

Detecting Play and Learning Styles for Adaptive Educational Games

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Abstract: Digital games have emerged as promising tools that aim to make learning more fun. As each person has different learning and play styles, educational games can become more effective should they adapt content delivery according to the user's learning and play styles. To achieve this, models are needed to represent these styles. Several learning and play style models exist today with varying levels of validity and complexity. With the emergence of educational games, the importance of using such models for enhancing the effectiveness of games as viable educational tools increases. However, not many studies have been conducted that simultaneously consider both style groups. We first analysed existing learning and play models. Based on the analysis results, we created a questionnaire that uses Bartle's Player Types model and Honey and Mumford's Learning Style Questionnaire, and tested it with 127 South Korean elementary school children. The results indicated that within the play style model specific styles were clearly more preferred, whereas learning styles were distributed more evenly. There also were some differences between genders. The results can be used to inform us on what sort of stimuli might yield better immersion in educational games and thereby facilitate the learning process.

1 INTRODUCTION

Digital games have risen to new heights as general entertainment to most age groups. They also have expanded beyond their traditional field of leisure, as they have been increasingly utilized as tools to support and provide education (Nygren et al., 2012; Coenen et al., 2013; Popescu et al., 2011), and as catalysts for people do physical exercise (Morelli et al., 2011; Macvean and Robertson, 2012). These types of games that have other purpose than pure entertainment, are generally referred to as serious games. Within the umbrella of serious games, game-based learning in particular is a heavily trodden research field. It has been shown that utilizing games in education can yield positive results in learning and motivation (Connolly et al., 2012; Popescu et al., 2011; Coenen et al., 2013; Arnab et al., 2013; Nygren et al., 2012; Kim et al., 2009; Ke and Grabowski, 2007).

While researching education and especially learning, it is not uncommon to come across different learning style models and discussions for and against them. Researchers have proposed several models for mapping out various learning styles with the purpose of understanding the differences among heterogeneous learners and thereby optimizing the learning experience for each learning style. Popular learn-

ing styles include Kolb's Learning Style Inventory (LSI) (Kolb, 1984), Honey and Mumford's Learning Style Questionnaire (LSQ) (Honey and Mumford, 1982), and Felder and Silverman's Learning Style Model Felder1988.

There are several game genres – ranging from first person shooters (FPS) to a large scale country governing simulations, and from role-playing games to sport games – that cater for and expect vastly different play styles. For example, a majority of FPS games expect a combination of aggressiveness and cunning, whereas a typical role-playing game might want the player to have more of a strategic mindset. Perhaps due to the youth of the gaming research field, there are not many validated play style models that tackle the heterogeneity in player population. Examples of models that are dedicated to categorize play styles are: Bartle's Player Types (BPT) (Bartle, 2015), Bateman's Demographic Game Design (DGD1, DGD2) (Bateman and Boon, 2005), and Lazzaro's Four Keys (4K) (Gomez et al., 2004). In addition, personality models have also been suggested for identifying different player types, such as Keirseley Temperament Sorter (KTS) (Keirseley and Bates, 1984).

The reasoning for adapting educational games to cater for both play and learning styles of a person is threefold. Firstly, adaptive educational games could

offer learning materials to the person in a way that the person would be more attuned to receiving and processing. Secondly, by offering a play style more suitable for the person, the game mechanics would be easier to understand and thus cut down the learning curve at the beginning. Thirdly, a well-aligned play and learning styles, through which learning materials are provided, could increase the person's motivation to continue playing the game and increase the possibility for the person to enter the flow state (Mirvis, 1991).

This work is part of a three-year (2015-2018) Korean National Research Foundation project, which aims at developing a learner-aware adaptation framework for developing games for programming education. In this paper, we present the results of multiple research activities that contribute towards the project's goals. Firstly, we review existing models for learning and play styles. Secondly, based on the review, we select one learning style model and one play style model, and develop a questionnaire for identifying a child's play and learning styles. Thirdly, we present an analysis of data that were collected from 127 South Korean elementary school students using the questionnaire. The purpose of this study is to see how learning and play styles manifest themselves in a sample population of South Korean elementary school students.

