Addressing the Dilemma of Online Gamification with Subgame Perfect Equilibria

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***Abstract*—Gamification, a concept originally derived from games, is defined as the extraction and inclusion of game mechanics within ordinary activities. Applying gamification to the educational context had surged over the past decade due to the recognition of the potential in motivating, promoting engagement, and enhancing student performance. The current study sought to overcome three dilemmas, including gamified depths, online gamification, and interaction, when gamifying the online learning environment through game theory, which investigates the arising conflict and collaboration among logical and intelligent decision-makers. This study used learning analytics based on the qualitative data collected from 57 undergraduates from the School of Educational Studies by exposing the students to gamified and non-gamified e-learning environments throughout eight weeks. By scrutinising the online gamification dilemma as a sequential game, the perfect equilibrium or Nash equilibrium at each subgame can be achieved using backward induction with synchronous online shallow gamification (4,6) and asynchronous online shallow gamification (3,5) as the optimal outcome. Hence, shallow gamification would allow players' payoff maximization even when the asynchronous approach was selected, compared to asynchronous deep gamification.**

***Index Terms*—Dilemma, education, gamification, game theory**

I. Introduction

In previous research, Lim *et al.* [1] discovered three dilemmas frequently encountered by educators when attempting to gamify online classrooms during the coronavirus (COVID-19) pandemic. The dilemmas include gamified depth, which describes the difficulties in long-term employment of shallow gamification when the utilization would deteriorate learner motivation owing to the absence of a proper application, thus preventing a deep gamified learning environment. Another dilemma is online gamification, which elucidates insufficient technological foundation in constructing an online gamified environment due to connectivity issues and access restrictions. Meanwhile, the dilemma of interaction indicates the predicament in establishing social connections from distinct students' preferences for either synchronous or asynchronous lessons. Consequently, a conundrum is frequently posed for educators to decide on the gamification of online classrooms.

The term gamification is formally defined by Nick Pelling as applying game mechanics in a non-game situation [2]. The game mechanics or elements could be categorized into mechanics (the core game elements), dynamics (players' experience) and aesthetics (players' perceived feelings) [3]. For example, the game elements encompass achieved points, levels, badges, leaderboards, quests, and rewards which are frequently designed to instil enjoyment in a particular task [4]. The gamification concept perceivably originates from the usage of badges in boy scouts or military rankings [5]. Nonetheless, the application of gamification in learning revealed researchers' mixed opinions due to the equivocal effectiveness of gamified learning. Although gamification studies discovered students' increased intrinsic and extrinsic motivation [6, 7], engagement [8, 9] and performance [10, 11], other academicians also demonstrated several negative effects, including learning indifference, low performance, undesired behaviour, and other deteriorations of learning outcomes in a gamified classroom [12]. Specifically, Alsawaier [13] postulated that excessive gamification would divert student attention from the current tasks.

Game theory emerged from another discipline to complement the gamification concept, although gamification and game theory possess similarities in terms of appellation. Game theory refers to the concept derived from scrutinizing mathematical representations of conflict and cooperation between rational and intelligent individuals [14] which aims to assist in understanding and explicating a situation with relevant decision-making to be applied in quotidian activities [15]. Thus, the present study sought to surmount the existing dilemma through game theory while elucidating the concept of future instructional designers and educators by answering the current research question.

Research Question (RQ): What rational decisions should be performed by educators to resolve the dilemma of online gamification?

II. Literature Review

A. Gamification

Educational gamification is defined as a well-established setting comprising various choices and low-risk interaction, which utilises relevant aspects of game designs and game thinking to promote student participation and motivation [16, 17]. Toda and Klock *et al.* [18] analysed the gamification elements employed within a learning environment before classifying five dimensions, namely performance, ecological, social, personal and fictional, as summarized in Table I.

Huang and Soman [19] outlined a five-step process for implementing game elements within an educational setting:

1) Understanding the target audience and context by determining the student size, setting, skills, and timeline in the course.

