# Effects of Gamification on academic task completion rates of adolescents

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ABSTRACT

Gamification is a technique which uses motivational aspects of games to motivate and engage users. This study investigates how gamification affects adolescents' academic task completion rates. It aims to understand how gamification impacts task-completion rates. It involved 21 students of ages 12 to 14 of an Indian school in Dubai, United Arab Emirates, solving mathematics questions on Volume and Surface Area of Cubes and Cuboids. The experimental group solved questions on this topic on Mindspark, while the control group solved questions on the topic on paper. The results of the study indicate a positive correlation between gamification and adolescents' task completion rate and accuracy. Through a one-tailed Wilcoxon rank-sum test, these results were proven for the larger population of adolescents. Possible causes of these results discussed are the optimal difficulty and high level of control provided by gamification.

Keywords:

## INTRODUCTION

Gamification is a technique which uses the stimulating motivational aspects of games (game mechanics) in real-world scenarios to motivate and engage people. Gamification is increasingly being used in the classroom through badges/trophies as rewards, friendly competition through scoreboards, etc. Most research today considers that the only features gamification involves are basic feedback mechanisms. However, gamification also involves other less conventional engaging elements of games like a narrative. (Kapp, 2014).

In this study, gamification has been investigated through an adaptive learning tool called Mindspark. Mindspark is an online gamified adaptive learning platform where students can practise questions and build their mathematical skills with instant feedback in gamification. Gamification on Mindspark is achieved by gamification points known as 'sparkies.' These sparkies let you purchase games which you can play. These sparkies can be earned by high accuracy during practice sessions. A student gets 1 sparkie if they answer three questions correctly. If they answer 5 questions consecutively, they will get a challenge question and another sparkie. The student would get 5 sparkies if they got the challenge question right on their first try. They would get 2 sparkies if they got it right on their second try.

Additionally, Mindspark implements gamification through its adaptive learning system. While using Mindspark, users are always given questions that are optimal for their level of proficiency. The questions given will be slightly above the user's level of proficiency. Solving the question would increase the user's level of proficiency. This provides an optimal level of difficulty.

Gamification is a technique rapidly growing in popularity that may help increase the productivity of its users. Much research has been done about the impact of gamification on learning, motivation, and focus. Some research with gamification has been performed with younger children. This research indicates an increase in motivation with introducing gamification (Anthony & Irwin, 2013) [1]. Additionally, research has been conducted with ages 18-21, demonstrating an overall increase in attention values by introducing attention-based neurofeedback (Sethi and Dua 2018). Moreover, a paper has been written presenting an approach to apply gamification in universities using Lego Mindstorms (Müller et al., 2015). The studies revealed a relationship between gamification principles and goal-setting theory. (Tondello et al., 2018). Further, research

has been conducted regarding the impact of internet-based applications on English-as-a-Foreign-Language (EFL) classes. This research demonstrated that internet-based applications have positive effects on students' learning (2015). Research has also been ~~done~~ carried on applying gamification to teach computer programming. This research has indicated that gamification improves students' participation, focus, comprehension of concepts, and motivation. It also reveals that gamification makes learning to program languages fun (Fotaris et al., 2015). In addition, Khan in 2017 conducted research on the usage of gamification with secondary school students learning science in Pakistan. The studies indicated that gamification played an instrumental role in enhancing student engagement, understanding of complex concepts in science and students' enjoyment (Khan et al., 2017d). Sailer mentioned a meta-analysis of existing literature about gamification in 2019, finding that gamification has a positive effect on cognitive, motivational, and behavioural learning outcomes (Sailer & Homner, 2019l). Simões in 2015 revealed a framework for implementation of gamification in a Social Learning Environment. Finally, research has been conducted on how gamification affects how engaged a software engineering student team in a high intensity extreme programming course (Akpolat & Slany, 2014). The research indicated that gamification could have positive learning outcomes.

