Impact of Gamification on Online Learning Systems

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ABSTRACT

Gamification is the process of turning non-game systems and elements into a game-like experience. This makes the system more enjoyable and has many benefits, including better performance, attention and enjoyment. This project explores the use of gamification in the setting of online self-learning, in which users voluntarily choose to enrol and learn a module in a gamified system. We show that not only gamifying learning modules are empirically beneficial, but also provide a framework/model that other practitioners can use to validate their own gamified systems.

We follow a stringent methodology to build and validate our model. Our process involves building a highly structured questionnaire item set (40 items) that is first validated for similarity (Composite Reliability). Then we collect user data from 31 participants who are experienced users of a gamified language learning app (Duolingo). We then validate our structural model using the partial least squares method to minimize external factors and maximize path relationship between variables.

Our results confirm that our model is valid across 98% of our hypotheses. Path relationships are considerably high and confirm that they are valid predictors.

We validate our model empirically with this pilot study. This model can be used to validate gamified systems by industry or academic practitioners.

This project is one of the firsts to explore building a holistic model of behaviour in gamified systems in the context of self-learning - Where a user chooses to learn a topic/area of study all by himself with the help of the gamified system. Our model can help Gamified system designers by setting an empirical standard that must be met. We hope that our model and method can be used in various fields and can help designers and engineers build usable, actionable, and verifiable gamified experiences.

CCS CONCEPTS *• Insert your first CCS term here • Insert your second CCS term here • Insert your third CCS term here*

Additional Keywords and Phrases: *Insert comma delimited author-supplied keyword list, Keyword number 2, Keyword number 3, Keyword number 4*

1 INTRODUCTION

Gamification is being increasingly used in multiple facets of our society, from fitness to productivity, systems are adopting gamification to enhance their platforms and provide users with varied features that help them be more productive, attentive and engaged in an activity. According to Gartner (2011), by 2015, 50% of organizations will have gamified their systems and processes. Education can benefit a lot with gamification as it is shown to increase concentration and enjoyment.

Gamification models for Self-Learning are not extensively evaluated in the existing literature. Very few structural equation models exist in the context of online learning and motivational behaviour. We propose to fill this gap by building and validating a holistic model for gamifying learning platforms.

This phenomenon provides an immense opportunity in the self-education space as users often just rely on systems without tutors to learn what they desire. Coursera, Udemy, and other big online learning platforms are some of the big players in the space. However, their systems often seem like an endless catalogue of a variety of options without a specific structure or direction for a user.

We intend to fill this gap and seek to understand how and why users learn or carry out a task without academic incentive and motivation. We propose a structural equation model that extends TAM on three fronts, namely, Social Factors, Intrinsic Motivation and Flow, to understand game dynamics, behaviours, and factors contributing to learning outcomes in systems where the academic incentive is not a primary motivator.

1.1 Motivation

The primary motivation for this project was that there was a lack of empirical understanding of the holistic view of cognitive processes that drive gamified learning. More and more commercial apps and services are starting to offer some level of gamified features to their users, which seems to be becoming an industry norm.

In interaction research, any phenomenon that gets widespread acceptance starts to be an interesting mode for exploration and the need for empirically derived theory. Our goal is very similar, to build a holistic model of gamified learning that practitioners and researchers can use to implement interactive gamified education systems and explore more about the peculiar phenomenon of gamified learning.

For this project, we explored many gamified systems and applications that already exist in the market and also investigated building our own gamified learning platform. A simple prototype can easily be deployed to users with existing technologies like HTML, CSS, and JS, including higher-level front-end frameworks like React, lower-level communication systems like Websockets and custom libraries the author has personally built. However, due to the interest of time and available user base/interest for the study, we have decided to design our study according to the features provided by the most popular language learning app: Duolingo.

1.2 About Gamification

According to the standard definition, gamification is the process of converting a non-game system into a system with game-like features for enhanced productivity, motivation and enjoyment.

It is the use of game mechanics that are empirically proven to induce enjoyment and flow in non-gaming contexts like education, fitness and productivity, to name a few. Many productivity, fitness and health apps are already using gamification in some form to motivate users to be more productive every day or more active every day, like fitness apps giving rewards and achievement badges to users after they complete a number of steps every day or productivity apps showing performance charts and tracking + rewarding more time spent on productive tasks.

Common game mechanics that gamify a system include:

- Badges
- Levels
- Performance Charts
- Leaderboards
- In-game currency

These mechanics are design abstractions that can be implemented in multiple ways, but they serve the same purpose: to add an intrinsic motivation system. Immersion is another interaction paradigm that is commonly used to induce another factor for gamification: Flow.

A continuous sequence of attention-keeping tasks/activities in the systems contributes to a positive flow experience and hence, constant productive output by the user.

Another game-like interaction that can be leveraged is collaboration and sense of community. Social factors play a huge role in many social/multiplayer games with high attention rates and enjoyment among players. This is a crucial factor to consider as well in gamified systems. Apps usually have a social section in the app for users to compare their progress and discuss in-app events. The feeling of winning is the underlying principle driving game players to higher attention spans, flows, productivity, concentration, success drive and motivation (Hyunh, Iida, 2017).

1.3 Objective

To propose and evaluate a novel statistical model for gamification in online self-learning systems. To verify the effectiveness of the model by conducting a component analysis that is statistically valid for most variables in the model.

Our objective is to evaluate our novel model that summarised all our hypotheses in a holistic visual representation. It is essential to validate our hypotheses for the purposes of building a holistic framework that can be used by researchers and practitioners of the future.

Another goal of this project is to structure the current literature landscape regarding gamification that is scattered and make it more organized in one entity.

We do this by extensively reviewing the theory and literature behind every aspect of our model, no matter how small.

To evaluate our model, we utilize an existing gamified learning system called: Duolingo. It is a very popular language learning application available on the web, android and ios.

Our goal is also to get and synthesize descriptive feedback about the current state-of-the-art systems from our participants.

Overall, the overarching goal of this project is to build and validate a holistic model that can be used and expanded in the future.

2 LITERATURE REVIEW

This section reviews the vast literature revolving around predictive and relational models that describe a behaviour/phenomenon or a system.

First, we explore previous work related to cognitive learning and productivity processes. Next, we hypothesize our predictions in our own model, taking inspiration from previous literature.

The following explores the literature surrounding various cognitive factors that are being used in the project.