2 BACKGROUND

2.1 Game-based Learning

As we briefly stated above, using games to convey educational content has shown positive results in multiple areas. Connolly et al. (Connolly et al., 2012) conducted a systematic literature review on 129 papers of which 82 presented educational games in a range of fields such as business, engineering, geography, health, history, language and mathematics. The authors discovered that many of the reviewed papers reported that students enjoyed a game-based approach and found it motivating. They also mentioned that the diversity of research on positive impacts and outcomes associated with playing digital games was noteworthy.

As shown in Connolly et al's survey and several other studies (Garris et al., 2002; Eastern, 2009; Bostan, 2009; Nygren et al., 2012), using games to convey educational content shows clear results when it comes to raising people's motivation. However, an educational game that does not respond well to players' learning and play styles might damage motivation

and therefore negatively affect the learning experience. Moreover, as educational games' main focus is to educate the player on selected topics through gameplay, it is important to select appropriate pedagogical methods, game mechanics and content modalities to support the player's personal play and learning styles.

Several studies have been conducted in the field of game research that focus on either play style (McMahon et al., 2012; Orji et al., 2014) or learning style (Koops and Hoevenaar, 2012; Bontchev and Vassileva, 2011). We were, however, unable to find many studies that would consider both styles simultaneously. Finally, many models have been proposed to organize various play and learning styles. Thus, in the following sections we describe and compare the most well-known and well-tested models to see how they differ from one another.

2.2 Learning Styles

Learning styles have been researched by scholars for decades. In the following, we present three popular learning style models.

2.2.1 Kolb's Learning Style Inventory

One of the best known learning style models was created by Kolb, who published his Learning Style Inventory (LSI) in 1984 (Kolb, 1984). In his model, Kolb defined four distinct learning styles as follows:

- Accommodator (CE / AE): Prefers practical hands-on approach to problems.
- Converger (AC / AE): Prefers hands-on approach to applying theories.
- Diverger (CE / RO): Prefers discussing and thinking the problem through.
- Assimilator (AC / RO): Prefers reasoning and theoretical approach.

Kolb's learning styles are based on the four-stage learning cycle, which consists of: Concrete Experience (CE), Reflective Observation (RO), Abstract Conceptualization (AC) and Active Experimentation (AE). Essentially, the four learning styles are combinations of these four stages. For instance, Accommodator is a combination of Concrete Experience and Active Experimentation (Kolb, 1984). Since its emergence, LSI has been developed further with the latest iteration specifications having been published in 2005 (Kolb and Kolb, 2005).

2.2.2 Honey and Mumford Learning Style Questionnaire

Honey and Mumford (Honey and Mumford, 1982) built their Learning Style Questionnaire (LSQ) on top of Kolb's LSI. Their purpose was to use the model in the context of management of workspaces. Honey and Mumford redefined LSI's four learner types as:

- **Activist:** Learns by doing; prefers a practical approach.
- **Theorist:** Learns by an analytical approach; needs to understand the theory first.
- **Pragmatist:** Needs to see a connection between the theory and task at hand; prefers applying theory in real life.
- **Reflector:** An observer who does not directly interact, but rather collects data from multiple sources.

Honey and Mumford's model has a four-stage cyclical form with the following stages: (i) Having an experience, (ii) Reviewing the experience, (iii) Concluding from the experience, and (iv) Planning the next steps. Their model suggests that different people are more attuned to different stages, thus individual learning processes should be adapted accordingly.

2.2.3 Felder-Silverman Learning Styles Model

Originally aimed specifically at engineering students, Felder-Silverman Learning Styles Model was created by Felder and Silverman (Kapadia, 2008) and later improved upon by Felder and Soloman, who used the model to derive a questionnaire instrument named as the Index of Learning Styles (ILS) (Oxford, 2003; Felder and Spurlin, 2005). The model maps the learners into four dimensions: (i) Active and Reflective, (ii) Sensing and Intuitive, (iii) Visual and Verbal, and (iv) Sequential and Global. The extremes of these dimensions are defined as:

- **Active learner:** Hands on approach, discussing about the project. Likes group work.
- **Reflective learner:** Thinks about the problem quietly at first. Prefers working alone.
- **Sensory learner:** Likes to learn facts. Enjoys solving problems with well established methods.
- **Intuitive learner:** Enjoys discovering connections between the problems.
- **Visual learner:** Remembers best anything that they have seen, such as images, flow charts, diagrams.

