed Bandit (MAB) algorithms, specifically the Decision Tree Thompson Sampling (DTTS) algorithm. This approach introduces game-like elements into learning environments, providing a dynamic and engaging way to address educational challenges. DTTS, known for its adaptability, tailors content based on individual progress, fostering personalized learning experiences (Russo, 2018). This helps assess student understanding in real-time and boosts motivation through rewards, progress levels, and a more interactive learning structure. By optimizing resource allocation and gradually introducing positive change, gamified education with MAB algorithms presents an innovative solution to enhance the learning journey.

Moreover, the gamification strategy, especially with DTTS, is pivotal in promoting inclusivity. It ensures that students with various needs and preferences can access equitable learning experiences. This shift towards a more engaging, personalized, and inclusive educational environment marks a positive step forward in overcoming the complex challenges faced by educational institutions and educators. Gamified education, with its user-friendly and adaptive features, emerges as a promising avenue to reshape the way we approach teaching and learning.

Objective of the Study

This research is driven by the goal of enhancing the educational experience through integration of the Decision Tree Thompson Sampling (DTTS) algorithm into gamified content. The study focuses on evaluating the algorithm's effectiveness in personalized learning, understanding student satisfaction, and enjoyment, and exploring its adaptability across diverse subjects. The following objectives guide this investigation:

- Implement DTTS algorithm into gamified educational content.
- Assess student satisfaction and enjoyment in the gamified learning environment.
- Explore the adaptability of the DTTS algorithm academic subject particularly on Algebra.
- Investigate motivational factors influencing student engagement.
- Examine how the DTTS algorithm contributes to intrinsic motivation in the learning process.

Through these objectives, this research aims to provide valuable insights into the various impacts of DTTS on students' educational journeys.

Significance of the Study

In the rapidly evolving landscape of education, integrating innovative approaches is imperative. This research on gamification in education, specifically employing the Decision Tree Thompson Sampling (DTTS) algorithm, holds significance in several key dimensions:

For the Teachers:

- **Enhanced Teaching Strategies:** By incorporating gamification with the DTTS algorithm, teachers are equipped with innovative tools that make lessons more interactive and engaging. This approach helps in transforming traditional teaching methodologies, thereby increasing student participation and interest.

- **Data-Driven Insights:** The use of DTTS provides teachers with valuable insights into student performance and engagement patterns. These data-driven insights enable teachers to tailor their instructional strategies to meet the diverse needs of their students more effectively.
- **Professional Development:** Educators can benefit from training and development opportunities related to the implementation of gamified learning environments, enhancing their professional skills and staying abreast of technological advancements in education.

For the Students:

- **Increased Engagement:** Gamification, combined with DTTS, creates a dynamic learning environment that captures students' attention and motivates them to participate actively. This approach makes learning more enjoyable and less monotonous.
- **Personalized Learning Experience:** By personalizing learning paths through DTTS, students receive tailored educational content that aligns with their individual learning styles, strengths, and weaknesses. This personalization helps in maximizing their academic performance.
- **Inclusivity and Equal Opportunities:** The adaptive nature of this educational approach ensures that students from diverse backgrounds and learning abilities have equal access to effective learning tools, promoting inclusivity.

For the Future Researchers:

- **Pioneering Research Framework:** This study sets a precedent for future research on the integration of advanced algorithms like DTTS in educational settings. It provides a robust framework for exploring the intersection of gamification, personalization, and adaptive learning.
- **Broadening Research Horizons:** By contributing to the body of knowledge on educational technology, this research opens up new avenues for further investigation into how emerging technologies can be leveraged to enhance educational practices.

For the Junior High School Education Institutions:

- **Curriculum Development:** Junior high schools can integrate gamified learning modules designed with the DTTS algorithm into their curricula, providing students with a modern and engaging educational experience.
- **Improving Academic Outcomes:** Schools can leverage the insights gained from this research to implement strategies that improve overall student performance, particularly in subjects where traditional teaching methods may fall short.
- **Resource Allocation:** The findings can assist school administrators in making informed decisions about resource allocation for educational technologies, ensuring investments are made in tools that demonstrably improve learning outcomes.

For Educational Policy Makers:

- **Addressing Inequality:** Policy makers can use the findings to develop initiatives that aim to reduce educational inequality, ensuring that all students, regardless of their socio-economic background, have access to high-quality, personalized education.

For the Educational Technology Industry:

- **Product Development:** The insights from this research can guide the development of new educational technologies that incorporate gamification and adaptive algorithms, meeting the evolving needs of educational institutions and students.

In essence, this research seeks to not only explore the innovative fusion of gamification and DTTS but also to drive positive transformations in educational practices, ultimately benefiting both educators and students in a rapidly changing educational landscape.

Scope and Delimitations

This research on gamification in education, specifically employing the Decision Tree Thompson Sampling (DTTS) algorithm, delineates its boundaries to maintain focus and precision. The study is purposefully limited in scope to ensure clarity and coherence in its objectives:

- **Subject Focus:** The primary concentration of this research centers explicitly on the field of **mathematics**, with a specific focus on the subject of **algebra**. By narrowing the scope to a particular branch of mathematics, the study aims to delve deeply into the application of gamification and DTTS within this subject area.
- **Educational Level:** The research confines its investigation to the **secondary level of education**. This deliberate limitation ensures that the study's findings are tailored to the unique characteristics, challenges, and educational needs of secondary school students. The intent is to offer insights and recommendations that are directly applicable to this specific academic stage.
- **Geographical and Institutional Context:** The study does not extend its reach to a broad, international context but rather focuses on a specific geographical location or educational institution. By doing so, the research can consider local nuances, curriculum structures, and teaching methodologies that may influence the effectiveness of gamification and DTTS in the designated setting.

By outlining these scope and delimitation parameters, the research establishes a clear framework within which it can explore the integration of gamification and DTTS in mathematics education. This focused approach ensures a thorough and nuanced examination of the specified variables, contributing valuable insights within the defined boundaries of subject, level, and context.

Chapter 2

Conceptual and Theoretical Framework

This chapter serves as a comprehensive exploration of pertinent literature, delving into related papers that serve as a foundation and support for the present research. Through an in-depth analysis of these works, we aim to build a robust understanding of the existing knowledge landscape and identify key insights that contribute to the advancement of our research objectives.

In the subsequent sections, we will refer to Multi-Armed Bandit Algorithms as MABs and specifically use Decision Tree Thompson Sampling (DTTS) to denote the algorithm under consideration. This terminology clarification is intended to enhance reader understanding and maintain consistency throughout the paper.

Review of Related Literature

Gamification in Education

The systematic literature review conducted by Vrcelj, Hoic-Božic, and Dlab (2023) delves into the use of gamification in primary and secondary education, highlighting the prevalence of gamified elements to enhance student motivation and engagement. Despite its common application in university settings, the study reveals a gap in research supporting gamification in primary and secondary schools. This underscores a potential area for improvement through adaptive strategies. Considering the challenges identified, the integration of Multi-Armed Bandit (MAB) Algorithms, specifically the Decision Tree Thompson Sampling (DTTS) Algorithm, emerges as a promising avenue. The DTTS Algorithm, as a type of MAB, can dynamically personalize gamified educational experiences, optimizing resource allocation and content delivery to address the unique needs of students at these educational levels.

In parallel, the literature review by Kalogiannakis, Papadakis, and Zourmpakis (2021) focuses on the application of gamification in science education. The study emphasizes the role of technology, particularly gamification, in increasing student engagement and effective learning in science curricula. However, it also identifies challenges and gaps in the existing literature, indicating the need for adaptive strategies to optimize gamified content delivery. In this context, the integration of Multi-Armed Bandit (MAB) Algorithms, especially the Decision Tree Thompson Sampling (DTTS) Algorithm, stands out as a solution. DTTS, as a type of MAB, offers a personalized and efficient approach to content adaptation in gamified science education, dynamically adjusting elements based on individual student progress and engagement levels. This aligns with the broader goal of enhancing student outcomes and fostering effective learning experiences in science education.

These studies collectively suggest that the incorporation of Multi-Armed Bandit Algorithms, with a specific focus on the Decision Tree Thompson Sampling (DTTS) Algorithm, could bridge existing gaps and challenges in gamification strategies. The adaptive nature of DTTS presents an opportunity to tailor gamified educational content, optimizing engagement and learning outcomes in primary/secondary education and science education contexts. This research thus aims to contribute to the ongoing discourse on the effective utilization of adaptive algorithms in gamification, providing insights and recommendations for future research in the field.

Multi-Armed Bandit Algorithms in Education and Decision Tree Thompson Sampling (DTTS) Algorithm

In the pursuit of optimizing gamification in education, the integration of Multi-Armed Bandit (MAB) algorithms emerges as a pivotal strategy. Prihar et al.'s (2022) Automatic Personalized Learning Service (APLS), particularly the Decision Tree Thompson Sampling (DTTS) Algorithm, serves as a cornerstone in dynamically recommending effective support for students. This resonates with the core of gamification, where personalized learning experiences are crucial for enhancing student engagement and motivation. The transparency and interpretability introduced by DTTS address concerns related to the effectiveness and understanding of personalized learning platforms, providing a robust foundation for incorporating adaptive elements into gamified educational journeys.

Li et al.'s (2020) exploration of feature choice in online adaptive algorithms contributes valuable insights into the intricate balance required in adaptive strategies, aligning with the exploration-exploitation trade-off inherent in MAB algorithms. Considering the adaptability of features is crucial in gamification, as it involves tailoring experiences based on individual student interactions and performance. The study's findings underscore the need for careful consideration in feature selection, emphasizing the relevance of such considerations in the context of gamified educational platforms employing DTTS.