2.1 Introduction

Self-Learning in the title refers to the phenomenon where a user is not guided by a mentor or teacher to learn a concept but is entirely reliant on the services provided by a system. In cases where a user is completely reliant on a service, gamification can be really helpful in motivating and engaging a user, even with the lack of a mentor. In these systems, users choose to start themselves and self-motivated at the start. However, with time, that drive can get low, making the user leave or discontinue learning. Gamification is really helpful in this case, and this project focuses on just that. We use a very popular application called Duolingo to construct and validate our model. Duolingo is a language learning app with gamified features where users often join by themselves and try to learn a new language, often self-motivated at the start.

We will first explore different psychological phenomena that underlie gamification and what makes games interesting. We will then apply these for our use case.

We will also build hypotheses based on previous literature for our model based on *figure 1*. And aim to argue all aspects of the model purely based on previous literature.

2.2 Analysis of Literature

Factors that contribute to a good gamified experience include:

2.2.1 Flow

Flow experience was introduced and defined by Csikszentmihalyi as "the holistic experience that people feel when they act with total involvement." (Csikszentmihalyi, 1988). Flow refers to a state of mind with very high concentration and focus on a particular activity, which initiates high pleasure and intrinsic motivation to continue the activity. The experience is sometimes described as 'zoning out' while working or in a game-playing context, hyper focusing on playing a game.

Csikszentmihalyi has laid out 9 dimensions people experience in the flow state. Namely, Optimal challenge and sufficient skill, establishing goals, knowledge about the task, getting feedback, autonomy, or a sense of being in control of the activity, loss of sense of time, loss of self-consciousness, and finally, rewarding experiences. Users experience all or most of the dimensions while in the flow state. In a learning context, the platform must maintain a balance between the task's challenge and the learner's competence. In gamified systems as games are considered to be intrinsically rewarding and motivating activities (Shernoff, Csikszentmihalyi, Schneider, & Shernoff, 2014), gameful activities can help leverage this to help users focus and as a consequence, learn better.

Flow experience has been studied intensively with regard to entertainment and has been recommended as useful in understanding the attitude people have towards playing games (Refiana et al., 2005; Xiang, Lee, & Li, 2005). It was also suggested that flow experience provides a surrogate measure for positive experiences of users and the success of online games (Kim, Oh, and Heejin 2005). While some findings have contradicted this and found no correlation between flow experience and attitude in online game systems (Hsu, 2003), most have found a positive correlation between the two (Lee 2009; Lee and Tsai 2010; Alzahrani, 2017).

As it is, flow has been identified as a possible measure of online user experience by many (Ghani and Deshpande 1994, Hoffman and Novak 1996, Trevino and Webster 1992, Webster, Ryan and Trevino 1993) Furthermore, Cheng et al. predicted that the higher the flow experience within the games, the higher the level of encouragement of individual keenness will turn into intention, and Webster et al. also noted that flow was associated with exploratory behaviour and positive subjective experience (Cheng et al 2014, Webster et al.,, 1993). Alzahrani, (2017) has also found flow to be a notable predictor of actual system use. Therefore, as our model aims

to understand why users may want to learn without academic incentive, the following hypothesis is proposed:

H: Flow experience has a positive relation with attitude in a gamified online learning system
H: Flow experience has a positive relation with Actual Learning Outcome in a gamified online learning system

Silva, Rodrigues and Leal (2019) have found Autonomy of activity and social interaction to be a important predictor of flow experience in a gamified learning activity, but other items like feedback, challenge, perceived learning outcome, clarity were, although a positive predictor, did not significantly contribute to predicting flow. We hypothesize the following for prediction of flow in relation to autonomy and social interaction:

H: Autonomy of activity will have a positive relation with the flow experience
H: Social interaction will have a positive effect on flow experience.

2.2.2 Social Factors

Social Influence is defined by Ajzen, 1991 as the influence a user's peers have on the subsequent behaviour that the user shows. It essentially acts as a reward system for the user to be motivated to perform a certain action/use a certain system or platform.

Ashrafi et al., (2020) found that social influence has a highly significant correlation with Intention of use in a virtual learning environment. Alzahrani, et al., (2016) also found social influence to be a significant predictor of actual game playing. In an attempt to answer the extensive popularity of online games, Hsu, lu, (2003) proved the significance of social influence among players on continuance intention to use the game further and also found social influence to be a positive factor contributing towards attitude towards game playing.

Furthermore, Hamari, (2013) found a significant correlation between social influence and attitude towards system use in a gamified environment. Users invite their friends into the gamified platform to compete, make groups and share experiences & resources.

Hamari, (2013) also explained that social Influence is mediated by Network Effects where the onset of new users to the gamified system depends on the quality and number of people already using the platform. We still categorize this phenomenon as social influence as we believe these fits well with Ajzen's original definition. Users are more inclined to join a gamified platform to learn something new if there's an already established user base on the platform. Based on the arguments above, we propose the following hypotheses:

H: Social influence has a positive effect on user's intention of use
H: Social influence has a positive effect on user's Attitude towards system use

Social Interaction refers to the ability of a user to interact with their peers in a connected environment within or outside the application. Not just being able to talk and communicate but also being able to show their progress, achievements, gain of knowledge, levels and being able to see others' progress in the same aforementioned areas in a live updated environment. Previous studies reported that if the platform of any online activity is considered a social place, then it assists players to be comfortable to their peers and induce social relationships (Huang and Hsieh, 2011). It is also suggested that players seem to find a place in a virtual environment with their social relationships on the platform under consideration or a physical environment with the platform as the centre of discussion (Liu and Chang, 2016). It was further proved by Voiskounsky et al. (2004) that a user enjoys a Game when they can enhance their social contacts and interact with fellow players. (Lee and Tsai, 2010)

It was found by Li et al (2015), that the process of using a socially interactive application is highly associated with the virtual social environment. If players receive stimulation through the social interaction during the use of an application, they may have a greater chance of wanting to use that application for a longer period. Hence it can be hypothesized that:

H: Social interaction is positively associated with intention of use

2.2.3 Intrinsic Motivation

Self Determination Theory, first introduced by Edward Deci and Richard Ryan, is currently a popular theory in understanding intrinsic human motivation towards an activity. The theory itself suggests that people are able to become self-determined when their needs for competence, social relatedness and autonomy are fulfilled. It has shown that it can explain both hedonic (e.g., Enjoyment) and utilitarian variables (e.g., reuse).