- **Verbal learner:** Gets more out of words, both written and spoken.
- **Sequential learner:** Approaches a problem in a stepwise manner, solving one subproblem at a time.
- **Global learner:** Move forward in large jumps, absorbing materials in a seemingly random manner.

It is worth noting that "Verbal" was "Auditory" in the original model, and the term "Verbal" was proposed by Felder and Solomon in ILS (Oxford, 2003; Felder and Spurlin, 2005). Furthermore, within one dimension, such as Active-Reflective, a person may converge towards one of the extremes or diverge away from both extremes.

2.3 Play Styles

Compared to learning styles, play styles for games is a much less researched area. In the following section, we describe three play style models and one personality model, which have been used in game studies.

2.3.1 Bartle's Player Types

Perhaps the best known play style model was described by Bartle in his paper "Hearts, Clubs, Diamonds, Spades: Players who suit MUDs" (Bartle, 2015). The Bartle's Player Types (BPT) model was originally created for multiplayer games, from where the term MUD (Multi-User Dungeon) has been derived. Since its emergence, the model has been cited often in game-related studies across game genres. The BPT model defines four player types as Killers, Achievers, Explorers and Socializers. These four player types are distributed in the corners of a two-dimensional space where the X-axis represents Player vs. World and the Y-axis denotes Acting vs. Interacting. The characteristics of the four types are:

- **Killers:** Aggressive predators of other players who get their enjoyment from harassing other players. To some extent they do socialize with other Killers, explore the game and gather resources, but these are only means to an end. Also being in control and dominating the game are appealing to Killers.
- **Achievers:** Solely focused on beating the game as perfectly as possible. In a multiplayer game this typically means gathering resources and level-ups, whereas in a single player game the focus would be to clear every achievement and the game perfectly.

- Explorers: Interested in mapping the game mechanics inside and outside. Inside means discovering every corner of the game and outside refers to utilizing possible bugs that might give benefits to the player.
- Socializers: Are into the game nearly solely to use it as a communication forum to connect and talk with other people. The other game mechanics represent merely a backdrop to achieve this.

Despite originally creating the model for researching and mapping socio-centric behaviour of players in multiplayer games, Bartle's model can also, with ease, be used to map the dominant play style of an individual playing a single player game. This view is supported by the emergence of newer models that are very similar to Bartle's model, such as DGD1 and Four Keys. These models will be discussed in greater depth on the following sections.

While Bartle did not create a questionnaire for his model, the Bartle Test was proposed by Andreassen and Downey (Andersen and Downey, 2001). The Bartle Test is based on binary choice questions following the style "I would rather do this or that", and it has gained significant popularity as a play style mapping tool within the gaming community.

2.3.2 Demographic Game Design Model (DGD1 and DGD2)

The first Demographic Game Design Model (DGD1) was revealed in the book "21st-Century Game Design" by Bateman and Boon (Bateman and Boon, 2005). DGD1 comprises four player styles:

- Wanderer: Associated with experience and identity. They enjoy new experiences and discovering the game area or story elements rather than challenging gameplay, which they tolerate in order to advance in the game.
- Conqueror: Aim to defeat the games they play. They enjoy challenges introduced by the game and the pay off when overcoming those challenges.
- Manager: Aim to master the game and understand its gameplay mechanics. They do not care much about winning the game, but rather to reach point where there is nothing new to learn.
- Participant: Associated with immersing themselves into a game world mainly through social interaction with other players or with game characters. Any game that gives emotional feedback (good or bad) appeals to this player type.

The DGD1 model is dependant on the Myers-Briggs Type Indicator that has 16 different personality types,

which, in turn, are different combinations of 8 core types: Extraversion/Introversion, Sensing/Intuition, Thinking/Feeling, Judging/Perceiving (Myers, 1962).

