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Short Paper

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Abstract

E-Learning, as a prevalent instructional approach in the midst of the COVID-19 pandemic, is often criticized for reducing motivation and increasing mental fatigue among learners. Despite the attractiveness of various gamification designs to resolve these issues, there still exists a lack of comprehensive and integrated understanding of the pedagogic effectiveness of gamification rewards. Motivated thus, this study assesses and compares four different types of gamification rewards: unexpected-hedonic rewards, expected-hedonic rewards, unexpected-utilitarian rewards, and expected-utilitarian rewards. Drawing from self-determination theory and opportunity cost model of subjective effort and task performance, this study evaluates the effect of gamification reward type on learning motivation and mental fatigue. The effect of gamification reward type will be examined in a longitudinal field experiment in an introductory undergraduate computer science course.

Keywords: Gamification rewards, mental fatigue, motivation, longitudinal field study

Introduction

The rapid development of information technologies has transformed the existing education landscape by generating a new instructional method – E-Learning. This new learning method is gaining increasingly more attention and popularity because it can provide a convenient and efficient channel for online learners to achieve learning goals without time and space restrictions (Parsad et al. 2008). This is particularly true in the recent COVID-19 pandemic, during which online learning has become the new normal. Yet, E-Learning is frequently criticized for reducing learner-instructor interaction, impairing communication and socializing skills, and lowering learning efficiency and motivation (Malik and Rana 2020). Indeed, it has been shown that learners often complain about negative online learning experiences such as feelings of isolation, stress, anxiety, depression, and mental fatigue (Dirzyte et al. 2021). This can be concerning if we

consider that accumulated mental fatigue can exert detrimental effects on one's cognitive function development (Mizuno et al. 2011) and even mental health (Peng et al. 2021). Against this backdrop, it is essential for instructors to develop effective learning strategies that help resolve the mental issues of learners in the E-Learning context.

Mental fatigue, as one of the most common mental issues among learners, is highly correlated with poor grades, academic probation, and social isolation, which greatly increases the drop-out rate (Megivern et al. 2003). In the E-learning context, mental fatigue is defined as a condition of cognitive impairment that can adversely affect learner engagement and learning (Boksem and Top 2008). While scholars are calling for further research to alleviate the negative effects of mental fatigue, recent research on motivation and mental fatigue sheds light on new possibilities (Kurzban et al. 2013). Particularly, learners are more likely to suffer from mental fatigue when performing unmotivated tasks (Hockey 2010). Rewards, as a common way to boost motivation, have shown their vast potential in counteracting the effect of mental fatigue (Hopstaken et al. 2015). Accordingly, one solution to resolve the above-mentioned mental fatigue issue is to incorporate gamification elements, which borrow elements from game designs to make online learning tasks more engaging and motivating for learners (Liu et al. 2017). For example, gamification rewards, such as badges, have been widely adopted to help learners attain their learning goals and achievements in traditional classroom settings and can be applied to incentive and motivate learners in the E-learning context (Hanus and Fox 2015).

However, empirical research examining the effectiveness of gamification elements in online learning is rather limited, and it still lags in at least three aspects. First, despite the great effort in conceptualizing the mental health issues associated with E-Learning, most research has focused on how to improve academic performance (Hanus and Fox 2015). In contrast, little attention has been paid to mental health challenges (Dirzyte et al. 2021). Second, extant evidence of the effect of reward-based gamification elements on learning motivation is inconclusive. Although some studies have shown that gamification rewards can effectively enhance student learning motivation (Mekler et al. 2017), others have revealed that rewards might decrease motivation and further harm satisfaction and academic performance (Hanus and Fox 2015). As a result, effective guidelines regarding how to design reward-based gamification elements to boost motivation are still lacking. Finally, despite prior research suggesting that increasing motivation could alleviate people's mental fatigue (Hopstaken et al. 2015), the effect of changes in a finer-granularity view, such as the potential differential impacts of intrinsic and extrinsic motivation on mental fatigue, is still under investigation. Therefore, more research efforts are needed to examine effective approaches to alleviate the negative effects associated with mental fatigue. To summarize, this research aims to answer the following two research questions in detail:

How will gamification rewards affect intrinsic and extrinsic motivation?