From Self Determination theory, Intrinsic motivation is defined as the motivation or will to carry out a task that stems from the individual itself without influence of external rewards like money, social status etc (Ryan and Deci, 2000). Stemming from this, Basic psychological needs theory (cognitive evaluation theory, Deci EL, 1975)

explains the causes and factors of intrinsic motivation (Deci and Ryan, 1985; Ryan and Deci, 2000; Ryan and Deci, 2000). It illustrates that systems or experiences and/or tasks that support a person's perception of autonomy, competence and relatedness will contribute a higher intrinsic motivation towards the said task.

Autonomy is described as an internal willingness to do a task without external influence. The feeling of being in control while doing a task and the willingness to continue can be categorized into autonomy. Competence is the feeling of being capable of doing a task and being successful at it. And Lastly, Relatedness is the feeling of being connected to other people who are doing the same task.

The need for autonomy describes one's need to feel in control of their actions. When an individual feels like they may take actions that have a clear impact, and hence hold psychological freedom, it helps them feel more self-determined. When the gamified system controls the player's activities and results, they tend to feel less involved with the system. The user's need for autonomy would only be satisfied when the perceived autonomy provided by the system allows them to engage and attach personal value to it.

The need for competence describes the degree to which one may feel like they have the skills in the task. This would, in turn, compel them to take further action in achieving their goals. In relation to gamified systems, when users feel that their skills or abilities are challenged and in turn feel that they are achieving mastery through use, there tends to be a greater perceived competence.
The need for social relatedness is one's need to experience a sense of belonging or connectedness to other individuals. When the gamified system provides means for users to interact with each other, it promotes the feelings of mutual care and perceived relatedness. This would fulfil the player's need for connectedness, and, consequently, promote determination to continue usage of the system.

CET argues that the feeling of autonomy, competence and relatedness plays a huge role in an individual's intrinsic motivation towards a task and subsequently, these factors affect user's enjoyment. In a gamified educational setting, the experience of winning rewards, accomplishing educational goals, being in control of choosing tasks, and feeling connected & interacting with other users will yield greater intrinsic motivation and subsequently greater enjoyment. Applying this school of thought into a gamified educational scenario, we can deduce that if a gamified system satisfies the experience of Autonomy, Competence, and Relatedness in an individual, it will lead to higher intrinsic motivation and enjoyment towards the system and experience.

Suh, 2015; Suh, Wagner, Liu, 2016 proved the significance of Autonomy, Competence and Relatedness on User Enjoyment in a gamified information system and we believe that it is portable to educational settings as well. Hence, we propose the following:

H: Autonomy will lead to enjoyment in a gamified learning environment.
H: Competence will lead to enjoyment in a gamified learning environment.
H: Relatedness will lead to enjoyment in a gamified learning environment.

2.2.4 Competition

Competition motivates users to display their best performance and strive to be the best at a game. Competitive environments enable greater performance from players (Ryan and Deci, 2000).

Players feel competent after beating other players fairly. After successive wins, players generally feel competent at the game as a whole and strive to be better. Competition is also proposed to increase relatedness of players as it brings them together in the frame of reference of the game and they feel closer due to the shared experience of the difficulty of the game.

Suh, Wagner, (2015) analyzed the significance competition has on competence and relatedness among users of a gamified system and found a positive correlation. Based on this we hypothesize the following, with regards to competition of a gamified system.

H: Competition in a gamified system will introduce the feeling of competence in players/users
H: Competition in the gamified system will positively influence feeling of relatedness among players

2.2.5 Rewards

Rewards refer to the various elements in the app that imply to reward the user- such as points, badges, and achievements. Not just earning these rewards, but the ability to showcase their achievements is also a must have. For this element to be effective, the reward gained must be meaningful to the learner, or otherwise be somewhat difficult to obtain. (Strmečki, Bernik and Radošević, 2015; Enders, 2013).

PLB- Points, Levels and Badges- as a game dynamic hosts significant correlation to rewards, status, and achievement, according to Suh, Wagner, and Liu, 2015. This correlates to our definition of rewards.

They tested PLB against Autonomy, Competence and Relatedness, and found there to be significant relation between PLB and Autonomy and Competence.

This was then further tested in another paper by Suh, Wagner and Liu, 2016, where they directly correlate rewards as a positive influence towards Competence and Autonomy within a gamified IS, determining that rewards were integral to the user's needs satisfaction. According to them, The more rewards a user receives through PLB, the more competent they feel. Rewards also help the user experience autonomy because they signify choice through PLB.

Therefore, as our model aims to understand the same for an online learning system, the following hypothesis can be proposed:

H: Rewards in a gamified system will positively influence the feeling of competence in players
H: Rewards in a gamified system will positively influence the feeling of autonomy in players

2.2.6 Enjoyment

Enjoyment, by Davis et al, 1992 is explained as "the extent to which the activity of using a specific system is perceived to be enjoyable in its own right, apart from any performance consequences resulting from system use". It is the intrinsic pleasure perceived by the user based on their system use. Park et al., 2014 found a significant relationship between enjoyment and continuance intention of use of a social networking game. Furthermore, Alzahrani et al., 2017 found enjoyment to be a highly significant predictor of actual use or actual game playing among undergraduate students. Research has been done in assessing the influence of enjoyment on learning, where Chen & Jang, 2010 found needs satisfaction (drawing from SDT, Autonomy, Competence, and Relatedness) to be an important predictor for various learning outcomes. They looked at 4 learning outcomes: Final Grade, Perceived Learning, Course satisfaction, and Hours spent studying, and found needs satisfaction to be highly influential to all learning outcomes.

In a gamified learning app, actual play and use of the system can be translated as one dimension of learning, which is actual learning. As a user can only progress through the app when a task is completed, and to complete a task, a user must have knowledge of perquisites and a grasp on the topic. Self determination in a gamified learning system can highly influence their learning outcomes, and we propose the following hypotheses for the same.

H: Enjoyment in a gamified learning system can positively influence user's intention of use
H: Enjoyment in a gamified learning system can positively influence learning outcome

2.2.7 Technology Acceptance Model (TAM)

TAM's main premise is based on the idea that a person's attitude toward adopting a new technology is made up of two distinct beliefs: perceived usefulness and perceived ease of use.

