Gamification in Online Education: Enhancing Primary School Students' Engagement in Arithmetic after the COVID-19 Pandemic

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Abstract

The shift to online education in 2020 due to the COVID-19 pandemic has led to a noticeable decline in the engagement of primary school students in their education, especially in critical skills like arithmetic. This study explores the potential of gamification, a technique that incorporates game-like elements into educational activities, a tool for promoting student engagement. Utilising the Android application QuickDigits, which offers fast-paced, competitive, and adaptive arithmetic problems, we examined the change in students' involvement with arithmetic following exposure to the game. The study involved a pre & post-survey design, with a sample of 25 primary school students from Noida, India. Engagement was quantified through an 'engagement score' obtained from a Google Forms survey which asked 3 questions about the students' enthusiasm, motivation, and enjoyment of arithmetic. Results from a paired right-tailed t-test indicated a significant increase in engagement scores post-application usage ($p<0.005$), suggesting that gamified learning can boost primary school students' engagement with arithmetic. Furthermore, the data revealed a potential link between intrinsic motivation and external requirements among students, hinting at a complex interplay of factors affecting their engagement. These findings underscore the potential of gamification as an effective strategy for maintaining student engagement in a digital learning environment, particularly in crucial skill areas like arithmetic. It also suggests that further research is required to elucidate the relationship between intrinsic motivation, extrinsic motivation, and gamified learning.

Keywords:

Gamification; Online education; Primary school students; Student motivation; Educational apps; Mathematics.

Introduction

In the year 2020, due to a rise in the number of COVID cases, mass public gatherings & travelling were restricted by the government, making it imperative for schools to adopt the online mode of education (Berger et al., 2022). The shift to online education has had a lasting impact on millions of students' lives, as they have spent multiple years of their lives adapting to a new style of learning, while teachers have put in their best efforts into keeping students engaged with education during this drastic change in its system, including using educational games to increase student engagement in their classes (Data Source: Google Trends).

Despite the efforts made by the education system, students in primary schools have been observed to have reduced engagement with their education. Reasons for this decline may include a lack of environmental elements that support learning including lack of internet connectivity (Rannaware et al., 2022), and the large number of distractions that a student easily has access to in their home, including electronic devices (Salman et al., 2022). Due to their disengagement, many primary schoolers have not learned crucial skills like arithmetic that are used in daily life.. Lowered motivation to learn and the repetitiveness of arithmetic practice has caused many students to become disengaged and fall behind on a highly important skill.

To tackle this issue of disengagement, an increasingly common solution that is being implemented is to use apps and websites that help 'gamify' (the process of adding games or gamelike elements to something (such as a task)to encourage participation) education for children. These platforms have elements that resemble those of a game to deliver both a fun and educational experience to children. Platforms that are commonly used to gamify education have certain common traits: they reward players for doing well in a certain field and encourage them to do even better by including more rewards, or even competitions. By combining reward, competition, and adaptivity, educational video games have rapidly increased in popularity as a means to help students develop a passion for learning, with the most popular learning related apps having downloads in the tens of millions (Data Source: Google Trends).

Some popular 'edtech' (educational technology) apps include Kahoot, a quiz platform most suitable for a class of many students, Duolingo, a platform used by millions of students worldwide to learn language skills, and Classcraft, a social and emotional learning platform for school students. These apps have experienced massive growth in popularity in the last several

years due to their creative approaches to learning (Data Source: Google Trends). However, they cover a wide variety of subjects and are not fully inclusive of all three key features (Reward, competition, and adaptivity) one may look for in an educational video game.

- Reward: The inclusion of rewards in educational video games helps to motivate and engage players. When learners receive immediate feedback or recognition for their achievements, such as earning points, unlocking new levels, or receiving virtual rewards, it reinforces their sense of progress and accomplishment. Rewards create a positive reinforcement loop, encouraging players to continue engaging with the game and fostering a sense of achievement and satisfaction.
- Competition: Incorporating elements of competition in educational video games can enhance learner engagement and motivation. Healthy competition can spur players to strive for improvement, as they compare their performance with others or aim to beat their self-high scores. Leaderboards, time trials, or multiplayer modes that allow players to compete against friends or classmates can add an exciting dimension to the learning experience. Competition can encourage students to put forth their best effort and increase their investment in educational content.
- Adaptivity: Adaptivity refers to the game's ability to dynamically adjust its content and difficulty level based on the player's performance and learning needs. By adapting to the individual player's progress, educational video games can provide personalised learning experiences. This feature allows learners to receive targeted challenges and support, ensuring that they are appropriately challenged without feeling overwhelmed or bored. Adaptivity tailors the game's content to the learner's abilities, optimising their learning potential and promoting a more effective and engaging educational experience.