The DGD1 model was developed further into DGD2, which aimed at improving upon DGD1 (Bateman et al., 2011). Furthermore, the Brain Hex model has been proposed that combines the two older DGD models and adds new types to them (Seeker, Survivor, Daredevil and Mastermind) while discarding the Manager type (Nacke et al., 2014).

2.3.3 Keirsey Temperament Sorter

In their book "Please understand me" (Keirsey and Bates, 1984), Keirsey and Bates proposed the Keirsey Temperament Sorter (KTS), a personality questionnaire for identifying temperaments. This widely used personality mapper is quite similar to Myers-Briggs Type Indicator (Myers, 1962), but they have some differences. KST defines four temperaments as:

- Artisan: Very practical who like working with their hands. They are adventurous in the nature and always looking for new challenges.
- Guardian: Social persons who are serious about their duties and responsibilities. They believe in following the rules and cooperating with others.
- Rational: Tend to be pragmatic and focus on problem solving. They also have insatiable hunger to accomplish their goals and work tirelessly on any project that they are focused on.
- Idealist: Believe that friendly cooperation is the best way to achieve one's goals. They shy away from conflicts as these upset them.

"Please Understand Me II" (Keirsey and Bates, 1998) placed these temperaments into a two-dimensional space akin to Bartle's model. The X-axis represents Internals versus Externals and the Y-Axis comprises Change versus Structure.

It is important to note that KST was not designed to be a play style model, but rather to map out observable personality traits. Therefore, it can help game researchers understand the player's personality, which has a direct influence on their play style. Following this train of thought, KST could also be placed under the category of learning styles because it can be used to understand the personality traits of heterogeneous learners.

2.3.4 Four Keys

Lazzaro published her Four Keys (4K) model in a conference paper "Why We Play Games: Four Keys to More Emotion without Story" (Gomez et al., 2004)

in which she discussed the emotions created by gameplay. The 4K model's approach to mapping players is through different emotions that games may evoke in them:

- **Hard Fun:** Competitive and playing to beat the game that also requires strategy.
- **Easy Fun:** Exploration and wanting to figure the game out.
- **Altered States:** Game is a tool to pass time, to clear thoughts, or to change one's mental state.
- **The People Factor:** Play the game to socialize and spend time with friends. Game itself is not important.

3 EVALUATION

As we have shown above, there are several learning and play style models which could be used for making educational games more adaptive. In this section, we present an evaluation of play and learning styles among South Korean elementary school students. Before presenting the results, we explain the details of research design, including the formation of a questionnaire.

3.1 Research Design

3.1.1 Participants

The test group consisted of 127 South Korean elementary school students of whom 33 were from the 3th grade (10 years old) and remaining 94 were from the 5th grade (12 years old). The ages follow the Korean age reckoning system where a person is one year old at the time of birth. The test group had a nearly equal gender distribution with one undisclosed, 61 females and 65 males.

3.1.2 Instrument Development

The questionnaire, based on the models proposed by Honey and Mumford (LSQ) and Bartle (BPT), was first created in English and later translated to Korean. A teacher from the target school helped in validating the questionnaire in two ways. First, she confirmed the clarity of the questions in English format. Second, after translation of the questionnaire to Korean, she validated the question to ensure that the language used was appropriate to the target population's comprehension ability.

Honey and Mumford's learning style model was chosen over Kolb's model mainly due to having simpler terms describing the four styles. The comparison conducted by Coffield et al. (Coffield et al., 2004) indicated the two models to be standing on a very equal footing.

Bartle's Player Types model was chosen mainly due to the lack of validated competing models and also to avoid unnecessary complexity that would ensue from using models that define play styles overly detailed, such as the Brain Hex model, that has seven styles in total (Nacke et al., 2014). Despite having originally been intended mainly as a tool for analysing socio-centric interaction of different people within multiplayer games, Bartle's player types can with relative ease be used to define play styles within single player games, as was shown in section 2.3.1.

It should be noted that our questionnaire does not expect everyone to play games, but if someone plays even irregularly, they will naturally adopt a certain play style. It is to be expected that a player's play style might vary depending on his or her's familiarity with the game being played.