Usefulness is described as "the degree to which a person believes that using a particular system would enhance his or her job performance" by the technology acceptance model (Davis, 1989, p.320). In the context of learning outcomes, which may not be synonymous with performance, J. Bourgonjon et al., (2010) proposed another definition: "the degree to which a person believes that using video games in the classroom can offer him or her opportunities for learning".

We describe Intention of use as the perceived want of a user to continue using the system further. Fillipou, Cheong and Cheong, 2018 and more recently, Ashraji, (2020) found significant correlation between the two dimensions but R. Zatarain Cabada et al., (2018) in the context of gamification of a coding course and Hsu and Lu, 2004 in the framework of game playing, found no evidence that perceived usefulness positively affected intention of use or continued intention, but found that it positively affected the student's subsequent attitude towards using the system. Several studies support the positive influence of perceived usefulness on intention of use in non-learning contexts (Bhattacherjee, 2001; Lin, 2015; Oghuma et al., 2016).

Ease of use is described as the degree to which a person believes that using a particular system would be free from effort (Davis, 1989). Van Heijden (2003), who sought to construct a model to investigate factors influencing website usage, suggested that a website's ease of use affects users' perceptions of its utility. The more user-friendly a website is (ease of use), the more useful it is perceived to be.

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TAM primarily serves to imply that the user's attitude towards using new technology is composed of perceived usefulness and ease of use. The study by Hsu and Lu (2003) extended TAM to include the influences of online games in user behaviour. Ashrafi, 2020, explored and proved the same more recently by studying the factors influencing continuance use intention in a learning management system. As supported by previous studies in other contexts, ease of use should positively influence an individual's attitude towards using the system.

Attitude is defined as the overall opinion, favourable or unfavourable, towards the use of a system. (Fishbein and Ajzen, 1975; Davis, 1989). Attitude can be measured after the user has used the system and formed an opinion based on their usage. Continued intention can be condensed as the extent to which an individual intends to use or continues to use the technology to perform a specific behaviour. (Davis, 1989).

Hamari (2013) found that attitude has a strong influence on continued intention of use for a gamified service and in the frame of an e-learning environment, Esteban-Millat et al. (2018) found significant correlation between the two. In the context of online game playing Hsu and Lu (2004) also found attitude to be a good predictor of intention to play the game.

In contrast, Ashrafi et al. (2020) did not find any significant correlation between the two variables. For which they laid out the following reasons: Inability of the LMS to meet the learning expectations or lack of availability of time for the participants to commit to the LMS.

In accordance with the previous literature, we propose the following hypothesis:

H: Attitude towards the gamified learning system will positively influence the user's continued intention to use the system.
H: Perceived Usefulness will have a positive influence on attitude
H: Ease of use is positively correlated with usefulness
H: Ease of Use positively influences user's Attitude towards the system

2.3 Summary

We have extensively reviewed the previous literature in this field regarding different aspects of gamification. While a lot of literature exists regarding this field, not a lot exists with respect to self-learning systems and there is no holistic model that acts as a framework for practitioners to build interactive systems on.

We have hypothesized a lot of possible relationships between phenomena to build our own model to address this gap.

Main core of our literature search and hypothesis building is condensed into 3 parts:

- The review of Flow state and its usefulness. We reviewed its inception and how it connects to enhancing learning experience in gamified systems.
- We also reviewed various social factors that go into motivation building and learning interest. We hypothesized their relationship to various factors thus leading to learning outcome.
- We extensively reviewed literature surrounding intrinsic motivation to learn and how it can be enhanced through gamification. We explored various of its factors and their relationship with flow, continuance intention and learning outcome.

We have also explored the highly validated technology acceptance model which we decided to include in our literature as gamification is a fairly new concept and it is needed, empirically, to validate its acceptance before moving on to higher level exploration.

In summary, We hypothesized our statements based on the relationships we have in the extensive review we had conducted.

3 METHODOLOGY

Based on the various hypotheses argues in the last chapter, we would like to propose our novel structural equation model as shown on *figure 1.*

The hypotheses are structured in the form of a predictive path model. We use the extensively validated method called Structural equation modelling to validate our model. Structural equation modelling is a set of quantitative methods to empirically validate and test relationships between higher dimensional variables and find connections between these. In this study we use a special variant of SEM called PLS-SEM (or widely known as partial least squares path modelling), which is short for 'Partial Least Squares'. The PLS based method has a few advantages, mainly that it is more suited for prediction oriented probes. It is also non-parametric, meaning it makes no prior assumptions about distribution of data. This gives us a chance to explore a wider range of question items and deployments. (Chin et al., 2003).

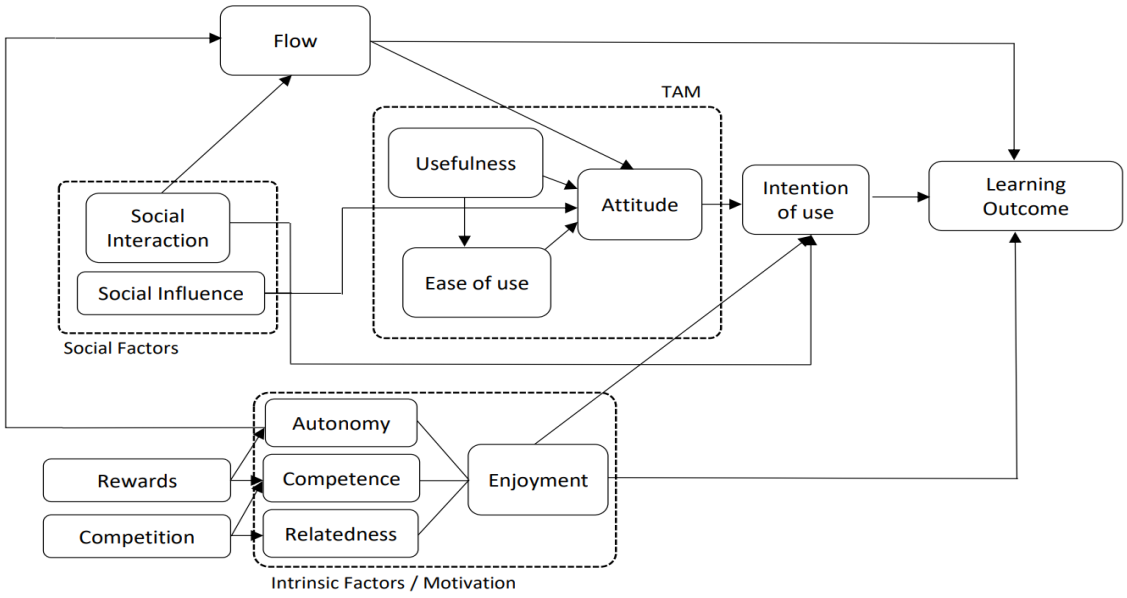

Figure 1. Proposed Structural Model

3.1 Structural Equation Modelling

The term "Structural Equation Modelling" (SEM) refers to a broad range of mathematical modelling techniques that researchers in the sciences, business, and other sectors utilize in both experimental and observational research.