Zhi-Han et al.'s (2022) introduction of adversarial MAB algorithms resonates with the dynamic nature of gamified education. The robust experimentation framework they propose aligns with the challenges of variability in gamified learning environments. Adapting such adversarial approaches could enhance the reliability of gamification experiments, ensuring that the integration of gamified elements through DTTS remains effective and statistically robust.

Rafferty et al.'s (2019) insights into the statistical consequences of using MAB algorithms for adaptive educational experiments provide a foundational understanding. In the context of gamification, where experimentation is inherent in refining engagement strategies, the trade-off between acquiring reliable information and benefiting students is a critical consideration. The potential benefits to students in terms of learning outcomes, as demonstrated in their simulations, highlight the positive impact that adaptive strategies, particularly those driven by algorithms like DTTS, can have on the overall effectiveness of gamified education.

Clement et al.'s (2015) approach to Intelligent Tutoring Systems, leveraging MAB algorithms for personalized learning paths, offers a comprehensive framework. Applying this framework to gamification in education, especially with the incorporation of DTTS, showcases the adaptability of MAB algorithms to tailor sequences of learning activities. This adaptability aligns with the dynamic nature of gamification, allowing for the personalized and efficient delivery of content to maximize student engagement.

In essence, the integration of DTTS, a Decision Tree Thompson Sampling Algorithm, within the broader context of MAB algorithms, presents a promising avenue for optimizing gamification in education. The adaptive and personalized nature of DTTS aligns with the objectives of gamification, offering a robust strategy to enhance engagement, reinforce theoretical concepts, and dynamically tailor educational experiences for individual students. The insights from these MAB algorithm studies collectively provide a comprehensive foundation for understanding the potential and implications of incorporating DTTS into gamified educational platforms.

Personalized Learning

The pursuit of personalized learning aligns seamlessly with the objectives of gamification in education, and the insights from Digital Promise Global's perspective on research and personalized learning (Digital Promise Global) provide a foundational understanding. Effective personalized learning begins with leveraging research about how students learn, and this principle resonates strongly with the gamification strategy explored in our research. The incorporation of technology, as highlighted in the paper, is analogous to the technological underpinning of the Decision Tree Thompson Sampling (DTTS) Algorithm in our study, emphasizing the role of technology in translating research to support learner variability. This connection reinforces the idea that personalized learning practices, supported by robust structures and strategies, are pivotal not only in traditional educational contexts but also in the gamified learning environments optimized by DTTS.

The Review of Personalized Learning in China (Li et al., 2020) sheds light on the global perspective of personalized learning, emphasizing individualized training and the use of technology to support diverse learning needs. In the context of gamification, the insights from China's progress in personalized learning resonate with the adaptability and customization inherent in gamified educational experiences. The incorporation of learning analysis technology, personalized recommendation technology, and similar support technologies aligns with the technological framework of DTTS in gamification, highlighting a convergence of strategies to tailor educational experiences at an individual level.

Judy Hughey's exploration of Individual Personalized Learning (Hughey, 2020) provides a practical lens on personalized learning, emphasizing engagement, intrinsic motivation, and active involvement in goal-setting. These principles find a parallel in the gamification approach, where the Decision Tree Thompson Sampling (DTTS) Algorithm becomes a catalyst for engaging students through adaptive, personalized gamified experiences. The concept of micro-credentials aligns with the idea of optimizing gamified learning in specific areas of interest, providing learners with opportunities for personalized, bite-sized achievements.

The articles on personalized learning provide a theoretical and practical foundation that seamlessly integrates with the gamification strategy explored in your research. The shared emphasis on research, technology, individualization, and learner engagement aligns cohesively, suggesting that the principles of personalized learning can be effectively extended into the realm of gamification using the Decision Tree Thompson Sampling (DTTS) Algorithm.

Student Engagement and Motivation

According to a recent study by Sungjin Park and Sangkyun Kim (2021), gamification in online learning has emerged as a strategy to promote sustainable learning, especially during the COVID-19 era. The research investigates the impact of gamified online learning on student motivation and understanding of educational content. The study, conducted with 140 elementary and middle school students, suggests that gamification has a positive influence on learner motivation and content comprehension, advocating for its use as a sustainable method to achieve the United Nations' Sustainable Development Goal 4 (SDG 4) of ensuring quality education.

This study explores the effects of gamified online learning, particularly utilizing the Science Level Up platform, on learner motivation and comprehension of educational content. In the context of the COVID-19 pandemic, the research aims to create sustainable learning environments to address the challenges posed by the ongoing global health crisis. The chosen platform, Science Level Up, distinguished itself with its accessibility on various devices and provision by South Korean public institutions without charge.

In relation to the research on Student Engagement and Motivation in gamified education using the Decision Tree Thompson Sampling (DTTS) algorithm, Sungjin Park and Sangkyun Kim's study provides valuable insights. The positive impact of gamification on learner motivation aligns with the research investigation's goal of enhancing student engagement. The sustainable learning approach proposed in Sungjin Park and Sangkyun Kim's study resonates with the adaptive nature of DTTS, ensuring continual adjustments to content delivery based on evolving learner needs for sustained engagement.

Moreover, the study emphasizes the positive influence of gamification on understanding difficult content, suggesting a potential synergy with a Multi-Armed Bandit (MAB) Algorithm. The integration of a MAB Algorithm, as discussed in my research, aligns with the need for dynamic personalization to strike a balance between engagement and frustration, contributing to sustained engagement.

Sungjin Park and Sangkyun Kim's findings underscore the potential of gamification, coupled with a MAB Algorithm, to address educational inequality by tailoring learning experiences and promoting personalized and equitable education. The adaptability of the algorithm aligns with the continuous adjustment needed in gamified education, responding to changes in learner preferences for sustained engagement.

Effectiveness of Educational Technology

According to the research conducted by Nurfalah et.al. (2021), the significance of digital knowledge in mathematical education is emphasized to enhance students' understanding of steps and logical thinking. The study identifies obstacles faced by mathematics lecturers, including limited time, insufficient facilities, and restricted access to digital resources for students. In response to these challenges, the research provides solutions to facilitate better learning, exploring various choices of digital technology for mathematics education, such as online learning, social media-based learning, interactive discussions, and the use of mathematical software.

In the context of this research on the Effectiveness of Educational Technology, Nurfalah et.al. study holds relevance. The exploration of digital technology choices, particularly mathematical software, aligns with the investigation into the impact of educational technology on student outcomes. The positive influence of mathematical software on enhancing the understanding of subject matter resonates with the broader goals of incorporating technology in education to improve comprehension and learning outcomes.

The mixed-methods approach employed by Nurfalah et.al. provides a comprehensive evaluation of the strengths and weaknesses of mathematical software, incorporating both quantitative and exploratory techniques. This methodological approach contributes to the robustness of their findings and aligns with the multifaceted evaluation approach in my research on the effectiveness of educational technology.

Moreover, Nurfalah et.al. underscores the importance of designing learning with digital technology based on principles such as freedom, independence, flexibility, recency, suitability, mobility, and efficiency. These principles, as discussed in their research, provide valuable insights into the key considerations in implementing educational technology effectively. Drawing from their findings, this research can benefit from considering these design principles when evaluating the impact of educational technology on student learning outcomes.

While Nurfalah et.al. acknowledges drawbacks, such as limited face-to-face interaction, associated with digital learning, the overall positive impact of digital technology on enhancing global learning opportunities is highlighted. This perspective aligns with the overarching theme of my research, which seeks to assess the effectiveness of educational technology in improving learning outcomes despite potential challenges.

Online Learning Platforms

The integration of online learning platforms, as explored in the articles, aligns synergistically with the gamification strategy in our research, wherein Decision Tree Thompson Sampling (DTTS) Algorithm plays a pivotal role. The study by Haji (2022) on Cameroonian students' use of online learning platforms reflects the widespread adoption of web 2.0 technologies, showcasing the increasing reliance on digital tools for education. In our research, the Decision Tree Thompson Sampling (DTTS) Algorithm optimizes gamified learning experiences on these platforms by adapting content based on individual student progress, contributing to the effective blending of online and gamified education.

Gascoigne's (2023) review of language practice exercises within commercially-available eBooks and electronic companion practices highlights the mechanical and drill-focused nature of online learning platforms. In our gamification research, the Decision Tree Thompson Sampling (DTTS) Algorithm counters the potential monotony by dynamically personalizing gamified content, ensuring that students engage in meaningful and communicative learning experiences within these platforms. This connection reinforces the idea that personalized gamification strategies can mitigate concerns about the mechanical nature of certain online learning activities.

The exploration of common trends in online educational experiments by Prihar et al. (2022) aligns with the overarching goal of our gamification research, emphasizing the need to evaluate and optimize online learning platforms. The Decision Tree Thompson Sampling (DTTS) Algorithm in our study serves as a mechanism to explore and identify trends in student engagement, providing insights that can inform the design and improvement of online learning platforms. This connection emphasizes the complementary nature of adaptive algorithms like DTTS in enhancing the effectiveness of online educational experiences.

Padohinog et al.'s (2022) study assessing the effectiveness of Google Classroom and Blackboard Learn provides additional context to the online learning platform landscape. In our research, the Decision Tree Thompson Sampling (DTTS) Algorithm is positioned as a key element in enhancing the gamified aspects of these platforms. The personalized adaptation capabilities of DTTS ensure that the gamified elements are aligned with individual student needs, potentially addressing variations in perception observed between students and teachers in online learning platforms.

The articles on online learning platforms provide a contextual foundation for understanding the challenges and opportunities in digital education. When integrated with the gamification strategy and the Decision Tree Thompson Sampling (DTTS) Algorithm, these platforms can be optimized to deliver engaging, personalized, and effective educational experiences.