How will mental fatigue be affected by intrinsic and extrinsic motivation over the long-term course?

More specifically, we seek to evaluate and compare the effects of four different types of gamification rewards on motivation and mental fatigue among online learners through a longitudinal field experiment. First, we categorize gamification rewards based on their functions and fulfillment conditions and adopt a granular view of the relationship between gamification rewards and student motivation and mental fatigue. Second, we theorize the potential differential effects of intrinsic and extrinsic motivation on mental fatigue. Finally, we investigate the above-mentioned relationships over a long-term course. Overall, our research can provide an integrated and comprehensive understanding of the role of gamification rewards in alleviating mental fatigue in E-Learning settings. It can also offer valuable insights to E-Learning system designers and instructors regarding the proper design and use of gamification reward elements.

The paper is arranged as follows. First, we summarize the relevant literature on intrinsic and extrinsic motivation, gamification, and mental fatigue. Next, we present our research model, hypotheses, and methodology. Finally, we conclude with potential implications, limitations, and directions for future work.

Literature Review

Mental Fatigue

Mental issues, such as mental fatigue, anxiety, and depression, are one of the main concerns among educators. For example, one study has shown that 47% of learners have reported at least one cognitive

concern, indicating the prevalence of mental issues among learners (Roberts et al. 2001). These mental issues will in turn have a negative impact on learners' academic performance, behavioral and social skills, and increase the dropout rate (Megivern et al. 2003). As one of the most common mental issues, mental fatigue has been found to adversely affect the development of cognitive functions, particularly among younger students such as elementary and junior high school pupils (Mizuno et al. 2011). In addition, mental fatigue is often associated with reduced well-being and lower academic performance (Smith 2018). However, the research on online learners' mental fatigue is just beginning. This issue is further exacerbated by the prevalent E-Learning instructional approach in the COVID-19 pandemic, which significantly reduces learner-instructor interaction and lowers learning motivation (Malik and Rana 2020). Indeed, online learners often complain about negative learning experiences such as feelings of isolation, stress, anxiety, depression, and mental fatigue (Dirzyte et al. 2021). This calls for more research to alleviate the negative effects of mental fatigue in the online learning context (Smith 2018).

Opportunity Cost Model of Subjective Effort and Task Performance

Earlier studies have maintained that mental fatigue often results from a loss of energy (Rabinbach 1992). However, this theoretical account of the depletion effect has been doubted due to the lack of supportive experimental evidence (Johnston et al. 2019). Instead, Kurzban et al. (2013) proposed the Opportunity Cost Model of Subjective Effort and Task Performance to provide an alternative account of mental fatigue. This model has received empirical support in various contexts, including healthcare (Gergelyfi et al. 2015), sports (Smith et al. 2015), and organizational research (Hirsh et al. 2018). This model establishes a theoretical link between motivation and mental fatigue and emphasizes the importance of mental fatigue in individual task-switching decisions. Specifically, this theory assumes that people cannot execute all the tasks at the same time. Instead, they tend to adaptively switch their behaviors towards more motivating and beneficial tasks (Pinker 1997). In other words, they will naturally balance the costs of persisting on their current tasks with the benefits of switching to other alternative tasks (Hockey 2010). This is because focusing on the current task means sacrificing the opportunity to work on other tasks. When the opportunity cost of continuing with the current task is excessive, people will feel demotivated. The feeling of mental fatigue generated by the motivational systems will then interrupt ongoing behavior (Inzlicht and Macrae 2014) and drive people away from prolonged unmotivated tasks and towards potentially more motivating and beneficial activities (Kurzban et al. 2013). In our context, we focus on two types of tasks: learning tasks and non-learning tasks. Learning tasks cover all the learning-related activities such as reading, class engagement, and assignment accomplishment, whereas non-learning tasks cover all the other activities that are unrelated to learning. Learners who feel demotivated about learning tasks tend to experience mental fatigue and switch toward potentially more motivating and beneficial non-learning tasks (Kurzban et al. 2013).