From the literature mentioned above, very few studies pertain to adolescents. Most studies in this field focus either on university students of ages 18-21 or much younger children. Few focus on the subject of this paper: adolescents of ages 12 and above. Little research has been done on the effect that gamification has on productivity. Most research conducted in the field is regarding learning instead. Looking at the limitations of literature review, the following study has been carried out with an intention to know…



*How does gamification affect the academic task completion rates of adolescents?*

The main aim of our research is to investigate the effects of gamification on the task completion of adolescents. This gamification will be through Mindspark. Mindspark is a gamification centric app. In this experiment, the tasks measured are the completion of mathematics questions. The author hypothesise gamification has an overall positive effect on the task completion rates of adolescents. Some prudent ideas the research aims to investigate are (1) how gamification impacts academic task completion rates and (2) the causes of the impacts seen in point 1.

## II. MATERIAL AND METHODOLOGY

### Overall Approach

This experiment uses a fixed, cross-sectional and field research design and primary and quantitative data. It uses non-probability sampling. This sample includes 21 students of ages 12 to 14 from an Indian school located in Dubai, United Arab Emirates. The research design is fixed, hence ensuring higher validity and reliability. It was done in the field to ensure higher external validity. Non-probability sampling was used so that the experimental and control groups could have an equal number of students with equal mathematical ability. Consequently, unfair skewing of results in one direction because of an inequality in mathematical ability is prevented. This method, apart from the non-probability sampling, is quite standard in gamification research.

### Data collection methods

*Tools used*

The main materials used were an online gamified learning platform known as Mindspark and mathematics worksheets. 30 mathematics worksheets for the topic volume and surface area of three-dimensional figures

were prepared and 21 of these were used (the other 9 were extras). Students used Mindspark through their personal devices (tablets or laptops).

*Control and experimental group*

The control group was given a Mathematics worksheet on the, with the 'task' of solving as many questions as they could in the 40 mins with pen and paper, with working/proofs. Meanwhile, the experimental group studied the same topic, volume and surface area, using Mindspark's adaptive and gamified learning system. Their 'task' was to finish as much of the Mindspark module as they could in 40 mins. Additionally, the students who were using their devices were closely monitored. This was done to ensure they did not use their devices for any other purposes. Students in each group were of equal mathematical ability. The grouping based on equal ability was decided by their mathematics teacher. The names of the participants have been hidden in further discussion to maintain anonymity.

*Skills practised*

The topic studied by the students was Volume and surface area of three-dimensional figures. The skills to practise, as described in the students' syllabus, were:

- Concept of volume, measurement of volume using a basic unit, volume of a cube, cuboid and cylinder
- Volume and capacity

*Sample*

The experiment was conducted in a 40-minute period with a sample of 21 Indian 8th grade students studying at GEMS Modern Academy, Dubai. The students were of ages ranging from 12 to 14, but most of them were 13 years old. 12 of the students were taken into an experimental group, while 9 of them were taken into a control group.

*Variables*

In this setup, a few variables were present. The dependent variables we studied were problems completed, accuracy (i.e., percentage of problems correct), and time taken for completion. Based on problems completed and time taken for completion, the problem completion rate was estimated. The independent variable was gamification. Other variables, such as topic studied and duration of session, remained constant between the control and experimental group.

Statistical analysis method

*Software*

The software used for statistical analysis was Python. More specifically, using the Pandas library of Python.

*Data preparation*

Data for the control group was prepared by manually checking the worksheet responses of the student and recording the problems attempted and accuracy of each student. The data for the experimental group was prepared by accessing students' data on Mindspark.

*Statistical Tests*

A one-tailed Wilcoxon rank-sum test was used to infer characteristics of the population from this sample. There was little homogeneity of variance in the data gathered from the experimental and control groups, so this test was appropriate.