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2) Defining learning objectives by carefully stipulating the goals, such as general instructional goals, specific learning goals, or behavioural goals to be achieved in a lesson.
3) Structuring the experience by dividing a lesson into several stages and identifying potential difficulties encountered by students.
4) Identifying resources by evaluating the gamification suitability and mechanisms of a lesson, along with the defined regulations and received feedback.
5) Applying gamification elements by incorporating personal or game elements into a designed course.

Meanwhile, Nicholson [20] proposed the application of six different elements, including play, exposition, choice, information, engagement and reflection to construct a successful and meaningful gamification while encompassing three crucial educational features, namely freedom to fail, rapid feedback and progression [21].

TABLE I: TAXONOMY OF GAMIFICATION BY TODA AND KLOCK *ET AL.* [18]

Dimensions	Definition	Game elements
Ecological	The gamification setting	Rarity, economy, imposed choices, chances, and time pressure
Social	The occurrence of student interactions	Social pressure, competition, collaboration, and reputation
Personal	Student practices in the surroundings	Sensation, objectives, puzzles, renovation, and novelty
Fictional	The merging of student and gamified experiences through fantasy.	Narrative and storytelling
Performance	The provision of student evaluation.	Acknowledgement, statistics, points, levels, and progression

B. Game Theory

Game theory, a branch of decision theory, delineates the action after assessing all players' potential options [22] to generate decisions for a group of individuals during uncertainties. Particularly, game theory resolves the issues of knowledge scarcity regarding specific environment, interpersonal decision-making process, and opponents' incentives and capabilities [23]. Notably, game theory conveys a dissimilar connotation of games compared to conventional video games, wherein games resemble a situation with specific rules involving a party or an individual recognized as a player. Specifically, the term could be comprehended as simple quotidian activities, such as coin flipping, a decision on a destination to visit, or the direction where goalkeeper should approach in a football match. Nitisha [24] categorised games in game theory into five branches:

1) Cooperative and non-cooperative games—In cooperative games, collaboration is required to achieve the most optimal outcome, whereas each player focuses on maximizing personal benefits in non-cooperative games.
2) Normal form and extensive form games—Matrices are utilized to present a normal form game while a decision tree is employed for an extensive form game.
3) Simultaneous move games and sequential games- Both players perform a move in simultaneous games without being aware of the opponent's action, thus requiring the players to develop a strategy beforehand. Meanwhile, sequential games allow players to observe and learn the opponent's strategy during the game.
4) Constant sum, zero-sum and non-zero-sum games- A constant sum game produces a constant total outcome for all participants even when the results vary, whereas a zero-sum game consists of various constant-sum games with the total results for each player equal to zero. Meanwhile, including a dummy player in a zero-sum game would transform the game into a non-zero-sum game.
5) Symmetric and asymmetric games- Consistent strategies adopted by players would be considered as a symmetric game, whereas distinct approaches are typical in an asymmetric game.

Several predefined assumptions are required before constructing a game [25]:

1) The adoption of several strategies in resolving a problem.
2) The availability of pre-defined outcomes.
3) The overall outcome is zero at the end of the game
4) All players are aware of the game and the outcome of other players
5) Players would perform a rational decision to maximise personal benefits or desired payoff.