After a demographics section, the questionnaire is divided into three portions. The first portion is meant to find out about the gaming habits of the respondents, including how much they play games, their preferred game genres, and their favourite game titles. The purpose of this portion is to get an overview of the landscape of digital gaming among South Korean elementary school students.

The second portion focuses on identifying play styles of the respondents. It is based on the aforementioned Bartle Test. We transformed the Bartle Test's binary choice questions into four-point Likert scale ("Strongly Agree", "Somewhat Agree", "Somewhat Disagree", "Strongly Disagree") to allow greater flexibility and depth for answering and data analysis. Furthermore, as the test group consisted of elementary school students, we simplified the questions in order to decrease the chances of misunderstanding the questions or simply not understanding them at all. Another reason why rewording the questions was necessary was due to the Bartle Test's original purpose of being used by multiplayer gamers, whereas our questionnaire did not make any assumptions of the types of games the respondent might like to play.

The third portion of the questionnaire focuses on mapping learning styles of the respondents. It is a shorter version of the original Honey and Mumford Learning Style Questionnaire with simplified language. We applied Likert scale statements instead of yes/no statements, which were originally used to determine a dominant learning style. Rewording the

questions was necessary so as to make the statements, which were originally aimed at adults, easier for children to understand. This rewording, however, was done carefully so as to retain the original meanings of the claims used by Honey and Mumford in their questionnaire.

Our questionnaire contains 16 questions per model, with 4 dedicated for each style. The original Bartle's Test has 41 questions and the number of questions in LSQ is 40 or 80 depending on the version. Both original questionnaires were deemed to be too long because children are known to have short attention spans (Abadzi, 2008).

3.1.3 Data Collection and Preprocessing

After receiving appropriate permissions to conduct an experiment at a South Korean public elementary school, the questionnaire was distributed to students in four classes with the aid of teachers who briefly explained the purpose of the questionnaire to their students. The students were encouraged to ask questions should they find any question difficult to understand. The teachers remained in the classrooms for the duration of filling in the questionnaire in order to answer any questions raised by the students.

The questionnaire data consisted of 127 responses, which were pruned down to 100 (46 Females, 53 Males, 1 undisclosed) for play style and learn style analyses. Pruning was done by disregarding questionnaires that were not properly filled, that is multiple blank answers or "Strongly Disagree" or "Strongly Agree" in all statements. For play time analysis, we were able to use the entire data set.

3.2 Results

The following sections present the results of the questionnaire data analysis. After describing the play time analysis, we show the results on how the play and learning styles manifested themselves among the respondents.

3.2.1 Play time

In the gaming habits portion of the questionnaire, we investigated how much the respondents spend time playing video games. Figure 1 illustrates the respondents' estimations of their video game playing time within a scale of 1-6 where 1 depicts daily playing and 6 indicates never playing. Mean (μ) and standard deviation (σ) values are also reported. Answers within the range of 1 to 3 can be considered regular to semi-regular playing and 4-6 to be from irregular to very rarely or never. Out of all respondents there

were clearly more males who played games regularly, with 52 out of total of 65 answering between 1 to 3, whereas among females the difference was practically 50/50 as 30 out of 61 answered between 1 to 3.

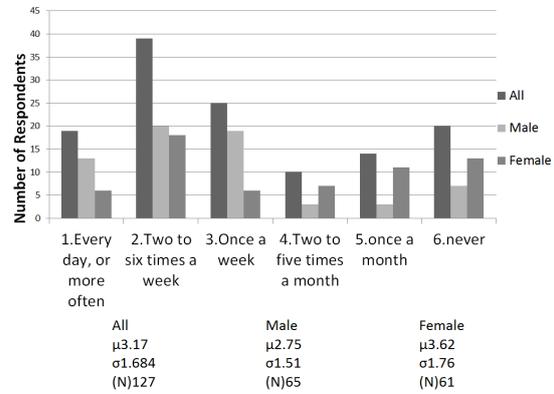


Figure 1: How regularly do respondents play video games.