This study focuses on the field of arithmetic at the primary school level, for which there are several apps, most of which are not accessible, being available only on desktop computers or demanding high internet connectivity on the user’s end. The current research utilises QuickDigits to understand how a student can engage in arithmetic through a video game. QuickDigits is an Android game that engages students with arithmetic through fast-paced

quiz-like gameplay combined with competitive leaderboards and rewards like profile customization.

Methodology

Research Aim

The present research study aims to determine the effectiveness of the Android application QuickDigits, designed to contain all 3 of the aforementioned criteria, in engaging primary school students with arithmetic. The question of whether the gamification of arithmetic practice via this application can enhance students' engagement, motivation, and enthusiasm for learning the subject was explored.

Hypotheses

The **Null Hypothesis** (H0) suggests that there would be no significant difference in the arithmetic engagement of primary schoolers before and after playing QuickDigits. This hypothesis is rooted in the belief that traditional learning techniques are equally effective as modern gamified techniques in engaging students (Lee & Hammer, 2011).

The **Alternative Hypothesis** (H1) proposes that there would be an increase in the arithmetic engagement of primary schoolers after playing QuickDigits.

Research Design

The study adopts a pre-post survey design (Dimitrov & Rumrill, 2003). The pre-post survey design facilitates a measure of change or comparison of groups from experimental treatments, in this case, the influence of QuickDigits on arithmetic engagement.

Sample

The sample population for the research was 25 primary school students (N=25) supported by an NGO in Noida, India, between the ages of 8 to 11, chosen by convenience sampling.

Tools and Procedures

In QuickDigits, users can play 90 second rounds where they must accurately answer as many arithmetic questions as possible. Questions involving more arithmetic and complex procedures, such as combinations of addition, multiplication and division, are rewarded with higher scores. High scores are rewarded with leaderboard positions and high playtime is rewarded with a higher variety of profile customization options allowing users to change their appearance on the global leaderboards. The app also tries to adapt to the skill level of the current user to ensure a healthy challenge that isn't overwhelmingly difficult: If the user answers a small number of questions with lower accuracy, they are given questions of lower complexity featuring smaller numerical values, and the opposite is true if they answer many questions with high accuracy. By combining these features, the game aims to engage primary school students with arithmetic while also helping them practise. This study also uses Google Forms, an online survey system developed by Google which allows users to gather many different types of data and easily process the data by automatically creating spreadsheets with tables containing prompts and responses.

These surveys measured the students' engagement using questions that, along with demographic information, asked students to rate on a scale of 1 to 5 their enthusiasm, motivation, and enjoyment of cooperation or competition in arithmetic. The individual ratings on these scales were then combined to generate an engagement score between 3 and 15.

Informed consent was obtained from all participants before data collection, respecting their rights to privacy and voluntary participation.

Data collection involved a two-part process, the first part was a pre-test survey administered before the students started playing QuickDigits. After seven days of using the app, the same survey was re-administered as a post-test.

The engagement of each participant was measured using three key questions:

"On a scale of 1 to 5, how eager do you feel about practising/learning arithmetic?"

"On a scale of 1 to 5, how motivated do you feel to improve at arithmetic?"

"Do you enjoy cooperating/competing with your classmates?"

The responses to these questions were then combined to create a comprehensive 'engagement score' between 3 and 15 for each participant. By comparing the pre-app and

post-app engagement scores for each student, we identified the influence of the QuickDigits app on student engagement.

Results and Discussion

This section of the research paper focuses on presenting and discussing the results obtained through statistical analysis of students' self-reported arithmetic engagement scores on both rounds of the survey mentioned in the previous section.

Old Engagement Score		**New Engagement Score**		**t**	**p**
M	SD	M	SD		
10.28	3.691	10.88	3.700	-2.777	0.005

Note. $p < .05$

Table 1: *Dependent Sample T-Test Analysis: Old and New Engagement Scores For Primary School Students (N=25)*

Our statistical analysis of this data utilised a paired right-tailed t-test. This test is commonly used when we are interested in the direction of the change, and our alternative hypothesis indicated that we expected the engagement score to increase (McDonald, 2014). The test revealed a t-score of -2.77, giving a p-value of 0.005. Given the standard alpha level of 0.05 for statistical significance, the p-value of 0.005 suggests a significant increase in the engagement score post-app usage, thus supporting our alternative hypothesis. These results align with those of past studies, as previous research has identified a positive relationship between gamification and student engagement (Bouchrika et al., 2019; Poondej and Lerdpornkulrat et al., 2016).