Paturel [22] stated that it is essential to have the following featured elements which are:

1) A finite number of competitors. A fixed number of players are involved in the game, either solely an individual or a group.
2) A finite number of actions. Each participant could access a limited number of options, either similar to or different from one another for the following steps.
3) Knowledge and alternatives: Each participant is aware of the opponent's options.
4) Choices. Different game types would allow players to choose particular strategies simultaneously or sequentially.
5) Outcomes or gains. The game produces an outcome or a gain based on every performed decision, wherein a negative number suggests a loss.
6) Opponents' choices. Each player's potential gain or loss is based on personal and opponents' decisions

C. Subgame Perfect Nash Equilibrium

The sequential rationality theory posits that the agent (player) would compute opponents' future behaviours from personal knowledge of the game structure without being misled by opponents' threats, which formalises a subgame-perfect equilibrium [26]. Accordingly, each participant is required to select the most optimal countermove to the opponent's action plan [27]. A subgame is a subset of the game tree where players' decisions could be examined independently [28] which is only feasible in a complete game. The analysis commences on an initial decision node before proceeding with the terminal nodes with the stated payoff, while the remaining nodes are also required to be included to allow comparing different payoffs for optimal action.

In game theory, Nash equilibrium functions to identify the most optimal outcome wherein a particular form of stability is exhibited when all players adhere to personal equilibrium strategies without deviations [29, 30]. Essentially, a subgame perfect equilibrium is the existence of Nash equilibrium in every subgame, which could be achieved by implementing the backward induction method to resolve an extensive form game through sequential moves [31].

The concept of subgame perfection was introduced by Selten [32]. For example, Selten's game describes the occurrence of kidnapping as a two-person sequential game involving the kidnapper (player K) and the hostage's family member (player F). Initially, the kidnapper could either kidnap or not kidnap the hostage. The game would be concluded when the kidnapper did not kidnap the hostage, while the hostage would be abducted to a hideout by the kidnapper who decided to perform the kidnapping. When an enormous ransom amount was requested by the kidnapper, the hostage's family members could either decide to abide by the request or negotiate the amount. In each action, a possibility exists of whether the kidnapper might execute the hostage or release the hostage, which is also similar to whether player K would be eventually apprehended. Fig. 1 summarises the game structure as a decision tree:

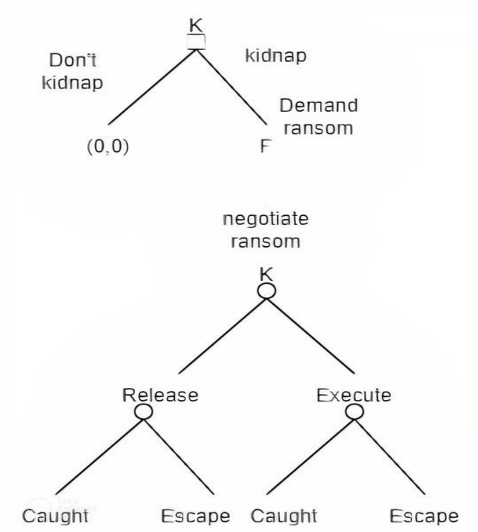

Fig. 1. The decision tree of Selten's game.

Four possible outcomes are presented at the end of Selten's game:

1) Player K releases the hostage and escapes;
2) Player K executes the hostage and escapes;
3) Player K releases the hostage before being apprehended;
4) Player K executes the hostage before being apprehended.

Thus, the question arises in the situation where, the hostage was executed even if player F provided the ransom to player K, as player F's rationale contradicts the outcome. Similarly, the paradox exists when player K would be apprehended eventually, which queries the rationale for paying the ransom. Therefore, the game should be observed comprehensively by scrutinizing every opponent's decision as perceiving the game as a whole would not provide detailed insights.

III. Methodology

The current study recruited 57 undergraduates from the School of Educational Studies for voluntary participation. The students were exposed to two types of learning environments namely e-learning and gamified e-learning with both synchronous and asynchronous learning content for eight weeks using Google Classroom, Kahoot!, and ZOOM. An interview session was conducted with every student to receive respective feedback, before proposing a pertinent solution for the gamification dilemma via the game theory based on the received mixed responses.