Learning Analytics

The introduction and exploration of learning analytics in the articles provide a foundation for understanding the significance of data-driven insights in education. In our gamification research, the Decision Tree Thompson Sampling (DTTS) Algorithm acts as an advanced analytical tool to harness the potential of learning analytics, specifically tailoring gamified content based on individual student needs and preferences.

Yilmaz and Çakir's (2021) study defines learning analytics as a means to measure, collect, and report data related to learners and learning environments, emphasizing its role in understanding and improving learning outcomes. In our research, the integration of Decision Tree Thompson Sampling (DTTS) Algorithm complements learning analytics by dynamically adapting gamified elements to enhance engagement and optimize learning experiences.

The case study by Nyland, Croft, and Jung (2021) on piloting learning analytics in a multidisciplinary online program showcases the positive impact of learning analytics on student success. In our gamification research, the Decision Tree Thompson Sampling (DTTS) Algorithm enhances the adaptability of gamified content, ensuring that interventions triggered by analytics contribute to a more personalized and effective gamified learning environment.

Maloney et al.'s (2022) exploration of Learning Management System (LMS) log data to understand student engagement with coursework videos highlights the potential of analytics in assessing student behavior. In our research, the Decision Tree Thompson Sampling (DTTS) Algorithm refines this approach by tailoring gamified elements based on students' engagement patterns, creating a more adaptive and engaging gamified learning experience.

Makruf and Tejaningsih's (2023) analysis of strategies to overcome online learning challenges during the COVID-19 pandemic underscores the importance of user-friendly platforms. In our gamification research, the Decision Tree Thompson Sampling (DTTS) Algorithm enhances the adaptability of gamified content, ensuring that user-friendly platforms are optimized to address specific challenges and preferences, contributing to a more effective and engaging gamified learning experience.

Learning analytics, when integrated with the Decision Tree Thompson Sampling (DTTS) Algorithm, becomes a powerful tool for optimizing gamified content. This connection ensures that the insights gained from learning analytics are effectively translated into personalized, engaging, and adaptive gamified learning experiences.

Human-Computer Interaction in Education

According to Guney's (2019) study on "Considerations for Human-Computer Interaction: User Interface Design Variables and Visual Learning in IDT," the intersection of human-computer interaction (HCI) and educational technology (ET) plays a crucial role in enhancing learning experiences. The article discusses the historical evolution of HCI in education, emphasizing visual design, learning variables, and user-interface design principles within instructional design and technology (IDT). Guney explores the perceptual approach of HCI, aligning with cognitive load and activity theories, and highlights the importance of UID and UED for effective learning from screens. In the context of gamification in education, this study offers valuable insights into how UID and UED strategies, influenced by HCI principles, can contribute to designing engaging learning environments. By incorporating the considerations outlined in Guney's research, gamification strategies can be informed by the visual design techniques and HCI roles discussed in the study. This connection underscores the significance of merging principles from HCI with gamification in educational technology, aiming to optimize user experiences, enhance learner engagement, and ultimately improve the effectiveness of gamified educational platforms.

Numerous researchers have explored the integration of computers in education, and with the increasing variety of computing devices, tablets have gained popularity in classrooms. According to Marques et.al. (2014), they employed in the research a multifaceted approach to assess the integration of Tablet PCs in the Human-Computer Interaction course. An experimental design was likely implemented, utilizing controlled experiments to compare the effectiveness of traditional teaching methods with those incorporating Tablet PCs. Observational studies were conducted to qualitatively analyze the classroom dynamics, student engagement, and the overall impact of the technology on the learning environment. Surveys and questionnaires were administered to gather quantitative data on students' perceptions and preferences regarding the use of tablets. Additionally, qualitative interviews were conducted to delve into in-depth experiences and perspectives of both students and instructors. Content analysis techniques were applied to systematically analyze the outputs generated by students using tablets, such as handwritten responses and digital annotations. The research also exhibited characteristics of action research, emphasizing continuous reflection and adaptation of teaching methods based on ongoing observations and insights gained throughout the course. This comprehensive methodology allowed for a thorough examination of the advantages and disadvantages associated with the integration of Tablet PCs in the Human-Computer Interaction educational context.

The exploration of Multi-Armed Bandit (MAB) algorithms in education, specifically the Decision Tree Thompson Sampling (DTTS) algorithm, offers insightful implications for the concept of using Tablet PCs in the classroom for teaching Human-Computer Interaction (HCI) at the higher education level. The adaptive personalization capabilities demonstrated by DTTS align with the potential for Tablet PCs to dynamically personalize HCI teaching content, adjusting materials based on individual student progress for a more tailored learning experience. The discussion on the exploration-exploitation trade-off in educational interventions resonates with the interactive nature of Tablet PCs in the HCI teaching context, where students can explore new concepts while exploiting established principles through practical applications. Moreover, the application of DTTS in gamification strategies suggests that Tablet PCs, with their interactive features, can effectively incorporate gamification elements into HCI courses, enhancing engagement and reinforcing theoretical concepts through practical application. The optimization focus in previous discussion also implies that Tablet PCs, when strategically integrated, can contribute to efficiency identification and optimization in HCI teaching methods. Overall, the insights from previous discussion provide a valuable framework for considering Tablet PCs as versatile tools for enhancing the effectiveness and personalization of HCI education in higher education settings.

Ethical Considerations in Educational Technology

Ethical reviews are vital in research to ensure participant safety, especially in the context of rapidly growing big data research within education, including learning analytics, artificial intelligence (AI), and Massive Open Online Courses (MOOCs). According to Costello et.al. (2023), the study examined peer-reviewed MOOC-related papers to assess explicit references to ethical considerations and the acquisition of formal ethical approval. Out of 1,249 articles reviewed, only 42 (5.08%) mentioned ethics, and merely 13 (1.57%) explicitly noted obtaining ethical approval. This lack of transparency in reporting indicates a need for increased engagement in ethics education for researchers, ethical considerations in big data studies, and publishing norms for reporting ethical considerations. The study draws inspiration from similar critiques of learning analytics and AI in education, highlighting the existing gap in discussing ethics within MOOC research. The importance of addressing ethical concerns in MOOC teaching and learning research is underscored, particularly given the ongoing significance of such research in the field of education.

According to the study by Costello et.al. (2023), they employed a scoping review methodology to systematically investigate ethical practices in research on Massive Open Online Courses (MOOCs) teaching and learning. The researchers conducted a comprehensive review of MOOC-related, English-language papers available in the Scopus database over the course of a year. From the initial 1,435 papers, a sample size was determined, and inter-rater reliability testing was conducted on a subset to ensure methodological rigor. The inclusion criteria specified that selected papers must be written in English, published in journals or peer-reviewed conference proceedings, and fall within the timeframe of January 2016 to January 2017. The search strategy involved using specific keywords related to MOOCs, and the results were refined to produce a dataset of 826 articles. The "pdfgrep" tool was then applied to search for the term "ethic" within these articles. The subsequent analysis focused on identifying articles that explicitly mentioned ethical considerations in relation to the studies and those that obtained formal ethical approval. The findings revealed a limited discussion of ethics in the analyzed literature, prompting recommendations for increased stakeholder engagement, sectoral dialogue, and the establishment of norms and policies for reporting ethical considerations in academic publishing. The study's methodologies underscore its systematic and rigorous approach to assessing ethical practices in MOOC research, contributing valuable insights to the broader academic discourse.

The research sheds light on the integration of Multi-Armed Bandit Algorithms, specifically the Decision Tree Thompson Sampling (DTTS) algorithm, in the realm of personalized learning, prompting critical insights and implications relevant to the concept of Massive Omission of Consent (MOOC) in ethical research within educational big data studies. The study introduces the Automatic Personalized Learning Service (APLS), underscoring a shift towards algorithmic personalization in education. This raises ethical considerations regarding transparency and informed consent, aligning with the MOOC concept's emphasis on robust ethical reviews in the context of big data research. Furthermore, the research's exploration of the adaptive experimentation and exploration-exploitation trade-off in educational interventions using Thompson Sampling resonates with the MOOC concept, emphasizing the dynamic nature of learning environments and the need for ethical frameworks in algorithm-driven personalization. The extension of DTTS to gamified learning aligns with the broader discourse on optimizing educational experiences through technology, emphasizing ethical considerations in the integration of personalized learning strategies within online education platforms like MOOCs.

The synthesis of findings underscores a transformative integration of gamification and educational technology, notably supported by Multi-Armed Bandit Algorithms like DTTS, signaling a paradigm shift in instructional design. The emphasis on personalized learning, adaptive strategies, and student engagement reaffirms the potential of gamification, coupled with DTTS, to cater to individual student needs and sustain motivation. Ethical considerations emphasize the responsible use of algorithms, highlighting the need for transparency in DTTS implementation. Furthermore, the focus on learning analytics advocates for data-informed decision-making, aligning with the research objective to assess the impact of DTTS through continuous improvement. The intersection of Human-Computer Interaction principles in educational technology and the significance of online learning platforms underscore the importance of user-centric design and the transformative role of digital ecosystems. These implications not only provide crucial insights but also directly relate to and support the proposed research objectives, offering a solid foundation for the conceptualization of the research framework.

Theoretical Framework

Reinforcement Learning (RL)

Reinforcement Learning (RL) serves as the overarching theoretical framework for this research, providing a lens through which to understand the dynamic interaction between students and gamified educational environments. In RL, the learner, akin to an agent, engages with the gamified platform (the environment) by making decisions (actions) that influence their learning experience (Sutton & Barto, 2018). The Decision Tree Thompson Sampling (DTTS) algorithm, a form of Multi-Armed Bandit (MAB) approach, functions as the learning mechanism within this RL framework. It enables adaptive decision-making, balancing the exploitation of known effective educational strategies with exploration to discover novel, potentially more rewarding approaches.