In addition to the engagement score, the survey also inquired about other information about the students' experience with arithmetic to gain more information regarding their internal and external motivation to study arithmetic. For instance, the fact that 19 out of 25 students reported feeling the need to be good at arithmetic due to factors such as parental pressure and responsibility. This information is important because external pressures can impact students' motivation and engagement, by increasing their anxiety and fear of underperforming (Nagpal and Sinha, et al. 2016).

Similarly, it was noted that 20 out of 25 students reported having some interest in arithmetic before using the app. Prior interest in a subject is a strong predictor of engagement since it ties into the students' intrinsic motivation to study arithmetic: some have defined intrinsic motivation in terms of the task being interesting while others have defined it in terms of the satisfaction a person gains from intrinsically motivated task engagement (Ryan & Deci, 2000).

An interesting correlation was observed between these two parameters. Out of the 25 students, 20 showed a pre-existing interest in arithmetic, and an almost equal number reported feeling the desire to be good at the subject. Importantly, 19 students responded affirmatively to both questions, suggesting a considerable overlap between external pressure to score highly in arithmetic and students' personal interest in the subject. This indicates a potential interplay between intrinsic (personal interest) and extrinsic (external requirement) motivations related to arithmetic among this group of students (Zhang et al., 2023).

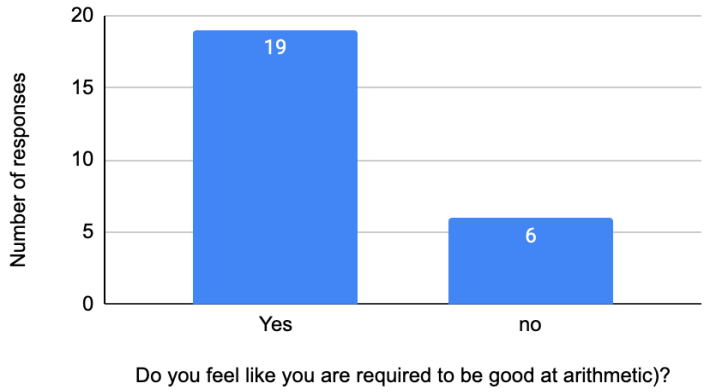

Figure 1: *Responses of students from the sample (N=25) to the question: "Do you feel like you are required to be good at arithmetic?"*

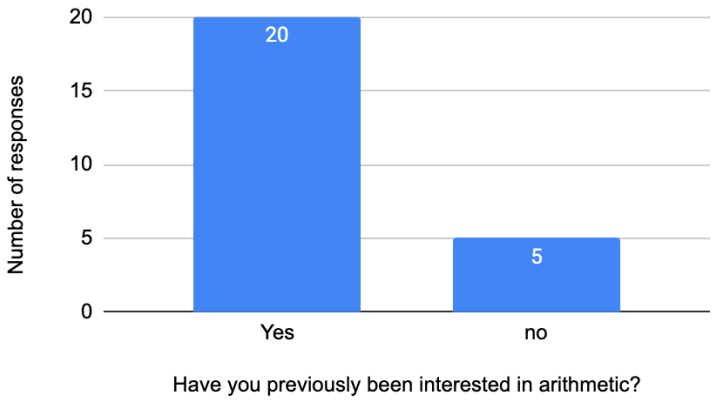

Figure 2: *Responses of students from the sample (N=25) to the question: "Have you previously been interested in arithmetic?"*

The students performance data, engagement scores, and demographic information provided valuable insights into the impact of gamification on their arithmetic engagement. The comparative analysis of pre-and post-app engagement scores alongside demographic factors and self-reported motivations provided a comprehensive evaluation of the influence of QuickDigits on student engagement. Detailed results, including the comprehensive table of pre- and post-app engagement scores, are included in the appendix.

Conclusion

This study sought to ascertain the impact of gamifying arithmetic through the Android app, QuickDigits, on the engagement levels of primary school students. Through a pre-post survey design, the study measured the students' arithmetic engagement before and after their introduction to the game. The results significantly confirmed our alternative hypothesis: there was indeed an increased level of engagement among the students after playing QuickDigits, suggesting that the gamification of arithmetic could be a viable strategy to rekindle interest and engagement in this crucial subject area.

While these findings contribute to the existing body of literature on educational technology and gamification, there are limitations to this study that should be considered when interpreting the results. Firstly, the sample size was relatively small (N=25) and was drawn from one geographical area in Noida, India, which may limit the generalisability of the findings. Further, the study duration was one week; a longer duration might allow for a better

understanding of the lasting effects of the app on students' engagement with arithmetic. Considering different age groups and increasing the number of questions on the survey may allow for a more focused and deep analysis of student engagement with arithmetic.