SEM involves the following components:

1. Development of a model: A functional representation of a theoretical or empirical phenomena. Usually the inception of the model stems from observable occurrences/behaviours.
2. A mathematical system of equations that essentially builds a structure of the model. This structure is usually outlined at a higher level by using arrows and blocks to model a 'Path based variable relationship' between different variables taken into account. This is converted into a lower level computational model by using validation and analysis of pilot data.
3. The equations then formed are statistical characteristics which are estimated by mathematical algorithms using observable data.

Path models consist of Latent Variables, which are factors a researcher might want to test the relation for and to compared to other variables. Factor analysis is conducted to determine the validity of variables used to find relationships between these variables. Analysis can either be confirmatory or exploratory in nature where one confirms a pre-existing model and the other explores interesting new relationships between various variables.

We reviewed over 100 papers and shortlisted 40 papers to form our questionnaire of 150 items. We further pruned the questionnaire to bring it down to 40 items with 3 items to each variable. Each question item in the variable is compared to the other 2 using a mathematical similarity method called Composite Reliability. This method looks at the responses given to all these items in a randomized survey to calculate how similar/related these questions are. The scale goals from 0-1 where 0 being least related and 1 being completely the same. This can be calculated as follows:

$$CR = \frac{(\Sigma\lambda_i)^2}{(\Sigma\lambda_i)^2 + (\Sigma\epsilon_i)}$$

in which λ represents the item's (i) standardized factor loading and ε represents the item's corresponding error variance. Based on the value of the standardized loading (λ), the error variance (ε) is calculated as follows:

$$\epsilon_i = 1 - \lambda_i^2$$

λ_i^2 is also denoted as r^2. r-squared value r which ranges from 0-1 indicates the relationship between variables and their dependence. Composite reliability is just the aggregate of R-squared and error variance.

The PLS algorithm has three stages

1. This stage estimates the latent variables and repeats the process till convergence is reached.

Iterative estimation of latent variables and scores.

Start at #4 repeat #1 - #4 till convergence.

#1 Inner weights

$$v_{ji} = \begin{cases} \text{sign cov}(Y_j; Y_i) & \text{if } Y_j \text{ and } Y_i \text{ are adjacent} \\ 0 & \text{otherwise} \end{cases}$$

#2 Inside approximation

$$\tilde{Y}_j := \sum_i v_{ji} Y_i$$

#3 Outer weights; solve for

$$y_{kjn} = \tilde{w}_{k_j} \tilde{Y}_{jn} + e_{k_{jn}} \quad \text{Mode A}$$

$$\tilde{Y}_{jn} = \sum_{k_j} \tilde{w}_{k_j} y_{k_{jn}} + d_{jn} \quad \text{Mode B}$$

#4 Outside approximation

$$Y_{jn} := \sum_{k_j} \tilde{w}_{k_j} y_{k_j n}$$

Figure 2. PLS Algorithm by Lohmöller (1989, p. 29)

2. Estimate weights and Path coefficients of the model
3. Finally, location parameter estimation

3.2 Tools and Methods Used

3.2.1 Tools

- **SmartPLS**: A structural equation modelling software suite to carry out complex calculations based on algorithms shared earlier.
- **Google Forms**: An online forms creation and deployment tool to make it easy for managing questionnaire responses
- **Duolingo**: An online language learning gamified app. It is used as the study prototype and the participants are assumed(required) to complete at least one language module before answering the questionnaire.

3.2.2 Method

As outlined in the earlier section regarding how Structural Equation Modelling studies are conducted and analyzed. We follow a similar approach to be consistent with the literature.

All the related items are validated through this method and predictors are loaded through the PLS-SEM system. We use Smart PLS 3.0 for our analysis of 31 questionnaire responses (40 items).

First, we deploy the responses to a sample of a few (N=5 or N=6) select users. Calculate composite reliability of the question items to reiterate. Next we deploy the validated questionnaire to select participants who attested to have experience using Duolingo.

We collected 31 valid samples and used Smart PLS to run Path analysis of the constructed model. We collected path coefficients of each line that indicate how good of a predictor they are. Each line in the model attests to a hypothesis stated in the above section.

We also have 3 descriptive open ended questions for the study participants to learn more about their thought process.

To analyze this we use Thematic analysis to get a gist of all the open ended responses. (Braun et al., 2012)

We present our findings in the following chapter.

4 ANALYSIS OF RESULTS

This chapter includes the in depth results recorded from all the studies carried out. First we analyze and discuss our results obtained from our study and then move on to the discussion around our results. We outline the significance our results have for the broader community. We conclude by putting our results in perspective of our project and scope.

4.1 Result Analysis

4.1.1 Participant Demographic

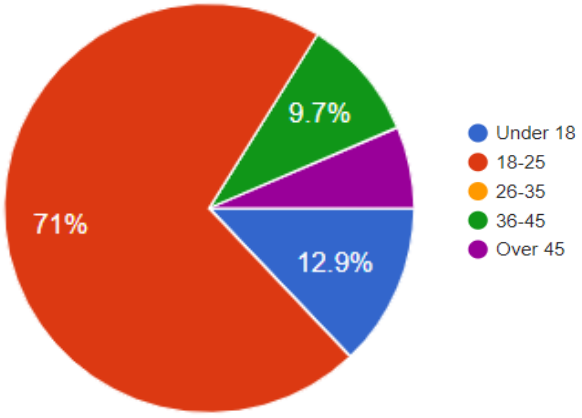

Figure 3. Participant Age Demographic

We asked 31 valid participants experienced in Duolingo to participate in our study and fill out the questionnaire. We are grateful to the users that participated in our study. Our study was primarily a questionnaire with 40 items and a few extra descriptive items.