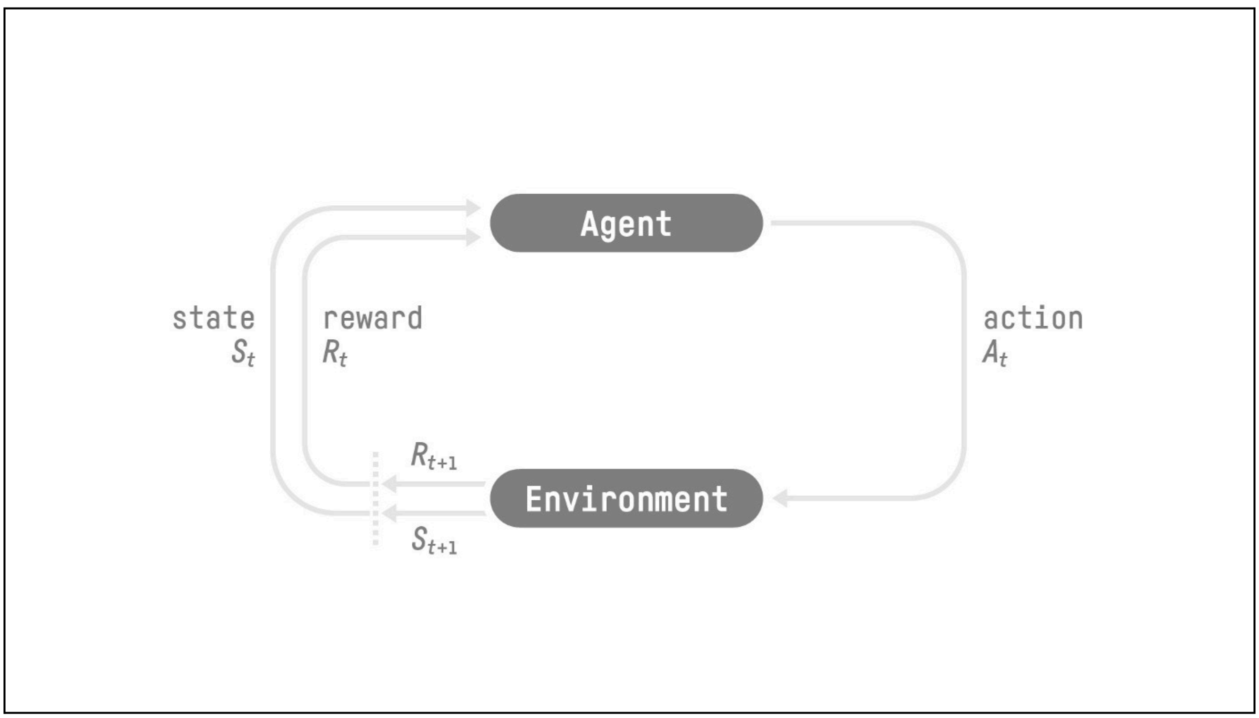

Figure 1. The RL Process: a loop of state, action, reward and next state

Source: Sutton, R. S., & Barto, A. G. (2018). Rich Sutton's Home Page. http://incompleteideas.net/book/RLbook2020.pdf

Reinforcement Learning (RL) provides a powerful theoretical foundation for understanding the interactions within gamified educational contexts, particularly when applied to the Decision Tree Thompson Sampling (DTTS) algorithm. In RL, the algorithm learns by receiving feedback in the form of rewards or penalties based on the decisions it makes. This aligns seamlessly with the educational setting, where students, acting as learners or agents, navigate through gamified content, making decisions that influence their learning experience. The DTTS algorithm, as a form of Multi-Armed Bandit (MAB) approach, operates within this RL framework, serving as the decision-making agent.

The application of RL to DTTS in gamified education is akin to a continuous loop of adaptive learning. As students interact with gamified elements, the algorithm dynamically adjusts its strategies based on the feedback received. If a particular gamified feature enhances student engagement or comprehension (positive reward), the algorithm is reinforced to prioritize similar strategies in the future. Conversely, if a feature proves less effective (negative reward), the algorithm adapts by exploring alternative approaches. This iterative process mirrors the RL framework, where learning is an ongoing, dynamic interaction between the algorithm and the students.

In essence, RL applied to the DTTS algorithm in gamified education facilitates personalized and adaptive learning experiences. It enables the algorithm to learn from student responses, optimize content delivery, and strike a balance between exploiting known effective strategies and exploring new possibilities. This iterative learning loop, grounded in RL principles, contributes to the overall effectiveness of gamified educational platforms by tailoring experiences to individual student needs and preferences.

Conceptual Framework

Adaptive Learning Theory

Adaptive Learning Theory is a conceptual framework that centers on tailoring educational experiences to the individual needs and progress of each learner. It operates on the premise that learners differ in their abilities, learning styles, and pace of understanding (Dhupia & Alameen, 2019). In the context of gamification, the Adaptive Learning Theory aligns with the goal of creating personalized and dynamic educational content, optimizing engagement, and fostering effective learning experiences.

When applied to gamification with the DTTS algorithm, the Adaptive Learning Theory serves as the guiding principle for the algorithm's decision-making processes. The theory acknowledges that students have varying levels of familiarity with gamified content and different preferences for interactive elements. The DTTS algorithm, as a Multi-Armed Bandit (MAB) approach, incorporates this theory by dynamically adapting its choices based on individual student interactions and performance.

In practical terms, the Adaptive Learning Theory within the DTTS algorithm ensures that gamified content is not static but evolves in response to each student's progress and engagement levels. If a particular gamified element proves effective for a student, the algorithm reinforces its presence or refines similar features to maintain engagement. Conversely, if a student shows disinterest or struggles with certain aspects, the algorithm adapts by exploring alternative gamification strategies. This continuous adaptation aligns with the principles of Adaptive Learning Theory, providing a personalized and efficient approach to gamified education.

Conceptual Model of the Study

The study aims to address key challenges in education, such as low student engagement and lack of personalization, by integrating gamified education with the Decision Tree Thompson Sampling (DTTS) algorithm, a type of Multi-Armed Bandit (MAB) algorithm. This approach combines game elements like points, badges, and leaderboards with adaptive learning to create a dynamic and personalized learning environment, particularly for Grade 10 algebra.

Central to the model is the Adaptive Learning Theory, which ensures that educational content evolves based on individual student progress and engagement. The DTTS algorithm adapts learning activities in real-time, optimizing student engagement and performance. The study also examines both intrinsic and extrinsic motivational factors to maintain high levels of student interest and satisfaction.

The expected outcomes include enhanced learning performance, increased student satisfaction, and greater inclusivity by catering to diverse student needs. Overall, this conceptual model illustrates how the fusion of gamified education and adaptive algorithms can transform traditional teaching methods, making education more engaging and effective.

INPUT

Gamified Education
(Game Elements, Algebra)

PROCESS

- Multi-Armed Bandit (DTTS Algorithm)
  - Adapts Choices
  - Collects Data
- Adaptive Learning Theory
  - Personalization
  - Continuous Adaptation
- Learner Engagement and Motivation
  - Intrinsic
  - Extrinsic

EXPECTED OUTCOME

- Multi-Armed Bandit (DTTS Algorithm)
  - Enhanced Learning
  - Student Satisfaction
  - Inclusivity

Research Paradigm

The Gamification of Education is driven by a multifaceted approach that incorporates essential elements like User Action, Webgame utilization, the DTTS Algorithm, user data analysis, and the Heuristic Method. By integrating these components, the educational paradigm aims to transform learning methodologies and elevate student engagement levels. The innovative use of the Multi-Armed Bandit (MAB) algorithm further enhances this approach, enabling the system to dynamically adapt and personalize learning experiences based on students' interactions, responses, and performance metrics. This holistic framework ensures a comprehensive and efficient gamified learning environment tailored to meet individual student needs and optimize educational outcomes.

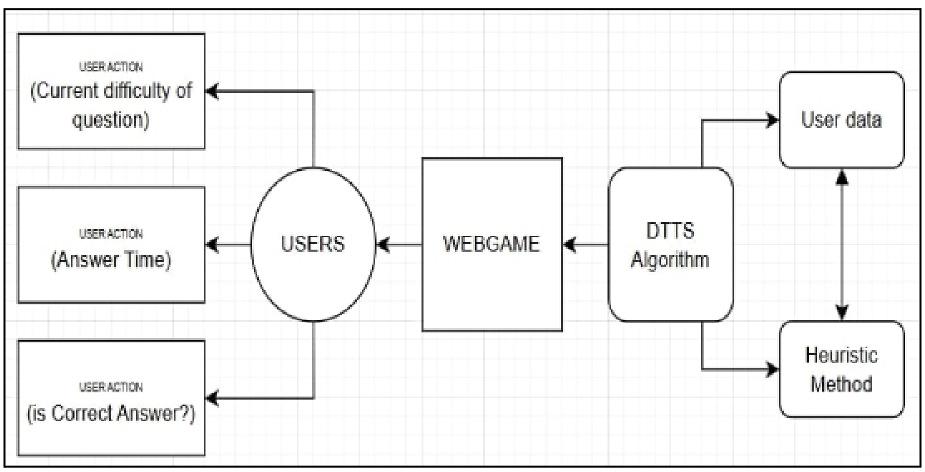

Figure 2: Research Paradigm

User Action - The process starts with students actively participating in the gamified learning platform through the user interface. Users encounter questions of varying difficulty levels, providing a personalized learning experience. The system tracks the time taken by users to answer questions, gauging their response speed and engagement. It also assesses the accuracy of user responses, shaping the learning journey based on their performance.