Self-determination Theory

We posit that one effective approach to alleviating mental fatigue in online learning tasks is to incorporate rewards that could boost motivation (Hopstaken et al. 2015). Self-determination theory (SDT) provides a theoretical framework to analyze the role of two different types of motivation that explain and predict human behavior (Ryan and Deci 2000). Specifically, intrinsic motivation refers to doing an activity for the sake of enjoyment or pleasure, while extrinsic motivation refers to doing an activity in pursuit of rewards (Ryan and Deci 2000). Prior research has demonstrated that rewards can be used to increase extrinsic motivation and motivate desired behaviors (Etkin 2016). An increase in extrinsic motivation, however, does not always imply an increase in intrinsic motivation. Indeed, only rewards that could enhance the feelings of autonomy (feeling of ownership of behavior), competence (feeling of effectiveness and mastery of environment), and relatedness (feeling of connection with other people) can increase intrinsic motivation over the long term (Ryan and Deci 2000). As an extension of SDT, Cognitive Evaluation Theory explicitly argues that tangible and expected rewards might even erode one's feelings of autonomy and hamper their intrinsic motivation (Deci and Ryan 1985).

Motivating learners to pay attention to and engage with learning materials is one of the primary learning goals (Hanus and Fox 2015). Although the enhancement in extrinsic motivation can have positive effects on immediate educational outcomes, such positive effects can be unsustainable and might be sensitive to the learning context and changes in the long term. In contrast, intrinsic motivation is often associated with long-term educational outcomes including better academic performance, improved self-efficacy, and a

stronger sense of identity (Liu and Hou 2017). Therefore, it is important to design E-Learning systems to motivate learners to learn intrinsically (Deci and Ryan 2001).

Gamification

Different reward designs can have varying impacts on intrinsic and extrinsic motivation. In this research, we focus on the role of gamification rewards in particular. As one of the most popular motivational information system designs, proper gamification design can bring joy that sparks the individuals' intrinsic enjoyment and keeps them interested in the activity for a long time. Generally, gamification elements are hedonic in nature and can involve utilitarian functions (Wolf and Tobias 2019). There are currently two types of elements: reward-based elements and meaningful elements (Nicholson 2014). Specifically, reward-based elements aim to reward users. Commonly used gamification rewards include points (Simões et al. 2013), badges (Mekler et al. 2017), and virtual goods or currency (Zichermann and Cunningham 2011). On the other hand, meaningful elements offer a variety of experiences to engage in, increasing the likelihood that every learner can find something meaningful (e.g., narratives). Prior studies have shown that meaningful gamification elements can be effective at increasing intrinsic motivation (Nicholson 2014). However, the evidence of the effect of reward-based gamification elements on learning motivation is still inconclusive (Hanus and Fox 2015; Mekler et al. 2017). Thus, an in-depth understanding of the pedagogic effectiveness of gamification rewards is necessary to resolve the debate and inform proper gamification reward designs in the E-Learning context.

In this study, we categorize gamification rewards based on their functions and fulfillment conditions. On the one hand, we follow the gamification literature and classify gamification rewards into two types based on reward functions: hedonic and utilitarian (Wolf and Tobias 2019). Generally, hedonic rewards can yield aesthetic pleasure, fantasy, and fun (Hirschman and Holbrook 1982), whereas utilitarian rewards can help accomplish functional goals and are cognitively motivated (Strahilevitz and Myers 1998). On the other hand, we incorporate the fulfillment conditions from SDT to enrich gamification reward design. More specifically, we categorize gamification rewards into expected or unexpected rewards depending on whether learners are clearly aware of the fulfillment conditions. For example, if learners know that they will receive one specific reward upon the completion of one specific class in advance, the reward should be considered as an expected reward in this case. In contrast, if learners are not aware of the fulfillment conditions of the reward in advance, the reward should be regarded as an unexpected reward. Overall, we argue that different reward designs can have varying impacts on individual learners' intrinsic and extrinsic motivation. In the next section, we develop our hypotheses based on the Opportunity Cost Model of Subjective Effort and Task Performance (Kurzban et al. 2013) and SDT (Ryan and Deci 2000).