Most participants (71%) were in the ages between 18 and 25 years of age. Which is considered the youth demographic. 12.9% were under 18 in school and 9.7% were in the ages between 36 and 45. The remaining 6.5% of participants were over 45 years of age.

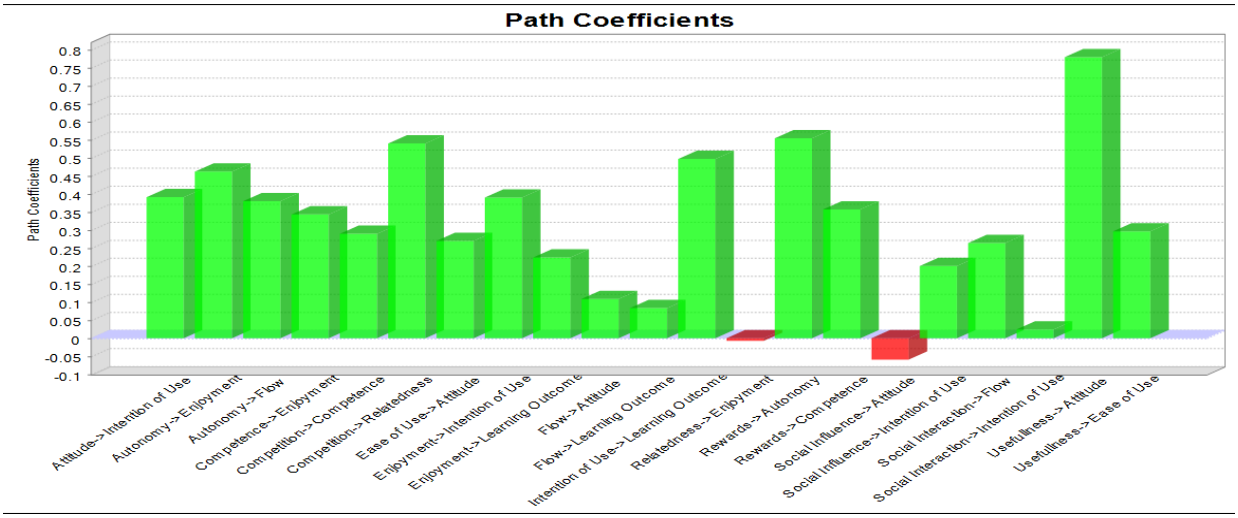

Figure 5. Path predictor coefficients bar chart

Due to the origin of the study and the context of the project (college report), it was difficult to find participants in an equitable balanced age group and demographic. But given the circumstances, all age demographic participants were considered for the study.

All the participants hail from India and are distributed evenly across states. Note that although the participants are from different states, all of them are really fluent in English and use that as their primary language. As we are studying a language learning app, I thought it was important to mention this. Socio-economic background of the participants is middle to upper-middle class indians. All of them have good access to the internet and ubiquitous technologies to use apps like Duolingo.

4.1.2 PLS-SEM Response Analysis

Final PLS-SEM results for 31 participants with 40 item questionnaire are as follows on *figure 4*.

Majority of our hypotheses proved to be significantly true, with the exception of Relatedness with respect to Enjoyment and Social Influence with respect to Attitude. Both of which are negative (negligible) predictors. As they are fairly negligible values, we can safely assume that they don't have any effect on the two respective latent variables mentioned.

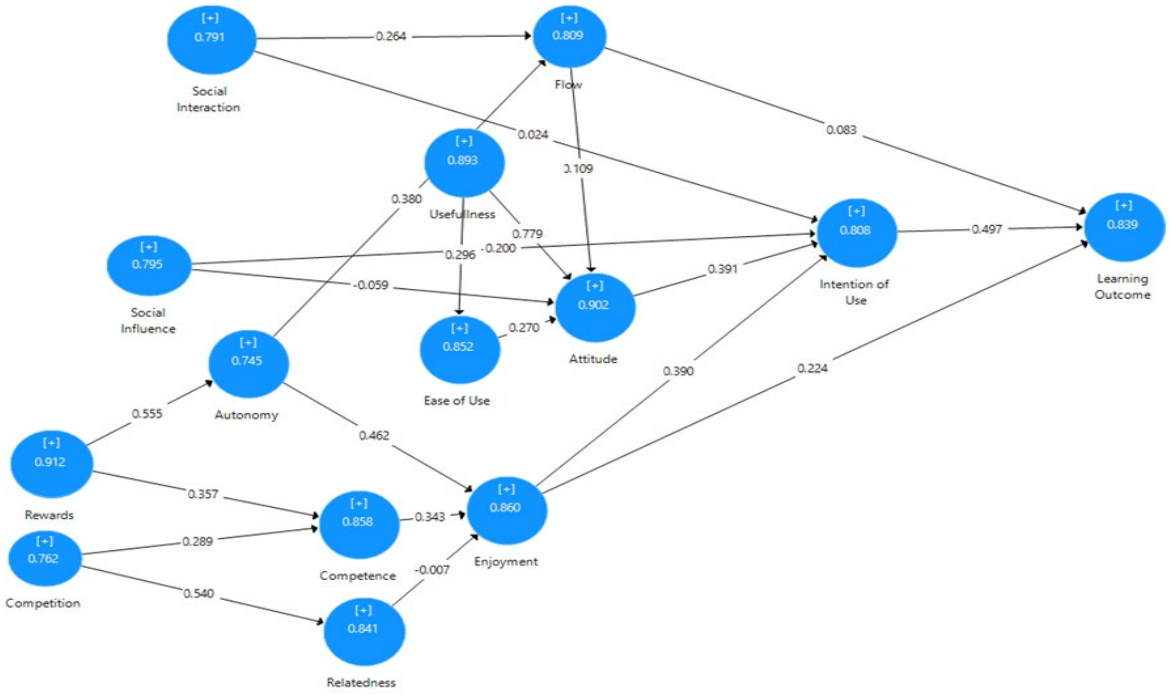

Figure 4. Final Path predictors of the model

We can clearly see the significance of our hypotheses in the bar chart shown in *figure 5*. Most of the model is proven to be a valid predictor of the respective latent variables and ultimately of Learning Outcome.