Webgame - As part of the gamification of education using the Multi-Armed Bandit Algorithm, a series of interactive web games will be developed. These web games will be designed to enhance students' understanding and retention of key concepts through engaging and immersive gameplay. Each game will focus on specific learning objectives, providing students with a dynamic and enjoyable way to apply their knowledge and skills. The use of the Multi-Armed Bandit Algorithm will optimize the difficulty levels of questions based on the response time and accuracy of the user. Additionally, it will tailor the content of the games to match students' performance, ensuring a personalized and adaptive learning experience.

DTTS Algorithm - The Gamification of Education integrates the Multi-Armed Bandit (MAB) Algorithm and the DTTS (Dynamic Time-Triggered Switching) Algorithm to enhance learning outcomes and student engagement. The MAB Algorithm optimizes the selection of learning content and activities based on students' performance metrics, ensuring a personalized and adaptive learning experience. Simultaneously, the DTTS Algorithm orchestrates real-time communication and scheduling within the gamified learning environment, guaranteeing deterministic timing and reliable question execution. This combined approach fosters efficient and interactive learning environments, particularly beneficial for complex educational systems and real-time applications.

User Data - The Multi-Armed Bandit Algorithm centers on efficient user data collection and analysis. It involves gathering performance metrics like completion rates and accuracy, as well as understanding user preferences such as learning styles and topic interests. Progress tracking and contextual information further enhance the data-driven approach, facilitating personalized learning experiences and optimizing content selection through the MAB Algorithm. This comprehensive user data strategy ensures continuous improvement and effective adaptation within the gamified educational environment.

Heuristic Method - The Multi-Armed Bandit Algorithm incorporates a heuristic method that leverages past user interactions, specifically focusing on how users have answered questions correctly and quickly. This heuristic approach uses historical data to dynamically adjust the difficulty levels of questions and the content presented to users. By analyzing users' past performance, the system can intelligently adapt and personalize the learning experience, providing challenges that are appropriately matched to individual abilities and promoting engagement and learning effectiveness.

Definition of Terms

- **Alge-bruh** - The name given to the webgame. It utilized gamification in education.
- **Gamification** - Gamification refers to the use of game-like elements, such as rewards, progress levels, and interactive structures, in educational settings to enhance learning experiences.
- **DTTS** - Decision Tree Thompson Sampling (DTTS) is a specific Multi-Armed Bandit (MAB) algorithm utilized in gamified education. DTTS is known for its adaptability and effectiveness in tailoring learning content based on individual student progress.
- **Webgame** - A webgame refers to an online game or interactive educational platform that incorporates gamification elements to enhance the learning experience.

Chapter 3

RESEARCH METHODOLOGY

This chapter provides a detailed discussion on the project design, development, operating and testing, and evaluation process of the system methods as well as the procedures that will be conducted by the researchers, as well as the proposed flow of the steps to be completed in order to accumulate information essential for the study.

Project Design

The main objective of this study, which focuses on junior high school students, especially Grade 10 students, is to modify the online educational game to better suit their unique learning requirements. The goal is to produce a useful and captivating teaching tool that fits this demographic's educational environment. The study focuses on evaluating the algorithm's effectiveness in personalized learning, understanding student satisfaction, and enjoyment, and exploring its adaptability across diverse subjects.

The survey will also include non-knowledgeable respondents, primarily students with little experience with algorithms, to guarantee a thorough review. Their input, which focuses on the end-user experience, will be crucial in determining how user-friendly and entertaining the game is. By using a random sampling technique, the study seeks to include a wide range of individuals. This all-inclusive strategy will support a more thorough examination of the game's efficacy and user experience.

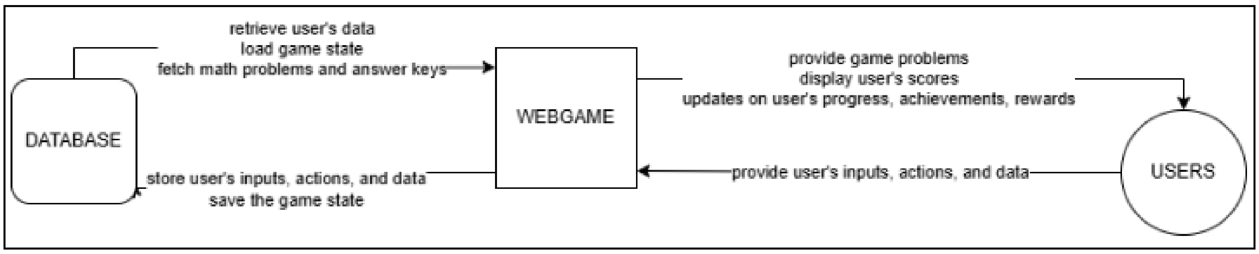

Figure 3. Context Diagram

A high-level view of a system is provided by a context diagram. It is a simple drawing intended to define an entity based on its range, restrictions, and connections to outside elements like stakeholders.

As depicted in the diagram, the user, typically a student, interacts with the system by providing various inputs. The ALGE-BRUH webgame is the primary platform where students engage with the gamified content. The webgame interacts with a database to store and retrieve user information and game data. This interaction ensures that user data is consistent and up-to-date. Based on the user data, the webgame uses the DTTS algorithm to generate personalized game actions. This algorithm helps tailor the educational content to match the student's learning style, preferences, and progress.

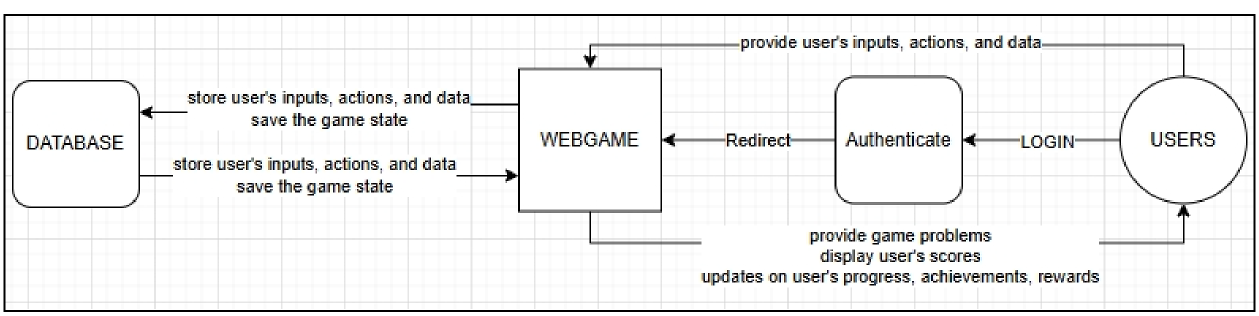

Figure 4. Data Flow Diagram (DFD) Level 0

As depicted within the Data Flow Diagram (DFD) Level 0, it is evident that the students shall initiate the process by entering their information, such as email and username, into the system. The entered information is authenticated to ensure its accuracy and validity. Once authenticated, this information is saved to the database for future reference and use. After authentication and storage, the system redirects the students to the ALGE-BRUH webgame. The webgame then retrieves the stored information from the database.

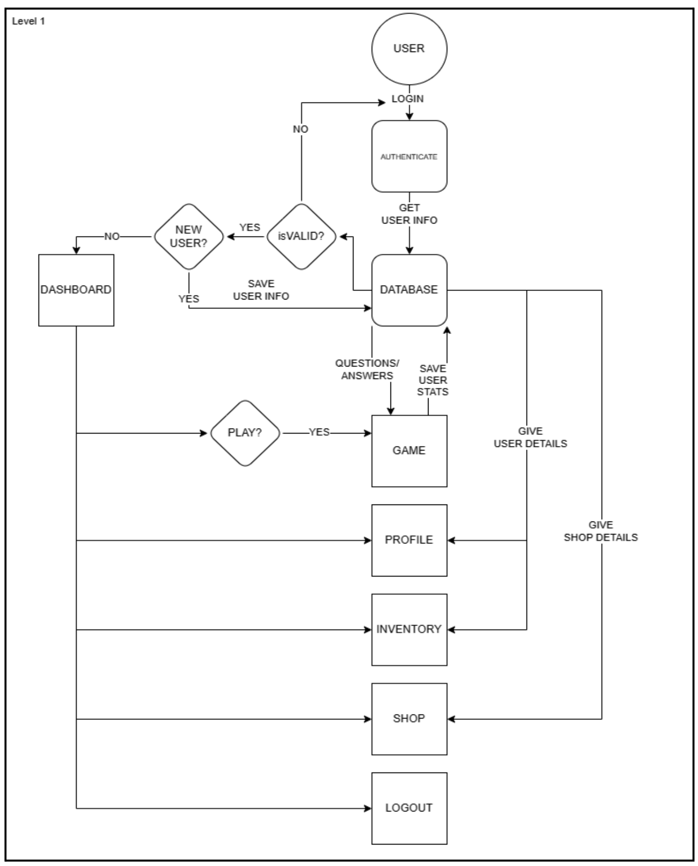

Figure 5. Data Flow Diagram (DFD) Level 1

The DFD Level 1 gives an overview of the system and its core processes at a more detailed level. It depicts the various actions that a user can perform and the interactions between these actions and the system components.

Students can register by providing their details, which are then authenticated and stored in the database. Existing users can log in using their credentials, retrieving their stored information from the database. Upon logging in, students interact with the ALGE-BRUH webgame. The game retrieves user data and adapts the gaming experience using the DTTS algorithm to personalize the content. As students engage with the game, their progress and performance data are continuously saved to the database. The system tracks this data to provide feedback and adjust future game actions accordingly.