## III. RESULTS

Alternative and null hypothesis

As stated earlier in this paper, the research problem investigated was: How does gamification affect the task-completion of adolescents? We hypothesise gamification has an overall positive effect on the task-completion rates of adolescents. Restating this as an alternative hypothesis ($H_a$): The median problems solved by and median accuracy of the population of which the experimental group is a sample is greater than the median accuracy and median problems solved of the population of which the control group is a sample, i.e., $\mu_a > k_a$ and $\mu_p > k_p$. The research hypothesis can be restated as a null hypothesis ($H_0$) as: The median problems solved by and the median accuracy of the population of which the experimental group is a sample is equal to the median accuracy and median problems solved by the population of which the control group is a sample, i.e., $\mu_a = k_a$. In these hypotheses, $\mu$ represents the population of the experimental group and k represents the population of the control group

Overall, it is apparent from the experiment that the overall accuracy and number of problems completed by the experimental group is much greater than that of the control group. The following table compares the mean and median values for the experimental and control group. Mode was not compared since no mode can be computed for the control group.

Table 1: Comparison of the number of questions attempted and accuracy of experimental and control group

| | Control group | | Experimental group | |
|---|---|---|---|---|
| Name | Total Questions Attempted | Accuracy | Total questions attempted | Accuracy |
| A | 13 | 92 | 8 | 75 |
| B | 15 | 40 | 16 | 81 |
| C | 11 | 89 | 41 | 73 |
| D | 13 | 46 | 57 | 77 |
| E | 6 | 60 | 57 | 75 |
| F | 14 | 43 | 61 | 75 |
| G | 9 | 74 | 69 | 78 |
| H | | | 67 | 75 |
| I | | | 41 | 80 |
| J | | | 35 | 77 |
| K | | | 27 | 6 |

Table 2: Comparison of mean and median of parameters of experimental and control group

| Parameter | Measure | Control | Experimental |
|---|---|---|---|
| Total questions completed | Mean | ≈12 | ≈44 |
| | Median | 13 | 41 |
| Accuracy | Mean | ≈63 | ≈70 |

| | | | |
|---|---|---|---|
| | Median | 60 | 75 |

Statistical analysis

From the data given above, inferences were made about the population which the experimental group and control groups belong to using the Wilcoxon rank-sum test. Confidence level was taken as 95% resulting in 0.05 alpha/significance level.

*Questions solved*

The test statistic found of questions solved ($U_q$) was 20. The smaller length (m), i.e., length of the control group and larger length (n), i.e., length of the experimental group are 7 and 11, respectively. The corresponding lower critical value and higher critical value for this pair of lengths is 44 and 89, respectively. Since $U_q$ < lower critical value, Ha is accepted for questions solved.

*Accuracy*

The test statistic calculated for accuracy ($U_a$) is 28. The smaller length, larger length, lower critical value and higher critical value remain the same. $U_a < 44$, so $H_a$ is accepted for accuracy.

Hence, through statistical analysis, our alternative hypothesis (and consequently our general research hypothesis) has been proven for the larger population of adolescents.

## IV. DISCUSSION

The results indicate that the experimental group (the group using Mindspark) has a much higher overall accuracy and number of problems completed than the control group (the group solving problems physically). Through a Wilcoxon rank-sum test, it was determined that these results would be present in the larger population of adolescents as well.

In line with the hypothesis, the results indicate gamification has an overall positive effect on the task completion rates of adolescents. The presence of Gamification was the only independent variable that differed between the experimental group and the control group. For the experimental group, gamification was applied. For the control group, it was not. The experimental group overall solved a higher number of problems in the same duration as the control group. Thus, it can be inferred that gamification caused higher task completion rates. Additionally, the experimental group demonstrated higher accuracy. Consequently, it can also be deduced that gamification may have caused higher accuracy. These inferences support our initial hypothesis. Our original hypothesis was that gamification would have a positive effect on the completion rates of adolescents.