In the case of reliability of the variable items, we analyzed composite reliability of all the items in the latent variable separately.

From *Figure 6*, we can clearly see that composite reliability of all latent variables used in our model is well above the minimum threshold. This means that our question items for each variable clearly convey and reflect their parent variable group.

	Composite Reliability
Attitude	0.902
Autonomy	0.745
Competence	0.858
Competition	0.762
Ease of Use	0.852
Enjoyment	0.860
Flow	0.809
Intention of Use	0.808
Learning Outcome	0.839
Relatedness	0.841
Rewards	0.912
Social Influence	0.795
Social Interaction	0.791
Usefullness	0.893

Figure 6. Composite Reliability of Latent variables

Based on the statistical results, it is clear that relatedness is not a significant predictor for enjoyment in the context of gamified learning systems. Similarly, social influence is not a predictor for attitude. We have modified our model to reflect the same analysis in Figure 6

4.1.3 Descriptive Question Item Analysis

We also asked participants 3 descriptive questions and thematically abstracted an average answer to them. We present an abstracted representation of their collective answers below:

What do you think are the best features of Duolingo and why?

Participant answers: In brief, participants suggested that the rewards system along with the leaderboards system were the best features in Duolingo as they motivated them to strive for more.

How did you know about Duolingo and why did you start using it?

Participants answered that they knew about Duolingo through either friends who were already using it or through social media ads.

What motivated you to continue using Duolingo and why?

Most participants answered that they were drawn to the ease of learning a whole new language along with the excitement of competing and earning rewards.

4.2 Result Significance

Our results demonstrate that it is possible, empirically, to holistically model a system gamification process pertaining to the user's self learning needs and validate it on a pilot study scale.

Practitioners and researchers can use this model to design their own gamified learning systems. Using this as a guide, they can build their own unique gamified experiences while being assured of its validity.

Other researchers can build on top of this model in other contexts like fitness, productivity and many more fields.

4.3 Result Conclusion

Our results are promising to us, design and system practitioners and other researchers alike. They provide a holistic view of the processes behind a gamified system that targets self learning.

In conclusion, others can use our model to build their own interfaces and systems without worrying about revalidation or experimentation.

Practitioners can use any question items from our questionnaire to verify if specific or complete parts of their systems are working as desired. They can send the question items to their users through feedback forms or users can voluntarily fill it out. It would depend on each practitioner to target and modify our questionnaire available in table 1 to modify it to fit their specific system.

We hope our contribution helps the industry and the amazing academic community surrounding gamification.

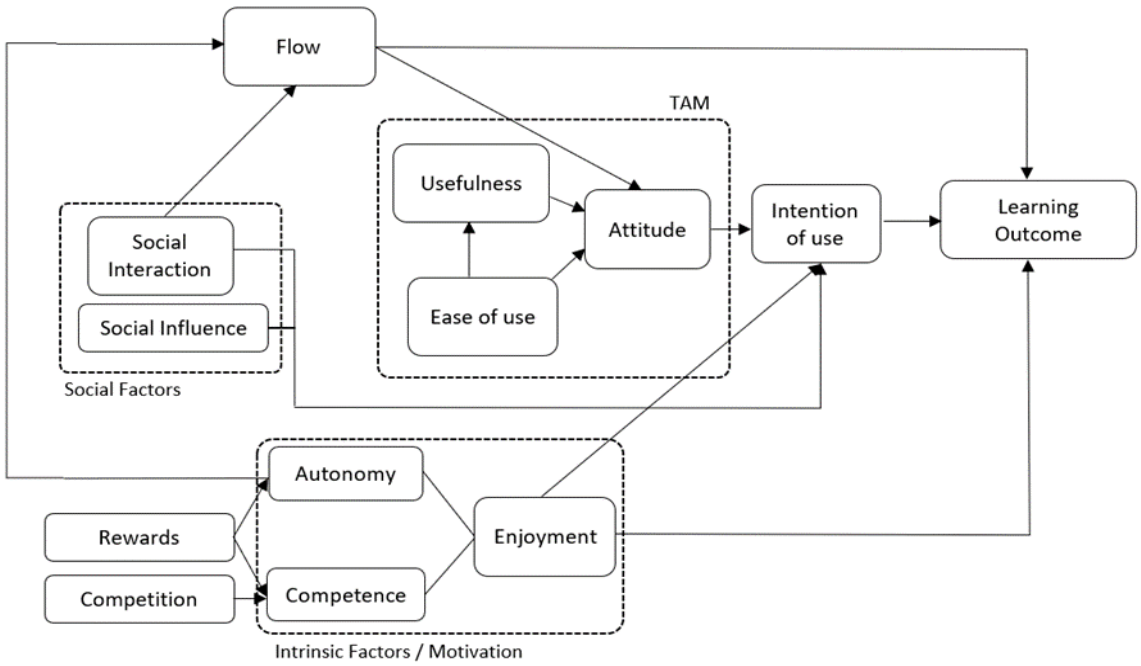

Figure 7. Validated Model

5 CONCLUSION AND FUTURE SCOPE

5.1 Summary

In this project we developed and validated a novel structural equation model of gamification in online user centric self-learning systems that don't rely on an external teacher (just the app/system) to enable students to learn.

5.1.1 Problem Statement

Gamification models for Self-Learning are not extensively evaluated in the existing literature. There are very few structural equation models in the context of online learning and motivational behaviour. We intend to fill this gap and seek to understand how and why users learn or carry out a task without academic incentive and motivation. We propose a structural equation model that extends TAM on three fronts, namely, Social Factors, Intrinsic Motivation and Flow, to understand game dynamics, behaviours, and factors contributing to learning outcomes in systems where the academic incentive is not a primary motivator.

5.1.2 Methodology

The project is carried out in the following parts:

Conducting literature review and scoping the problem

- Reading up on different theories in HCI and Psychology fields regarding online learning systems.
- Framing an arguable problem statement and relevant theories in accordance with the latest literature.

Proposing a novel structural equation model

- Conducting the review of literature for existing models for the problem.
- Conducting analysis of different and relevant theories for the model.
- Proposing a novel model and framing arguments for each of the connections made in the proposed model.

Conducting the study and data analysis

- Form a novel questionnaire in accordance with the testing prototype for the study (A set includes 5 items for each of the variables in the model).
- Conduct a preliminary analysis and validate all the hypotheses in the model.
- Conduct a confirmatory factor analysis and update the proposed structural model in accordance with the data.