Moreover, an unexpected but interesting result surfaced in this study—the overlap between the students' intrinsic motivation and extrinsic pressures related to arithmetic. This particular finding might be a foundation for future studies, expanding the exploration of the relationship between these two factors in the context of gamified learning. A potential strategy for future research may involve identifying intrinsic motivation and external pressure levels through surveys or tests, then testing for a correlation between these two variables.

In conclusion, the outcomes of this study substantiate the proposition that gamification, particularly through apps like QuickDigits, could be employed as an engaging and enjoyable approach to traditional subjects like arithmetic. However, more comprehensive research, perhaps with a larger and more diverse population and extended duration, is needed to fully understand the implications of these strategies on student engagement and learning outcomes. Nevertheless, this study provides a valuable stepping stone toward realising the full potential of edtech in enhancing educational engagement in a post-pandemic era.

References

1. Berger, M., Kuang, M., Jerry, L., & ETS, D. F. (2022, February 22). *Impact of the Coronavirus (COVID-19) Pandemic on Public and Private Elementary and Secondary Education in the United States (Preliminary Data): Results from the 2020-21 National Teacher and Principal Survey (NTPS)*. Nces.ed.gov. https://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2022019
2. Bouchrika, I., Harrati, N., Wanick, V., & Wills, G. (2019). Exploring the Impact of Gamification on Student Engagement and Involvement with e-learning Systems. *Interactive Learning Environments*, *29*(8), 1–14. https://doi.org/10.1080/10494820.2019.1623267
3. Ceci, L. (2023, January 9). *Top education apps worldwide by downloads 2022*. Statista. https://www.statista.com/statistics/1284623/top-education-apps-global-by-downloads/

4. Lee, J., & Hammer, J. (2011, January). *(PDF) Gamification in Education: What, How, Why Bother?* ResearchGate. https://www.researchgate.net/publication/258697764_Gamification_in_Education_What_How_Why_Bother
5. McDonald, JH. (2014). *Handbook of Biological Statistics* (3rd ed.). Sparky House Publishing. https://www.biostathandbook.com/HandbookBioStatThird.pdf
6. Poondej, C., & Lerdpornkulrat, T. (2016). The development of gamified learning activities to increase student engagement in learning. *Australian Educational Computing*, *31*(2). http://journal.acce.edu.au/index.php/AEC/article/view/110
7. Rannaware, A., Shaikh, U., Gaidhane, A., Choudhari, S. G., & Zilate, S. (2022). Challenges and Barriers for Accessing Online Education Amongst School Children in an Urban Slum Area of Pune, India. *Cureus*, *14*(9). https://doi.org/10.7759/cureus.29419
8. Salman, M. A., Kaharuddin, A., & Multazam. (2022). DIFFICULTIES IN ONLINE LEARNING DURING COVID-19 PANDEMIC: PERCEPTIONS OF EFL STUDENTS OF UIN ALAUDDIN MAKASSAR. *Journal of Islam and Science*, *9*(2), 83–93. https://doi.org/10.24252/jis.v9i2.30668
9. Zhang, Y., Yang, X., Sun, X., & Kaiser, G. (2023). The reciprocal relationship among Chinese senior secondary students' intrinsic and extrinsic motivation and cognitive engagement in learning mathematics: a three-wave longitudinal study. *ZDM – Mathematics Education*, *55*. https://doi.org/10.1007/s11858-022-01465-0
10. Nagpal, M., & Sinha, C. (2016). Perceived parental pressure and academic achievement among Students: Exploring the mediating effect of test anxiety among school students, Bangalore. Open Journal of Educational Psychology. https://www.researchgate.net/profile/Chetan-Sinha/publication/365647916_Perceived_parental_pr

essure_and_academic_achievement_among_students_Exploring_the_mediating_effect_of_test_anxiety_among_school_students/links/637ce2cb1766b34c5447ade9/Perceived-parental-pressure-and-academic-achievement-among-students-Exploring-the-mediating-effect-of-test-anxiety-among-school-students.pdf

11. gamification. 2023. In Merriam-Webster.com.

    Retrieved Feb 4, 2023, from https://www.merriam-webster.com/dictionary/gamification

12. Google Trends (https://trends.google.com/trends)

    https://trends.google.com/trends/explore?date=2018-01-01%202021-01-01&q=educational%20games

    https://trends.google.com/trends/explore?date=2018-01-01%202021-01-01&q=%2Fm%2F0gxzb2p,

    https://trends.google.com/trends/explore?date=2018-01-01%202021-01-01&q=%2Fg%2F11g6yrck6m,

    https://trends.google.com/trends/explore?date=2018-01-01%202021-01-01&q=%2Fm%2F010pkp62