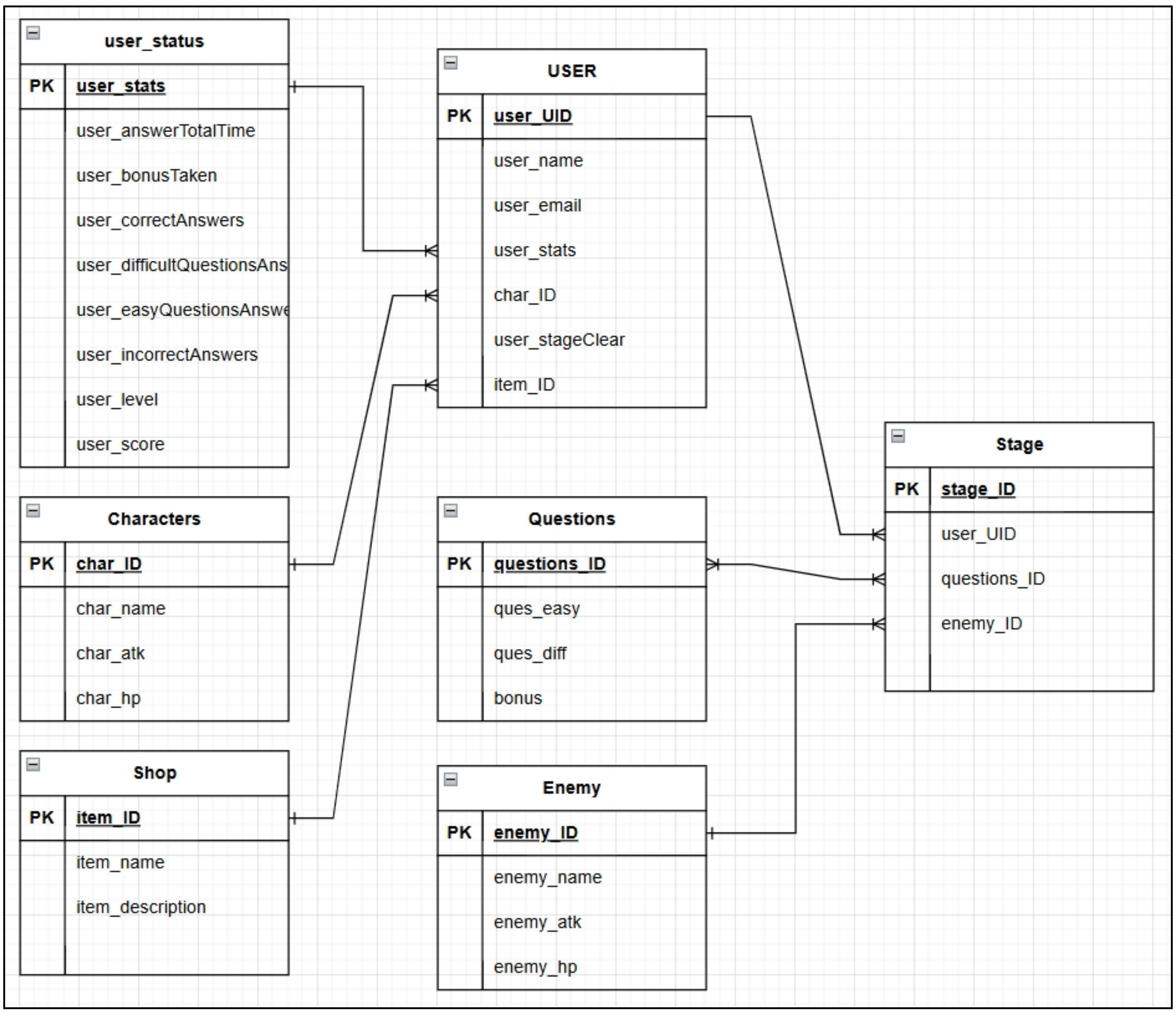

Figure 6. Entity Relationship Diagram (ERD)

The ALGE-BRUH webgame leverages real-time user data to inform the DTTS algorithm, which personalizes the learning experience. The algorithm adjusts the difficulty of questions, provides bonuses, or issues warnings based on the user's current progress and performance. This dynamic adaptation ensures that the educational content is tailored to each student's learning needs and preferences.

Project Development

Phase 1:

To initiate this process, it is essential to engage in meticulous planning. The purpose of this planning phase is to ensure the actual execution of all planned activities, thereby maintaining a comprehensive check on the overall development. The primary objective of this planning phase is to establish a well-defined project management workflow that encompasses the entirety of the project's development. It is crucial for the developer to acknowledge the significance of breaking down the project into smaller tasks. This approach facilitates the estimation of the required time and the determination of resource prerequisites for successfully completing the ALGE-BRUH webgame project.

Phase 2:

Upon completion of the study case for this system, the commencement of Phase 1 shall encompass all relevant aspects. Within this phase, the developer shall undertake a comprehensive delineation of the system's users, its intended function, as well as the specific details regarding its execution, including the time and location thereof.

The developer shall initiate the study by thoroughly scrutinizing the existing system to ascertain its inherent strengths and weaknesses. This critical evaluation is of paramount importance as it may unveil opportunities for the upgrade or replacement of the current system. Subsequently, the formulation of the new system shall be devised to rectify any deficiencies or drawbacks identified in the preceding analysis. The development of the new system's concept shall be predicated upon the insights derived from this research endeavor. Furthermore, various fact-finding techniques such as extensive background reading, conducting surveys, and employing observational methods shall be utilized to amass the requisite data.

In order to ensure the new system adequately caters to the users' preference, a diligent examination of the new system's feasibility shall be conducted by the developer. Moreover, an exhaustive assessment of the constraints and limitations imposed upon the new system shall be undertaken to ascertain its viability and compatibility.

Phase 3:

Phase 3 commenced subsequent to the completion of Phase 2. During this stage, meticulous technical designs were formulated, encompassing even the most minute details. It is customary for numerous potential solutions to be identified, yet ultimately, web based game applications are chosen as the preferred option for the system to cater users.

The development of the webgame involved a combination of HTML, CSS, and JavaScript, which provided a solid foundation and added complexity to the project. HTML was used to structure the game's content, CSS for styling and visual appeal, and JavaScript for interactive features and game logic. These technologies not only challenged the developers but also enhanced their web development skills. Additionally, Firebase was utilized for both the database and web hosting, ensuring seamless data management and making the game easily accessible online. Firebase's real-time database capabilities allowed for efficient data storage and retrieval, while its hosting service provided a reliable platform for deploying the webgame.

The objective of system design is to develop a blueprint for the new system that fulfills all documented requirements. Throughout the system design process, various elements must be identified, including essential processes, interfaces, and outputs. Furthermore, the most optimal design solution is devised in this phase. To ensure effective interaction among the system and user, each object must be functional and appropriately categorized into its respective class.

Respondents of the Study

The respondents for this study are Grade 10 students enrolled in junior high school. These students were selected to participate due to their transitional stage in education, which presents unique learning needs and challenges. Their experiences and feedback are crucial for assessing the effectiveness and adaptability of the ALGE-BRUH webgame in providing personalized educational content.

By focusing on Grade 10 students, the study aims to capture a diverse range of learning styles and preferences within this age group. This selection ensures that the data collected reflects the varying levels of algorithm familiarity and educational requirements typical of junior high school students, thereby supporting a comprehensive evaluation of the game's impact and efficacy.

The survey will include respondents with little experience with algorithms to ensure a thorough review. Their feedback, focused on the end-user experience, is crucial for assessing how user-friendly, engaging, and entertaining the game is. If students find the webgame engaging and entertaining, it indicates that the DTTS algorithm is effectively personalizing the content to meet their needs. By using a random sampling technique, the study includes a diverse range of participants across different age groups, educational backgrounds, and technological familiarity, supporting a comprehensive evaluation of the game's efficacy and user experience.

Research Instrument

The primary research instrument for this study will be a structured questionnaire, designed to gather valuable insights through a user-friendly 5-point Likert scale. This quantitative approach aims to measure user perceptions and preferences, offering a systematic way to assess various aspects of the web-based educational game. The questionnaire will feature carefully crafted questions, strategically aligned with the study's objectives, focusing on evaluating the educational effectiveness of the game, understanding the user experience, and gauging the perceived impact of the DTTS algorithm. This instrument ensures a standardized and efficient means of collecting data that will contribute to the overall analysis of the game's performance and its alignment with the research goals.

Data Gathering Procedure

The data collection approach for this study will be divided into two phases, each precisely intended to capture both user information and evaluations comprehensively. The first stage will involve the methodical collection of registration-related user data, including email addresses, age, and educational background. This baseline information provides a crucial demographic context by providing insightful information about the characteristics of users interacting with the online learning game.

The research will move into the second phase, which involves collecting user assessments via carefully constructed questionnaires, after user data has been collected. These 5-point Likert scale questionnaires will be carefully distributed to non-knowledgeable respondents (mostly students who have not before encountered algorithmic principles) and knowledgeable respondents (such as professors with experience in algorithms). The selection procedure will be guided by the adoption of a random sample method in order to guarantee a comprehensive and representative data. By taking into consideration the respondents' varying age groups, educational backgrounds, and degrees of technological familiarity, this strategic approach ensures broad participation.

Scale	Adjectival/Descriptive Rating
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

Table 1. 5-point Likert Scale

It is also important to remember that the content that is included in the game will be carefully selected in accordance with the approved school curriculum, with a special emphasis on algebra in the field of mathematics. This conformity to educational standards enhances the game's educational validity and relevance, which adds to the overall efficacy and suitability of the web-based learning game for academic settings.