5.2 Conclusion and Significance

Our results are very promising to practitioners in the industry and fellow researchers in academia. This provides a holistic view of the processes behind a gamified system that targets self learning in users.

Gamification models related to education/self education are not extensively evaluated in the existing literature. There are very few statistical models in the context of online learning and motivational behaviour. We tackled this gap and presented our understanding of how and why users learn or carry out a task without academic incentive and motivation. We find it to be really significant to industry adopters and academic researchers

5.3 Future Scope and Work

The future scope for this project is as follows:

1. Due to limited time and resources, this project could only conduct a pilot study with 31 participants. A further probing investigation regarding this model can be a possible direction to move forward. More participants (N>200) would lead to a robust and resilient validated model that can be trusted even more.

2. In addition to more sample size, a varied demographic participant pool can be really helpful in testing the model in different demographics and cultures. Different areas respond differently to specific designs and norms. Taking this into account and controlling for that would be a clear next step.

3. This study utilizes a very popular gamified learning app called Duolingo. Building a custom interactive system with control over rules and design paradigms would enable a more in-depth evaluation of the model, including the ability to test specific design changes and norms. This can also enable researchers to test varied designs and how they affect specific parts of the model or how users respond.

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ANNEXURE

Annexure 1. Attached on the next page is the full-length questionnaire we had tested our model with.

Questions							
This questionnaire is directed towards active users of the gamified language learning app, the app. Participants are expected to have completed and learnt at least 1 language set and used social features of the app like leaderboards and community tools from the app. Please tick ✓the box in the set of boxes beside the item that best fits your response. The boxes are scaled from left to right (1-5) with the left most box meaning 'I disagree', right most box meaning 'I agree with the statement', and lastly, the middle box meaning 'neutral to the statement'.							
1. **Rewards**							
REW1	The rewards drive to participate in the activities						
REW2	I will always participate in levels and events that carry a reward						
REW3	I am willing to put in extra effort to receive badges and achievements						
REW4	It is important to me to get as many points and rewards as possible						
REW5	I see having a higher status in the leaderboard as a reward of my efforts						
2. **Competition**							
COM1	It is important for me to know my position compared to others in the leaderboard						
COM2	I always strive to move up the leaderboard						
COM3	I prefer activities that have a score						
COM4	I find it important for the activity to offer new challenges at appropriate places						
COM5	I enjoy activities where I face intense competition						
3. **Social Interaction**							
INT1	I engage in discussions regarding the activities outside the app						
INT2	I find participating in the community discussions mutually helpful						
INT3	I think engaging with the community for any questions is helpful to my learning						
INT4	Helping others learn and use the app improves my relationship with others						
INT5	I find participating in discussions outside the app improves my motivation to use it						
4. **Flow**							
FLO1	When I use the app, I lose track of the world around me						
FLO2	I experience an altered sense of time as I use the app						
FLO3	I am absorbed in my learning experience as I use the app						
FLO4	I find that I often spend my time in the app						
FLO5	I think of other things even as I use the app to learn						
5. Social Relatedness/Influence							

SIN1	Everyone I know uses the app					
SIN2	People around me have discussed using the app for learning a language					
SIN3	People close to me have recommended using the app					
SIN4	I am connected to many people in the app					
SIN5	I have a lot of friends on the app who follow my in-app activities					
6. **Usefulness**						
USE1	Using the app helps me learn a language more quickly					
USE2	Using the app helps me learn a language more efficiently					
USE3	Using the app increases my productivity					
USE4	Using the app enables me to accomplish the learning objectives					
USE5	Using the app is more convenient than traditional learning methods					
7. Attitude						
ATT1	I think that using the app is good for me					
ATT2	I like the idea of learning using the app					
ATT3	Learning a language using the app is more interesting than learning it through traditional classes					
ATT4	Using the app to learn a language is a wise idea					
ATT5	I have a positive opinion of learning a language on the app					
8. Ease of Use						
EOU1	Understanding how to use the app was easy					
EOU2	I find it easy to navigate through the features of the app					
EOU3	It was easy for me to become comfortable and skilled at using the app's features					
EOU4	The user interface of the app was clear and easy to use					
EOU5	It is easy for me to get the information I want through the app					
9. (**Continuance) Intention of Use**						
IOU1	I intend to continue using the app in the future					
IOU2	I predict that I will use the app more frequently rather than less frequently					
IOU3	I will keep using the app as regularly as I do now					
IOU4	My first choice in learning a language will always be the app					

IOU5	The gamified features engage me to continue using the app					
10. Learning Outcome						
LOT1	Using the app increases my knowledge on the language					
LOT2	I can now easily catch the basic concepts of a language I learnt on the app					
LOT3	the app encourages me to integrate with the language taught					
LOT4	I try to apply the concepts taught out of the app					
LOT5	I want to know more about the language taught					
11. Autonomy						
AUT1	While using the app, I felt control over my actions					
AUT2	While using the app, I knew what the next step was					
AUT3	In the app, I have various ways to move forward with my learning experience					
AUT4	The choices I have made in the app have influenced my learning direction					
AUT5	The app does not allow users to comfortably make mistakes					
12. Competence						
CMP1	I think I am pretty good when I use the app					
CMP2	After using the app for a while, I feel pretty competent					
CMP3	I think I do pretty well when using the app compared to other users					
CMP4	I am satisfied with my progress and performance when I use the app					
CMP5	I feel like I am well versed in the language I'm learning when I use the app					
13. Relatedness						
REL1	Using the app is important to make me feel like I belong to a community					
REL2	While using the app, I feel like I can learn with other participants					
REL3	When I use the app, I feel supported by others					
REL4	When I use the app, I feel like I am a valuable person to others					
REL5	I feel really distant from other users of the app					
14. Enjoyment/ Needs Satisfaction						
ENJ1	I like the services offered by the app					
ENJ2	I learned surprising or unexpected things with the gamified teaching method					
ENJ3	Learning a language through the app gave me a satisfying sense of accomplishment					
ENJ4	Compared to other things I could have done, the time I spent on the app was truly enjoyable					
ENJ5	I felt involved with the learning progress and tasks					

1.	What do you think are the best features of the app and why?
1.	What motivates you to continue using the app and why?
1.	What are your suggestions for improving the learning experience through the app?