3.2.2 Play Styles

The length of the play style portion of the questionnaire was 16 statements in total. It was divided into four sections based on Bartle's play styles: Killer, Achiever, Explorer and Socializer. There was no option given to skip any of the statements separately, but if the respondent stated that they do not play games at all, they could jump directly to the learning style portion of the questionnaire.

In order to identify a dominant play style for each of the respondents, we used a point system in which we assigned 1, 0.5, -0.5 and -1 points for answers of Strongly Agree, Somewhat Agree, Somewhat Disagree and Strongly Disagree, respectively. The points in each style category were then added up, and the style with the highest points was designated as the respondent's dominant play style. This was done so as to see which style would be the strongest style for each respondent. If there were two or more equally strong styles, all of them were included in the total counts. A possible secondary style can also be identified through the point system. Figure 2 shows a histogram of dominant play styles of the respondents. Socializer

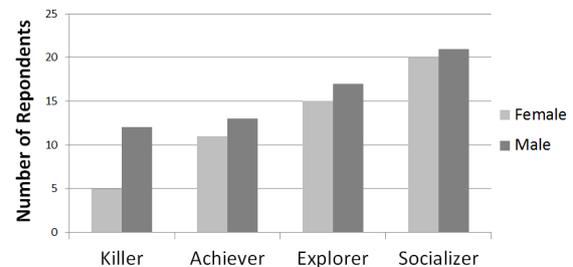


Figure 2: Distribution of dominant play styles.

was clearly the most common play style, followed by Explorer. Interestingly, only five Killers were identified among females, whereas the number of Killers was more than twice of that among males. Nevertheless, Killer was the least common style. This result is exemplified by the Killer style statement “I enjoy teasing other players in a multiplayer game”, which was rejected by 72% and 89% of males and females, respectively.

3.2.3 Learning Styles

Similarly to the play style portion of the questionnaire, the learning style portion also consisted of 16 statements, four for each learning style in LSQ: Activist, Reflector, Theorist and Pragmatist. We identified the dominant learning styles using the same point system than what was applied to the play styles above. Figure 3 illustrates the distribution of dominant learning styles. Activist and Reflector styles are clearly more common compared to Pragmatist and the least popular Theorist. Moreover, the results indicate that males are more practical and active than females, whereas females tend to prefer theories and contemplation than compared to males.

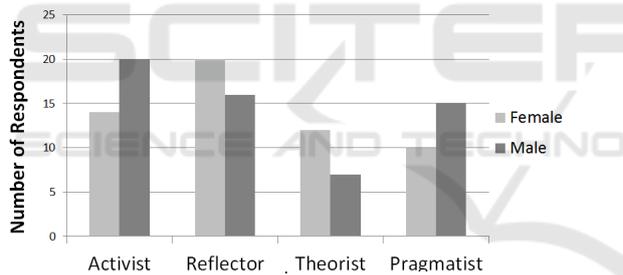


Figure 3: Distribution of dominant learning styles.

4 DISCUSSION

The evaluation presented above sheds some light to the play and learning styles among South Korean elementary school students. The results were as we expected in the sense that the respondents did not have a single very strong learning and play style while other styles would have been marginal. Instead, most respondents had several fairly strong styles. A consequence to this is that an adaptive educational game does not necessarily have to follow strictly one learning/play style combination throughout the game, but it can alternate between multiple strong styles that were identified for a given player. This allows us to create versatile adaptive games that could change even between repeated game sessions.

Finding the underlying reasons for highly negative answers to the Killer statement “I enjoy teasing other players in a multiplayer game” requires further studies, but we have initial ideas to investigate upon. On one hand, it is reasonable to assume that some of the students might have felt the need to mask their negative behaviour. On the other hand, a third grade teacher commented that her students are particularly eager to help each other, thus indicating altruistic mindsets, which is clearly against what the Killer style represents. It would be interesting to conduct a future study to see whether the results would be similar with older students who are likely to consume more “killer” games, such as first-person shooters.

The popularity of the Socializer style can be partially explained by the collective Korean culture and the general tendency for children to like to play games together. As for the Explorer style, its popularity is possibly to have influenced by the natural curiosity of children. To draw any relevant conclusions on what caused these two styles to be the most common dominant styles would require additional research within the same age group and also among older learners.