Sampling Method

The research sampling method will be designed using a random sampling technique to ensure each participant has an equal chance of being selected. This method aims to eliminate bias and enhance the representativeness of the sample, providing a solid foundation for the study's conclusions. Random sampling will help in obtaining a diverse group of participants, reflecting various demographics and educational backgrounds.

In the first phase, registration data such as email addresses, age, and educational background will be collected. This baseline information will offer crucial demographic context and insights into the characteristics of users engaging with the online learning game. By understanding these demographics, the study can better analyze how different factors influence user experience and interaction with the game.

The second phase involves collecting user assessments through carefully constructed questionnaires, using a 5-point Likert scale. These questionnaires will be distributed to both non-knowledgeable respondents, primarily students with limited algorithmic experience, and knowledgeable respondents, such as professors with algorithmic expertise. A stratified sampling method will be employed to ensure a comprehensive and representative dataset, considering varying age groups, educational backgrounds, and degrees of technological familiarity.

Tools and Languages

Regarding languages and tools, Visual Studio Code will serve as the main integrated development environment (IDE) due to its robust features and versatility. The actual web-based educational game will be diligently developed with HTML5, CSS, and JavaScript, paying close attention to the decision to use Bootstrap or React to improve the user interface design and user experience overall. Together, these tools help to create an interesting and dynamic learning environment.

Firebase will be essential on the backend, offering a dependable infrastructure for data retrieval and storage. This aligns seamlessly with the research goals, ensuring that the web-based game not only offers an immersive educational experience but also possesses the necessary backend support for efficient functionality.

CHAPTER 4

RESULTS AND DISCUSSION

This chapter discusses the project description, project structure, project capabilities and limitations, and project evaluation.

Project Description

The project involves the development of a web-based game system named ALGE-BRUH, designed to integrate the Decision Tree Thompson Sampling (DTTS) algorithm into gamified educational content. The primary objective of this webgame is to provide an effective method for assessing and engaging students' performance and learning, specifically in the subject of Grade 10 algebra. The system is built using HTML, CSS, and JavaScript for the front-end interface and game logic. Firebase is utilized for database management and web hosting, ensuring the webgame is accessible online.

ALGE-BRUH offers an interactive platform where students can track their progress and performance. The detailed statistics and adaptive learning paths aim to improve their understanding and retention of algebra concepts. The system offers tools for students to monitor their individual progress. It provides a comprehensive view of student statistics, such as number of correct and incorrect answers, time taken to answer questions, types and number of questions attempted, details of student-owned characters and items, and available stages or lessons. By engaging with the game, students are reminded of and can enhance their knowledge of Grade 10 algebra topics. While not explicitly mentioned, teachers can potentially use the data to tailor their instructional strategies, ensuring they meet the individual needs of each student.

The use of the DTTS algorithm allows for personalized learning experiences, adapting to each student's strengths and weaknesses. This personalized approach is expected to significantly enhance students' understanding and performance in algebra. By providing continuous feedback and a gamified learning environment, the system aims to foster academic excellence and support student success.

Upon completion, ALGE-BRUH will offer students a web game powered by the DTTS algorithm, enabling them to evaluate their performance and progress in algebra. This innovative educational tool is designed to enhance learning outcomes and support academic achievement in Grade 10 algebra.

Project Structure

The project structure contains screenshots and forms used in the program with its description and function in the system.

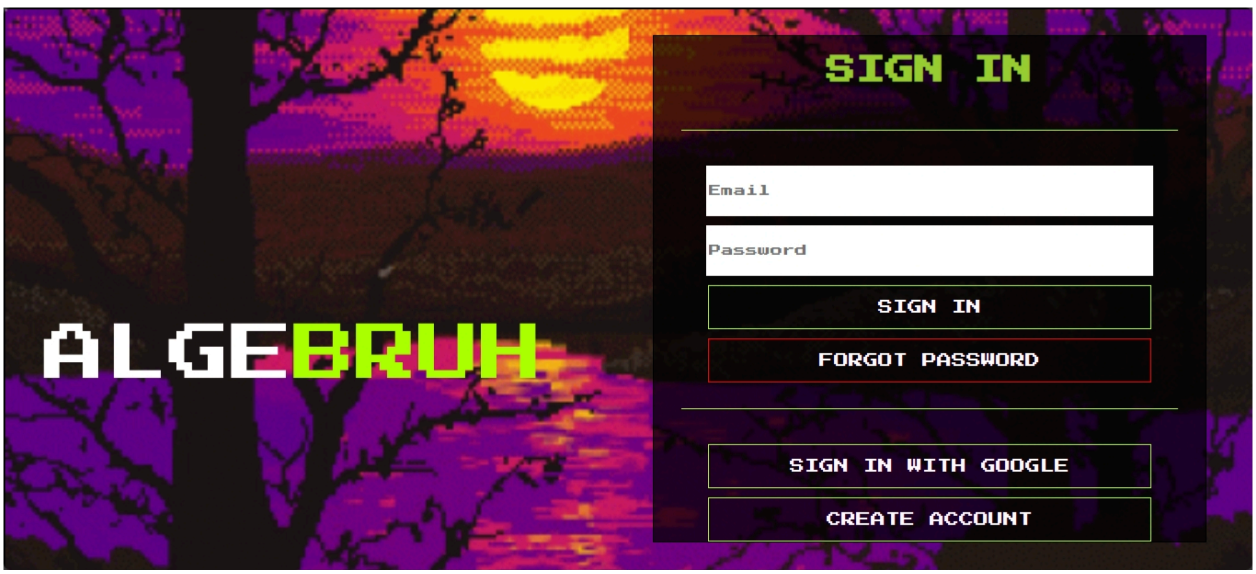

Figure 7. **Home page and Sign in page of ALGE-BRUH webgame**

Figure 7 depicts the Home page and Sign in page of the webgame. This is where the user signs in their account and the webgame will authenticate the given action and redirect the user to the appropriate page.

Figure 8. **Dashboard**

Figure 8 visually displays the dashboard page where it displays the various actions that the user can perform such as viewing the profile where it display the updated user status and other details such as username, viewing inventory where it displays the current characters and items that the user have, taking lessons by clicking the journey and pick which stage or lesson that the user can take, viewing the shop where the user can find available characters and items that the user can purchase to make the webgame more entertaining and make the user more encage to the game.

Figure 9. **Gameplay**

Figure 9 shows the actual gameplay of the game. It displays the current character that the user chooses. The user can use items to give the current character a ‘power up’. The questions given to the user are based on the user data to the database and to the current game. The next question will depend on the current difficulty level of the question, the time that the user answered the question, and if the answer is answered correctly or not using DTTS algorithm.

Project Capabilities and Limitations

The following are the capabilities of the developed system:

1. Data Management: The System can manage a vast amount of data related to students, including their owned characters and items, days active, username, stage cleared, and user stats such as total answer time, game currency, bonus, easy, and difficult questions taken, correct and incorrect answers, level, and score.
2. User-Friendly Interface: With a clean, intuitive interface, the webgame system ensures a smooth user experience for students that is more aligned to ‘memes’ in the internet to make the user entertain and engage.
3. Real-time Analytics: The System offers real-time analytics capabilities to monitor and analyze student performance and progress over time and for the DTTS algorithm to give appropriate action to the user during the gameplay.

Just like any other systems, the system has the following limitations:

1. Data Security and Privacy: Cyber threats can affect any system, despite strong security measures. Unauthorized access or data breaches are always possible.
2. Internet Dependence: Being a web-based system, access to it necessitates a steady internet connection. Users can have issues in places with inadequate internet connectivity.

Project Evaluation

The performance of the ALGE-BRUH webgame is a critical aspect of its effectiveness as an educational tool. The website is developed using HTML, CSS, and JavaScript, with Firebase handling database management and web hosting. This setup ensures that the webgame is accessible online and capable of managing a vast amount of data related to student performance and progress. The system's ability to offer real-time analytics further enhances its performance by allowing continuous monitoring and adaptive responses based on user interactions. However, the system's performance is highly dependent on a steady internet connection, which could be a limitation in areas with inadequate internet infrastructure.

The design of the ALGE-BRUH web game focuses on providing a user-friendly interface that is both clean and intuitive. This design approach aligns with popular internet 'meme' culture, aiming to make the user experience entertaining and engaging for Grade 10 students. The website includes essential features such as a home page, sign-in page, dashboard, and gameplay interface, each designed to guide users smoothly through their interactions with the game. The adaptability of the website for both phone and desktop use is crucial for its accessibility, although specific details on its mobile optimization are not extensively covered in the provided document.

The functionality of the ALGE-BRUH webgame is robust, offering several features to support educational engagement. The system allows students to track their progress through detailed statistics, including the number of correct and incorrect answers, time taken to answer questions, and more. The integration of the Decision Tree Thompson Sampling (DTTS) algorithm enables the game to provide personalized learning experiences by adapting to each student's strengths and weaknesses. The ability to manage extensive data and offer real-time analytics further enhances the functionality, making the webgame a comprehensive tool for learning and assessment.

User experience is a central focus of the ALGE-BRUH webgame, with a significant portion of the evaluation dedicated to assessing student satisfaction and engagement. According to survey results, the majority of students reported positive experiences, with high percentages indicating they felt content, skilled, engaged, and found the game enjoyable. The user-friendly interface and engaging game design contribute significantly to these positive outcomes, suggesting that the webgame successfully fosters an enjoyable learning environment.

The impact of the ALGE-BRUH webgame on students' learning experiences is substantial. The majority of students reported that the game helped improve their problem-solving abilities and overall academic performance. The engagement and enjoyment derived from the game likely contribute to higher motivation and sustained interest in learning algebra. By providing a gamified and interactive learning environment, the webgame has the potential to significantly enhance educational outcomes and support academic achievement in Grade 10 algebra.