There are several reasons for the results found. Two such reasons have been explained below. The author has supported these reasons with two motivational theories: Flow theory by Csikszentmihalyi (2008) and self-determination theory (Deci & Ryan, 2013).

- Optimal difficulty: Gamification provides an optimal level of difficulty for its users (Dichev et al., 2015), leading to higher motivation. According to flow theory, an optimal level of challenge is necessary to enter the flow state (a state of high motivation) (Csikszentmihalyi, 1990). According to the self-determination theory, it is necessary to experience proficiency for intrinsic motivation. Experiencing proficiency is not possible if adequate difficulty is not present.

- Elevated level of control: With gamification, users have an elevated level of control over the outcome (the rewards they receive) of their activity because the outcome is related to their efforts. According to the flow theory, a high sense of agency (high sense of control) is necessary to enter the flow state. According to the self-determination theory, autonomy (an elevated level of control over one's own life) is necessary for intrinsic motivation.

Implications of findings

This result supports existing evidence of the positive effect of gamification (Khan et al., 2017d) (Fotaris et al., 2015). It complements other research by providing a clear understanding specifically of the effect of gamification on productivity. Most other papers in this field focus on learning instead. While most previous research has focused on the effect of gamification on university students, this result reveals the effect of gamification on adolescents.

Additionally, these results should be considered when assigning schoolwork to adolescents. Since gamification has a general positive effect on the productivity of adolescents, more schoolwork should be done on gamification-centric platforms like Mindspark. These platforms produce a greater quality and rate of work. They make doing the work more enjoyable. The improvement in quality of work is demonstrated by the higher accuracy of the experimental group. The increase in pace is demonstrated by the higher number of questions solved by the experimental group in the same duration as the control group.

Finally, ways to gamify tasks in an adolescent's life, other than academic tasks, should also be developed. These would increase the adolescent's productivity greatly and make work more fun for the adolescent. It would positively impact them in several ways. These include freer time, less stress and so on.



Limitations of findings

The small sample size of this experiment and the non-probability sample taken may limit the generalisability of findings of this research. However, this research involved a field experiment. The effects of these factors are mitigated by the field experiment.

In the field experiment, the adolescents were sometimes distracted by one another. However, these distractions were scarce, and they were immediately halted by the adolescents' supervising teacher. Hence, the distractions are unlikely to affect the findings of this research.

There were numerous boys and a few girls in the experimental group. There were a few boys, but several girls in the control group. This may impact findings. However, it is unlikely to impact findings since gender has been demonstrated to have minor impact on academic performance (Joseph et al., 2015) (Udousuro, 2011).

Finally, these findings were recorded in only one forty-minute session. As a result, the reliability of these findings may be impacted.

Despite these limitations, the findings of this experiment are still valid because the findings of this experiment support established theories and research about gamification.

Recommendations for further study

Further research is necessary to establish the effect of gamification on task completion rates of other age groups (adults and young children). Further studies may also be conducted with a similar research goal using a larger sample size and multiple sessions. The larger sample size would give more generalisable results.

Multiple sessions would give more reliable results. Future studies may investigate the effect of game mechanics (such as points, leader boards, and so on) on task completion rates. Further studies could be conducted in a laboratory. These studies would have results of higher internal validity. More papers could also focus on the effect of gamification on other aspects of productivity, such as focus. These papers would compensate for the lack of papers regarding productivity in gamification research.

## V. CONCLUSION

This research paper considers the effect of gamification on the task completion rates of adolescents. It investigates the task completion rates of adolescents with and without gamification. Thus, this paper establishes that gamification is beneficial for adolescents' productivity. Gamification has a positive effect on the number of tasks an adolescent can finish in a certain amount of time. Additionally, it may increase the quality of the adolescent's work. Plausible causes for this phenomenon are that gamification provides an optimal level of difficulty for its users and that gamification offers an elevated level of control over outcomes to its users. This is supported by several psychological motivation theories (Csikszentmihalyi, 1990) (Deci & Ryan, 2013).

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