IV. Analytics

Analytics refers to producing applicable insights through resolving relevant issues, employing statistical models, and analysing current or simulated future data [33]. The application of data analytics in teaching and learning is regarded as Learning Analytics (LA), which emphasises the learners and respective learning processes. The LA is an innovative tool to gather, combine, and analyse static and dynamic data regarding learner profiles, learning resources, and learning contexts in modifying or supporting the existing educational processes [34, 35]. Nguyen and Gardner *et al.* [35] categorise the LA into several subsets, which consist of content analysis (examine texts to uncover hidden meanings.), discourse analytics (records user interactions to investigate relevant data about the linguistic characteristics from the learning discourse), social learning analytics (investigates the educational process from a social standpoint), and disposition analytics (discovers student dispositions and underlying relations to the learning process by examining educational data on student backgrounds and learning involvement).

A. Structuring the Game

The present study simulated a similar COVID-19 pandemic setting to motivate learners in a Malaysian online classroom. Similar to Selten's game, the simulation aims to obtain the optimal strategy at each subgame when encountering the dilemmas of gamified depth, online gamification, and in the classroom. Specifically, the situation is a sequential move game with strategic interactions progressing in predetermined steps [31], wherein each participant would select the most optimal countermove to the others' action plan [27]. Three elements described below are required in the current simulation.

1) Players: Teachers and students;
2) Actions: Choosing a learning delivery method;
3) Payoffs: Utility and motivation.
4) Player S and Player T represent students and teachers respectively in the game. The game would be concluded if player S chose offline in the beginning, teaching and learning were mandatory for safety precautions during the COVID-19 pandemic. Conversely, the game would proceed when online learning was selected followed by the choice between synchronous and asynchronous online learning experiences. Past scholars propounded that, asynchronous lessons ably increased online learning effectiveness [36] and vice versa [37]. Resultantly, the opportunities for selecting synchronous and

asynchronous lessons were presumed to be equivalent.

The gamification techniques employed by educators could be classified into shallow and deep gamification. Deep gamification is considered to ably retain and sustain students' intrinsic motivation compared to shallow gamification, which influences extrinsic motivation [38]. Shallow gamification refers to the use of points, badges, leaderboards, and levels (PBLs) without fundamentally transforming the learning process. Contrarily, deep gamification alters learning foundations by rendering a meaningful process, although the implementation is more challenging as higher levels of expertise and skillset are required [39, 40]. Furthermore, the absence of a feasible framework for integrating of deep gamification into higher education processes, the unidentified significance, and the lack of fitting gamification software increase the challenges for applying deep gamification in learning [39]. An and Zhu *et al.* [41] illustrated several online gamification obstacles including time constraints, limited expertise, inadequate financing, and a discrepancy between gamification and a specific subject matter, apart from the concerns on student perception and acceptance of learning gamification, relevant with detrimental impacts. Nevertheless, previous research demonstrated that 60% of the students anticipated fun elements in online classes [1]. Thus, the payoff depicted in the present decision tree (See Fig. 2) is distributed by assuming students' and teachers' preferences on the lesson delivery method ranging from 1 as the worst to 6 as the best. Notably, game theory does not normatively prescribe certain sentiments or desires to players, owing to the personal preferences being incorporated in advance into the received payoffs [31].

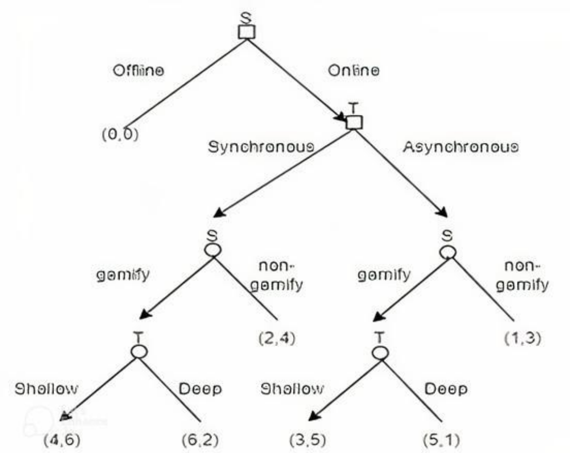

Fig. 2. A decision tree resembles the online gamification dilemma.