Currently, the questionnaire is aimed at elementary school children, which is why we limited the number of questions to four per learning/play style. On one hand, using a low number of questions bears some disadvantages, such as suboptimal accuracy and lack internal consistency validation. On the other hand, the time taken for filling in a concise questionnaire is less likely to exceed the children’s attention span. If the questionnaire would be aimed at teenagers or adults, it could be reasonable to include more questions to get a greater amount of data for analysis, hence increasing the accuracy and enabling thorough internal consistency validation. However, if the questionnaire is to be used within a game, then a lengthy questionnaire might severely damage the gameplay experience.

The lack of validation for reliability and internal consistency is certainly something that we must consider in the future evolutions of the questionnaire. Reliability metrics, such as Cronbach Alpha, can only be performed on data set having statements that measure the same property. In its current form, our questionnaire is minimized so that the statements for any given style are measuring different properties related to that style. However, since we based our questionnaire on previously tested models, it is reasonable to assume that the chosen questions, albeit simplified for the use of children, also have a sufficient degree of reliability.

In the Evaluation section, we were able to sufficiently map the students within learning and play style models, thus enabling us to tell what kind of

stimuli might enhance the respondents' immersion and therefore increase the likelihood for a higher degree of learning. In the next step of this research project, we envision using what we learned here for making an adaptive educational game prototype and evaluate it with elementary school children. Essentially, for such an adaptive game to use learning and play style models in an effective way, it should present a questionnaire at the beginning of the game, make calculations to deduce the learner and play styles for the player, and utilize the identified styles to adapt the gameplay and the game content. The questionnaire could be disguised in form of a character building dialogue in order to connect it closely to the game world. It would be even better if the game could be done in such a way that it would automatically learn about the play and learning styles as the player plays the game, and consequently generate the game area and educational content to match what it infers to be the best options for the player. Doing so, the game would not lose its initial fun factor as the player would not have to go through a questionnaire at the beginning.

Making a game as we envisioned above would require a lot of attention on gameplay elements, such as the type of gameplay (e.g., asymmetric, emergent, cooperative), and the modes that can be played (e.g., isometric, first-person). Another great challenge is to cater for various learning styles by presenting educational content in different ways. Finally, some play and learning styles require the game to offer a multi-player option to some extent.

Our questionnaire is based on two well-known learning and play style models, which have been used and validated by scholars across disciplines. Despite this and a lot of work invested in ensuring that the questionnaire was as clearly worded as possible to be suitable for elementary school children, it was evident from the feedback that a few of the respondents did not fully understand all of the questions. We intend to further enhance the questionnaire in order to ensure its full comprehensibility among the target audience.

As this was our first iteration of the combined questionnaire, we wanted to keep the number of styles as low and as clear as possible. In the future we may consider further modifications to the questionnaire such as adding more play styles from models such as Brain Hex (Nacke et al., 2014). Furthermore, once we have a working game prototype, taking into consideration additional factors such as the Self-Determination Theory (Ryan and Deci, 2000) would be relevant.

5 CONCLUSIONS

In this study we crafted a questionnaire to map out elementary school students' play and learning styles in order to make more adaptive educational games. After analysing and comparing popular learning and play style models, we decided to use Bartle's Player Types questionnaire and Honey and Mumford's Learning Style Questionnaire. Both of these questionnaires were modified to use Likert scale statements and language used was first simplified and then translated to Korean. The data collected with the questionnaire showed us the distribution of learning and play styles among South Korean elementary school students.

Our questionnaire is significant because until now most of the previous learning style and play style mapping instruments were created for older respondents and the two style groups were rarely combined. While the questionnaire yielded results that are useful for understanding the types of learners and players in South Korea, we intend to perform further studies in other countries such as Finland so as to compare the results between cultures. Moreover, in order to understand the interplay among learning styles and play styles, a study on the intra-model and inter-model relationships is needed.

The next research step is to first map out possible relationships between the two style models from the gathered data. Simultaneously, we will start making a prototype game for programming education that will utilize these findings. This will require tackling important design issues such as how to create an educational game that caters for different learning and play styles.

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