Hypothesis Development

This study examines the effectiveness of four different types of gamification rewards on student motivation and mental fatigue in the E-Learning context, i.e., expected-hedonic reward, unexpected-hedonic reward, expected-utilitarian reward, and unexpected-utilitarian reward. The research model is shown in Figure 1.

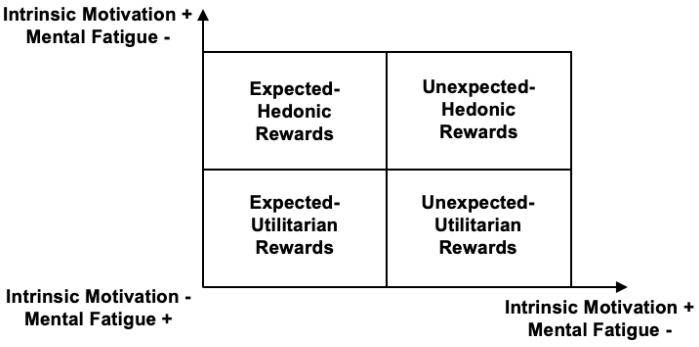

Figure 1. Research Model

Gamification Rewards and Motivation

Reward is a common gamification element that arouses extrinsic motivation (Ryan and Deci 2000). The incorporation of rewards will increase the perceived benefits of learning tasks, increasing learners' extrinsic motivation to complete the learning-related activities in the short term. However, as noted earlier, the increase in extrinsic motivation is often short-lived and does not last for long (Liu and Hou 2017). Thus, we should consider how to increase intrinsic motivation in the long term in the E-Learning context (Deci and Ryan 2001).

Different types of gamification rewards may have varying impacts on intrinsic motivation in the long term. From a functional perspective, utilitarian rewards primarily provide instrumental or functional support for learners (Hirschman and Holbrook 1982). They can effectively boost learners' extrinsic motivation in the short term: as the cost of the learning tasks is constant, the provision of utilitarian rewards will increase the perceived task benefits, increasing learners' extrinsic motivation to complete the learning-related activities. However, when learners work on the course for an extended period of time, they will become more familiar with these utilitarian rewards and perceive the rewards to be less fascinating and attractive. As a result, they will feel demotivated to continue with the learning tasks due to decreased perceived benefits. Furthermore, according to SDT, utilitarian rewards will drive intrinsically interested behavior controlled by extrinsic rewards by decreasing learners' autonomy (Ryan and Deci 2000). In contrast, hedonic rewards provide joy and pleasure to learners. Compared with utilitarian rewards, hedonic rewards provide a greater sense of competence and autonomy in the long run (Deci and Ryan 2001), hence keeping learners focused on learning tasks. Therefore, compared with hedonic rewards, utilitarian rewards will negatively affect the competence and autonomy of the learners and lead to lower intrinsic motivation.

As for the fulfillment conditions of the rewards, according to cognitive evaluation theory, learners tend to perceive the expected rewards as more controlling when they are clearly aware of the fulfillment conditions (Deci and Ryan 1985). The sense of controlling will reduce the perceived benefits of learning tasks, significantly hindering intrinsic motivation (Deci and Ryan 2001). Such sense of controlling can be significantly lessened when the rewards are provided in an unexpected manner. As such, the unexpected rewards are more likely to stimulate the learners' learning curiosity and further increase intrinsic motivation (Deci and Ryan 1985). In sum, we anticipate that all four types of gamification rewards can boost extrinsic motivation in the short term. However, both utilitarian and expected rewards can decrease intrinsic motivation in the long term. Therefore, we hypothesize that:

H1: In the short term, gamification rewards will increase extrinsic motivation.

H2a: In the long term, expected-utilitarian gamification rewards will decrease intrinsic motivation compared with unexpected-utilitarian gamification rewards.

H2b: In the long term, expected-utilitarian gamification rewards will decrease intrinsic motivation compared with expected-hedonic gamification rewards.

H2c: In the long term, unexpected-hedonic gamification rewards will increase intrinsic motivation compared with unexpected-utilitarian gamification rewards.