B. *Solving the Game*

The decision nodes of players are represented as squares while the chance nodes are depicted as circles in Fig. 2 and Fig. 3. To overcome the online gamification dilemma in the (See Fig. 3), backward induction, which is logical reasoning that uses mathematical induction [42] was conducted. By scrutinising the four chance nodes while considering the payoff, player T would most likely select the shallow gamification path as both outcomes were more beneficial compared to the deep gamification approach which Allowed player T to receive 5 or 6. By moving one step backwards, player S could choose gamification or non-gamification in a synchronous or asynchronous setting for the payoff of either 3 or 4. Hence, the rational decision would constantly be learning gamification. Meanwhile, player T's decision node suggested that the synchronous learning method would eventually produce the outcome of (4, 6) compared to the asynchronous choice (3, 5). When moving up towards the highest decision node, player S is recommended to employ the online method to receive a higher payoff regardless of the outcome. Summarily, the perfect subgame equilibrium in online gamification would frequently be Player T: < (synchronous, shallow), (asynchronous, shallow) >, player S < (online, gamify) >.

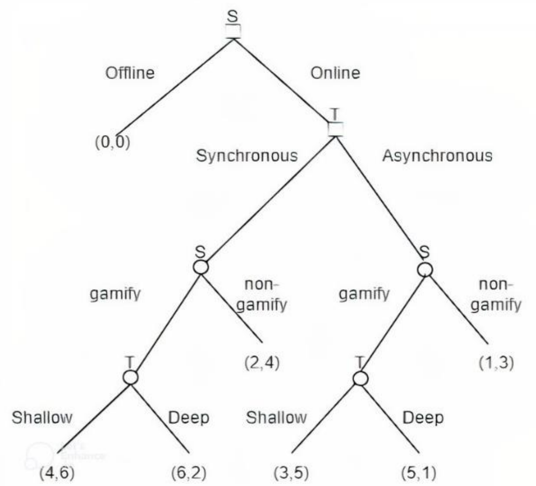

Fig. 3. The subgame perfect equilibrium in the online gamification dilemma.

V. Conclusion and Recommendations

The current study examined the online gamification dilemma posed as sequential games and resolved the predicament through backward induction to achieve a subgame perfect equilibrium. Simultaneously, this study contemplated the possible challenges associated with educators' and learners' presumed motivation. The study managed to fulfil the research question, namely the three dilemmas of gamified depth, online gamification and interaction via game theory. Resultantly, educators are recommended to employ online learning as using offline learning produced zero payoffs for involved participants or players. Subsequently, although the rational decision was discovered to be the synchronous approach, a synchronous or asynchronous approach would be conducive to learning gamification. Nonetheless, shallow gamification would allow players' payoff maximization even when the asynchronous approach was selected, compared to asynchronous deep gamification.

The present study provided a unique perspective and a rational solution to educators by addressing the constant quandary in gamifying a classroom through game theory. Nonetheless, several limitations existed, the game theory did not normatively dictate participants' thoughts, feelings, or desires. Although participants' preferences were being integrated into the payoff value of the game, the payoff value was generalised and generated based on predefined assumptions. Consequently, the game outcome would diverge when students possessed different opinions on classroom gamification. Future studies are recommended to comprehensively investigate potential conflicts in a classroom, as students' player traits and relevant technological infrastructure were not emphasized in this study. Furthermore, a proper framework is a prerequisite for higher educational gamification and total gamification by integrating shallow and deep gamification approaches to foster sustainable student motivation intrinsically and extrinsically.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Lim D. conducted the research, analyse the data and wrote the paper; Sanmugam M. review and further elaborate the paper; Yahaya W.A. J. W. review and make corrections to the paper; all authors have approved the final version.

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