In summary, the ALGE-BRUH webgame demonstrates strong performance, effective design, robust functionality, and positive user experience, contributing to its overall effectiveness and impact as an educational tool. However, considerations around data security, privacy, and internet dependence are essential for ensuring its sustainable success.

Respondents

Table 2: Total Number of Respondents

Type of Respondent	No. of Respondents	Percentage
Grade 10 Student	50	100
Total	50	**100**

Table 2: shows the total number of respondents and its respective percentage

Table 3: Summary of Results

Criteria	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
A. USER'S EXPERIENCE					
1.1 I felt content while playing the game.	60%	28.89%	6.67%	2.22%	2.22%
1.2 I felt skilled while playing the game.	55.56%	33.33%	8.89%	0%	2.22%
1.3 I was engaged in the game's story.	62.22%	22.22%	8.89%	4.44%	2.22%
1.4 I found the game enjoyable.	62.22%	26.67%	6.67%	2.22%	2.22%

1.5 I was fully immersed in the game.	57.78%	22.22%	17.78%	0%	2.22%
1.6 The game made me feel happy.	57.78%	31.11%	4.44%	4.44%	2.22%
1.7 I performed well in the game.	62.22%	26.67%	6.67%	0%	4.44%
1.8 The game was visually pleasing.	57.78%	28.89%	8.89%	2.22%	2.22%
1.9 I felt competent while playing the game.	60%	26.67%	11.11%	2.22%	0%
1.10 The game presented a good challenge.	57.78%	28.89%	11.11%	0%	2.22%
1.11 I found the game impressive.	66.67%	28.89%	2.22%	0%	2.22%
Mean Rating	**60.16%**	27.74%	8.57%	1.80%	2.22%

Criteria	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
B.. VALUE AND USEFULNESS OF THE GAME					
2.1 I believe this game could be valuable for my learning.	60%	26.67%	8.89%	0%	4.44%
2.2 I think playing this game is useful for enhancing my math skills.	57.78%	35.56%	6.67%	0%	0%
2.3 I would be willing to play this game again because it has educational value.	64.44%	26.67%	6.67%	0%	2.22%
2.4 Playing this game could help me improve my problem-solving abilities.	62.22%	26.67%	8.89%	0%	2.22%
2.5 I believe playing this game could benefit my overall academic performance.	57.78%	31.11%	8.89%	0%	2.22%
2.6 I think this game is an important educational activity	62.22%	28.89%	4.44%	2.22%	2.22%

Mean Rating	**60.74%**	29.26%	7.24%	0.37%	2.22%

Criteria	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
C. EFFORT AND ENGAGEMENT					
3.1 I didn't try very hard to succeed in this game..	17.78%	17.78%	17.78%	17.78%	**28.89%**
3.2 I thought this game was boring. (R)	11.11%	17.78%	15.56%	22.22%	**33.33%**
3.3 This game did not hold my attention at all. (R)	8.89%	11.11%	8.89%	26.67%	**44.44%**
3.4 I would describe this game as very interesting.	**62.22%**	24.44%	4.44%	2.22%	6.67%

Criteria	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
D. PERCEIVED COMPETENCE					
4.1 I think I am pretty good at this game.	53.33%	31.11%	6.67%	6.67%	2.22%
4.2 I think I did pretty well in this game compared to other students.	51.11%	24.44%	17.78%	4.44%	2.22%
4.3 After playing this game for a while, I felt pretty competent.	55.56%	28.89%	8.89%	4.44%	2.22%
4.4 I am satisfied with my performance in this game.	46.47%	40.00%	6.67%	4.44%	2.22%
4.5 I felt skilled at playing this game.	53.33%	28.89%	11.11%	4.44%	2.22%

4.6 This game was an activity that I couldn't do very well. (R)	22.22%	15.56%	22.22%	20%	20%
Mean Rating	**47.04%**	28.15%	12.06%	7.24%	5.02%

CHAPTER 5

SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

SUMMARY OF FINDINGS

The research on the "Gamification of Education using Multi-Armed Bandit Algorithm" gathered insights from Grade 10 students, focusing on their experiences with the educational game, its perceived value, usefulness, effort and engagement, and perceived competence. The findings indicate a predominantly positive reception among the respondents.

A significant majority, 60%, strongly agreed that they felt content while playing the game, with an additional 28.89% agreeing, suggesting that the game was generally well-received emotionally. When it comes to skill perception, 55.56% strongly agreed and 33.33% agreed, indicating that most students felt competent while engaging with the game. Engagement and enjoyment were also high, with 62.22% strongly agreeing that they were engaged in the story and found the game enjoyable. Similarly, 57.78% felt fully immersed, although 17.78% remained neutral on this aspect, suggesting some variance in the depth of immersion experienced. Happiness derived from the game was affirmed by 57.78% strongly agreeing, and 31.11% agreeing, underscoring the positive emotional impact.

Performance and visual appeal were also positively rated, with 62.22% strongly agreeing they performed well and 57.78% finding the game visually pleasing. Competence was strongly felt by 60%, while the game's challenge was appreciated by 57.78% of the respondents. Notably, 66.67% found the game impressive, highlighting its overall positive impact. The mean ratings across these criteria further illustrate the overall satisfaction: 60.16% strongly agreed, 27.74% agreed, 8.57% were neutral, 1.80% disagreed, and 2.22% strongly disagreed.

In terms of the value and usefulness of the game, 60% of the students strongly agreed that the game could be valuable for their learning, with 26.67% agreeing. Additionally, 57.78% strongly agreed that playing the game is useful for enhancing their math skills, with 35.56% agreeing. A noteworthy 64.44% would be willing to play the game again because of its educational value.

Furthermore, 62.22% strongly believed that playing the game could help improve their problem-solving abilities, and 57.78% felt it could benefit their overall academic performance. The importance of the game as an educational activity was highlighted by 62.22% strongly agreeing and 28.89% agreeing.

When it comes to effort and engagement, the responses were more varied. Only 17.78% strongly agreed and agreed that they didn't try very hard to succeed in the game, while 28.89% strongly disagreed, suggesting that a significant portion of students put in a considerable amount of effort. Regarding boredom, only 11.11% strongly agreed that the game was boring, and 33.33% strongly disagreed, indicating that the majority found the game engaging. Additionally, 8.89% strongly agreed that the game did not hold their attention, while 44.44% strongly disagreed. Moreover, 62.22% strongly agreed that the game was very interesting, demonstrating high engagement levels.

In terms of perceived competence, 53.33% strongly agreed that they were good at the game, and 31.11% agreed. Similarly, 51.11% felt they did well compared to other students, and 55.56% felt competent after playing the game for a while. Satisfaction with performance was high, with 46.47% strongly agreeing and 40% agreeing. Notably, 53.33% felt skilled at playing the game, although 22.22% felt they could not do very well, indicating some variation in self-assessment of skills.

These results suggest that the gamification approach, using the Multi-Armed Bandit Algorithm, was effective in creating an engaging, enjoyable, and educational experience for the students, achieving high levels of contentment, skill development, and overall satisfaction. Moreover, the game was perceived as valuable and useful for learning, particularly in enhancing math skills, problem-solving abilities, and overall academic performance. While there were some mixed feelings regarding effort and engagement, the majority found the game interesting and engaging. Perceived competence was also high, indicating that the game successfully fostered a sense of skill and achievement among the students. This highlights its potential as an important educational tool.

CONCLUSIONS

The research findings on the "Gamification of Education using Multi-Armed Bandit Algorithm" indicate a highly positive reception among Grade 10 students towards the educational game. The majority of students reported feeling content, engaged, and found the game enjoyable, suggesting its success in capturing student interest and fostering engagement. Additionally, students expressed a strong sense of competence and satisfaction with their performance, indicating that the game effectively instilled a sense of accomplishment and achievement. Moreover, the majority of students recognized the value and usefulness of the game for their learning, particularly in enhancing math skills, problem-solving abilities, and overall academic performance. However, there were varied responses regarding effort and engagement, highlighting the need for further exploration of factors influencing student motivation within gamified educational environments. Overall, the findings underscore the effectiveness of gamification using the Multi-Armed Bandit Algorithm in creating engaging and meaningful educational experiences for students, highlighting its potential as an important educational tool for enhancing learning outcomes and engagement.

RECOMMENDATIONS

Several recommendations can be made to enhance the educational game and its implementation. Firstly, it is crucial to continually refine the game's design to uphold the high levels of engagement and enjoyment reported by students. This refinement process could involve improving visual appeal, deepening the storyline, and enhancing interactive elements to sustain student interest over time. Additionally, a more effective implementation of adaptive difficulty levels is necessary to ensure that all students are appropriately challenged, thereby preventing boredom for advanced learners and frustration for struggling ones. Moreover, enhancing feedback mechanisms within the game can provide students with personalized and immediate feedback on their performance, reinforcing their learning and sense of accomplishment.

Encouraging collaboration among students through team-based challenges or social features can leverage the reported high engagement levels and foster peer interaction, enriching the learning experience. Addressing the varied responses regarding effort and engagement among students requires further exploration, with potential interventions or adjustments tailored to meet individual needs. Further research into the factors influencing student motivation within gamified educational environments can provide valuable insights for targeted improvements. Providing educator training and support on effectively integrating gamified learning tools into teaching practices is essential to maximize the game's educational impact in the classroom. Lastly, continuous monitoring, evaluation, and iterative improvement based on feedback from students and educators are vital to ensuring the ongoing success of the gamified approach. Implementing these recommendations can facilitate the evolution of the gamification of education using the Multi-Armed Bandit Algorithm as an engaging and effective learning tool, ultimately enhancing student outcomes and engagement.

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