H2d: In the long term, unexpected-hedonic gamification rewards will increase intrinsic motivation compared with expected-hedonic gamification rewards.

Motivation and Mental Fatigue

As noted previously, we categorize the tasks into two types: learning tasks and non-learning tasks. Based on the Opportunity Cost Model of Subjective Effort and Task Performance (Kurzban et al. 2013), we define the benefits of non-learning tasks as opportunity costs because the time spent on the learning tasks will deprive learners of the opportunity on non-learning ones. We further assume that learners will naturally weigh the benefits of various learning and non-learning tasks when they execute learning tasks. The higher the perceived benefits of learning tasks relative to the associated opportunity costs, the more motivated the learners are on their learning tasks, and more cognitive resources will be allocated to maintain the current learning performance. Specifically, gamification rewards that increase extrinsic motivation will encourage the learning tasks by increasing the perceived benefits of learning tasks as well as decreasing the opportunity costs of non-learning tasks, resulting in reduced mental fatigue. This is echoed by recent studies on task engagement, which suggest that extrinsic rewards could counteract the effect of mental

fatigue and restore task performance to pre-fatigue levels (Hopstaken et al. 2015). On the other hand, rewards that increase intrinsic motivation can also increase the perceived benefits of learning tasks. Indeed, prior studies have shown that people rarely experience mental fatigue when they are enthusiastic or engaged in activities they enjoy (Bartley and Chute 1947). Thus, intrinsically motivated learners tend to perceive the learning tasks to be highly beneficial, regardless of the perceived opportunity costs. They are far less likely to suffer mental fatigue compared with their unmotivated peers (Hockey 2010). Taken together, we hypothesize that both types of intrinsic and extrinsic motivation have a negative effect on feelings of mental fatigue among online learners, and both will mediate the relationship between gamification rewards and mental fatigue.

H3a: High intrinsic motivation will lead to lower mental fatigue among learners.

H3b: High extrinsic motivation will lead to lower mental fatigue among learners.

H4a. Intrinsic motivation acts as the mediator between gamification rewards and mental fatigue.

H4b. Extrinsic motivation acts as the mediator between gamification rewards and mental fatigue.

Methodology

The study is still in progress. A longitudinal field experiment will be conducted in an introductory undergraduate computer programming course to test our research hypotheses. We chose the longitudinal experimental approach to measure both short-term and long-term motivation and mental fatigue changes after exposure to our gamification rewards.

Gamification Design

A gamified LMS platform GameMooc has been designed based on the existing learning platform DoosMooc (Orooji et al. 2015). Specifically tailored gamification will be used to avoid confounds in the study. We follow the design from Ortega-Arranz et al. (2019) and use the badges as our main gamification design. Our experiment will be a 2 (Reward Function: Hedonic vs. Utilitarian) x 2 (Reward Fulfillment: Expected vs. Unexpected) between-subjects factorial design. A control group has been set up as well without gamification rewards. A pilot study will be conducted to evaluate the design of the gamification elements to ensure the types of rewards that these designs generate.

Experimental Materials and Procedures

Students enrolled in a 16-week introductory computer science course will be recruited as participants in the experiment. We plan to enroll five classes of undergraduate students and each class will be randomly assigned to one of the five experimental conditions. Before the start of the experiment, all of the participants need to fill out a pre-experiment survey, which collects information on control variables including gender, grade point average, declarative prior knowledge (Sailer and Sailer 2021), and pre-experiment motivation and mental welling-being level.

In the *control* condition, participants will be told that "It is a well-designed platform for this course, and please feel free to use the platform to engage in the course". No further information will be provided.

In the *unexpected-hedonic reward* condition, participants will be told that "It is a well-designed platform for this course and please feel free to use the platform to engage in the course. Besides, there exists a badge system in the platform." No further information will be informed.

In the *expected-hedonic reward* condition, participants will be told that "It is a well-designed platform for this course, and please feel free to use the platform to engage in the course. Besides, there exists a badge system in the platform." They will also receive guidance on how to gain these badges.

In the *unexpected-utilitarian reward* condition, participants will be told that "It is a well-designed platform for this course, and please feel free to use the platform to engage in the course. Besides, there exists a badge system in the platform." They will be informed that the badges can be used as virtual currency and can be exchanged for other rewards in the reward store.

In the *expected-utilitarian reward* condition, participants will be told that "It is a well-designed platform for this course, and please feel free to use the platform to engage in the course. Besides, there exists a badge

system in the platform." They will receive guidance on how to gain these badges. Besides, they will be informed that the badges can be used as virtual currency and can be exchanged for other rewards.

In the first class, students will be told that most of the class activities will be conducted on GameMooc. They will be provided with a detailed tour guide containing instructions on how to use the system to accomplish online learning tasks. At the end of the first class, students in treatment groups will receive a badge, congratulating finishing the first class. Then all students have to complete a short questionnaire investigating their level of motivation and mental fatigue. After the first class, they will continue studying on the E-Learning platform for the remaining 15 weeks and complete the questionnaire every four weeks. At the end of the semester, we will record the number of badges they collected as well as their course grades[1].

Measurement

Motivation will be measured by several well-established scales in the E-Learning context (Hanus and Fox 2015), including Academic Achievement Motivation Assessment (Hermans 1970) and intrinsic motivation inventory (Ryan et al. 1991). *Short-term motivation* will be measured using the first-week survey (Week 1) while *Long-term motivation* will be measured from the subsequent four surveys that were equally distributed throughout the semester (Week 4, Week 8, Week 12, and Week 16).

Mental Fatigue will be measured by Multidimensional Fatigue Inventory (MFI-20) (Smets et al. 1995). The MFI-20 test consists of 20 items classified into five dimensions: general fatigue, physical fatigue, reduced activity, reduced motivation, and mental fatigue.

We will also measure the following control variables: gender, grade point average, declarative prior knowledge about computer programming (Sailer and Sailer 2021), intensity of preparation (Sailer and Sailer 2021), and pre-experiment motivation and mental welling-being level.

We plan to use ANOVA to analyze the effects of four different types of rewards on intrinsic and extrinsic motivation in the short term. We will use repeated-measures ANOVA to analyze the effects of gamification reward design on intrinsic and extrinsic motivation in the long term. We will also test the mediating role of motivation through mediation analysis using PROCESS Macro.

Discussion and Conclusion

To our knowledge, this paper is one of the first studies investigating the potential effect of gamification rewards on learning motivation and mental fatigue. This study will contribute to gamification and online learning literature in three ways. First, although mental health issues are becoming more prevalent nowadays, little research has investigated solutions to address these challenges among online learners (Dirzyte et al. 2021). Our paper addresses this gap by designing and testing four types of gamification rewards to alleviate mental fatigue. We integrate three streams of literature to establish a holistic theoretical model that sheds light on the role of gamification rewards in alleviating mental fatigue through increased motivation. Second, building upon the Opportunity Cost Model, our study establishes and refines the theoretical link between intrinsic and extrinsic motivations and mental fatigue. It further suggests that motivation might mediate the effect of gamification design elements on mental fatigue. Third, results from our longitudinal studies will reveal both the short-term and long-term effects of gamification rewards.

The research will provide important practical implications as well. First, researchers and educators can use the findings from this study to settle the debate on the impact of reward manipulation on mental fatigue and motivation. For example, instructors can gain an enriched understanding of the potential effects of the gamification rewards over the long term and choose to use proper rewards in real-life e-learning scenarios. Second, for E-Learning system designers, we suggest that they should design more hedonic and unexpected rewards to encourage learners to be intrinsically motivated to learn.

The study is not without limitations. First, this study targets college students. However, mental fatigue issues also exist among elementary and high school students, and adult learners (Mizuno et al. 2011). Future research should explore the effects of gamification rewards among different learner groups to increase the generalizability of our results. Second, we only examine one type of reward-based gamification element –

[1] We will analyze students' academic performance in our future research although it is out of our research scope.

badges. More studies can be conducted to examine the potential effects of other reward-based gamification elements on mental fatigue among online learners. Finally, this study focuses on the role of rewards. Future research can further evaluate the effectiveness of other gamification elements, such as social comparison and social support, on mental fatigue.

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