



Making work fun: Investigating antecedents of perceived enjoyment in human computation games for information sharing



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ABSTRACT

The advent of online games, crowdsourcing, and user-generated content has led to the emergence of a new paradigm called the Human Computation Games (HCGs) which utilize games as a motivator to encourage users' participation in human computation. HCGs are different from games for pure entertainment which emphasize play and fun, rather than output generation. Therefore, research has yet to fully explore the factors underlying players' perception of HCG enjoyment. In this paper, we study the influence of motivational needs satisfaction and perceived output quality on perceived HCG enjoyment using a survey ($N = 205$) of a location-based information sharing HCG called *SPLASH*, developed as part of our research. According to the results, perceived needs for autonomy, competence, and relatedness influence perceived enjoyment of HCGs, suggesting that HCGs that fulfill these three needs are more likely to be enjoyable, thereby encouraging players to make useful computations. The results also show that participants who perceive higher levels output relevancy report a greater level of enjoyment, indicating that HCGs that assist players in generating relevant outputs are more likely to be perceived as enjoyable.

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1. Introduction

Human computation harnesses human intelligence to solve computational problems which are beyond the power of computer programs, but are performed well by humans (von Ahn & Dabbish, 2008). One such example is in the area of image labeling in which human users can easily create textual descriptions for them, while computer programs have yet to achieve the same level of performance. Human computation systems (HCSs) are traditionally operated by hiring human experts or asking volunteers to address computational problems. However, such approaches have two key drawbacks: costliness and a dependence on individuals' willingness to devote their time and effort (Yuen, Chen, & King, 2009). The growing popularity of social computing makes it easier for HCSs to harvest the brain power of online users. However, HCSs which lack motivational appeal to participants are still likely to result in insufficient participation (Doan, Ramakrishnan, & Halevy, 2011). Therefore, motivational mechanisms relevant to human computation contexts need to be examined.

Recently, utilizing the power of games to promote engagement and productivity has become a popular way of addressing real-world problems (de-Marcos, Domínguez, Saenz-de-Navarrete, & Pagés, 2014). This idea is grounded in the fact that games have become an integral part of daily life. According to the latest statistic reported by Entertainment Software Association (ESA, 2014), 59% of Americans play video games. Therefore, piggybacking computational tasks on games has a great potential to broaden user participation. Consequently, a novel paradigm called the Human Computation Games (HCGs) has emerged where users contribute their brain power to a given endeavor through enjoyable gameplay (Goh & Lee, 2011). In essence, HCGs are built upon individuals' desire to be entertained to generate useful computations as a by-product of gameplay (Goh, Ang, Lee, & Chua, 2011; Ho, Chang, Lee, Hsu, & Chen, 2009).

The past decade has seen an interest in the design and development of HCGs in various domain areas. The ESP Game (von Ahn & Dabbish, 2004) is one of the earlier examples, which aims to address the image-labeling problem. In this game, players are randomly paired with another player online, and tasked to generate labels for given images. Players were found to spend several hours on this game, thereby generating millions labels for images (Law & von Ahn, 2009). Consequently, other HCGs have been developed, attempting to address computational problems in areas such as music annotation, image tagging, ontology construction, protein folding, and even location-based information sharing

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(e.g., Barrington, O'Malley, Turnbull, & Lanckriet, 2009; Casey, Kirman, & Rowland, 2007; Cooper et al., 2010; Ho et al., 2009; Krause, Takhtamyshva, Wittstock, & Malaka, 2010). Nowadays, the concept of using games to promote user participation has been applied in several domain areas attempting to produce useful computations.

Although HCG play yields benefits, research has not fully explored individuals' perceptions toward such games. Much research on HCGs has paid attention toward design and implementation perspectives, output quality and performance differences across game genres, and gratifications derived from such games (Goh & Lee, 2011; Goh, Lee, Chua, Razikin, & Tan, 2011; Goh, Ang et al., 2011; Law & von Ahn, 2009). On the other hand, previous research on games for pure entertainment have examined players' enjoyment, and found its direct effect on individuals' attitudes toward such games (e.g. Hsu & Lu, 2007; Wu & Liu, 2007). Furthermore, enjoyment is considered to be a critical factor for task-oriented applications such as online shopping (Ahn, Ryu, & Han, 2007). As HCGs intend to yield valuable outputs while being entertained, enjoyment might be central to the success of such games. Consequently, it is important to examine how individuals derive enjoyment in HCGs to enhance their engagement, thereby offering a more enjoyable experience to them.

Individuals' enjoyment was found to be driven by the fulfillment of motivational needs in prior research on entertainment-oriented applications such as games (Bostan, 2009; Ryan, Rigby, & Przybylski, 2006), and task-oriented applications (Kim & Han, 2009). Additionally, enjoyment was found to be influenced by users' perceived quality of outputs in task-oriented contexts such as e-health and online travel information search (Chen, Shang, & Li, 2014; Hwang & Kim, 2007). As HCGs are entertainment-oriented applications in which computational tasks are embedded, motivational needs and output quality may be relevant to HCG enjoyment. However, HCGs are different from games for pure entertainment which are generally considered autotelic or intrinsically motivated (Koivisto & Hamari, 2014). Likewise, HCGs are not identical to task-oriented applications which provide instrumental value to users by assisting them to achieve intended goals (van der Heijden, 2004). Therefore, without empirical investigation, it cannot be assured that factors driving the enjoyment of entertainment- and task-oriented applications are still valid for HCG context. The major goal of this study is to investigate the factors contributing to perceived HCG enjoyment from the perspectives of motivational needs and perceived output quality, using our developed HCG for mobile information sharing named, *SPLASH*. The scope of this study is limited to mobile information sharing HCGs but nonetheless of importance because sharing information on the go has increasingly become an inescapable part of everyday life.

The remainder of this paper is organized as follows. The next section provides an overview of HCGs, focusing especially on mobile information sharing games. The HCG used in this study is introduced next. We then present the research model and hypotheses of our work. The research method is then described, followed by our results covering individuals' perceptions of motivational needs and output quality. Finally, we discuss the implications of our findings for HCGs for information sharing, and identify opportunities for future research.

2. Human computation games for mobile information sharing

2.1. Related games

Although HCGs have been introduced in various domain areas, they share a commonality in that they embrace the underlying concept of utilizing games to make computational tasks more

appealing and engaging to attract people's participation. As mentioned earlier, the ESP Game (von Ahn & Dabbish, 2004) is one of the pioneers designed to tackle the image labeling problem. Next, Herd It (Barrington, O'Malley, Turnbull, & Lanckriet, 2009) was deployed on Facebook to collect users' opinions on songs. Users described their opinions as labels or tags for a given song, and earned points based on the percentage agreement with others. HCGs have proliferated on Web platforms since, harnessing human intelligence in various domains.

With the increased popularity and widespread availability of mobile devices in recent years, a similar concept has been adopted in the location-based mobile information sharing context. In particular, mobile HCGs facilitate the co-creation, sharing, and seeking of location-based information by players anytime, anywhere (Lee, Goh, Chua, & Ang, 2010). One example is the *Gopher Game* (Casey et al., 2007), which allows players to contribute geospatial information by means of performing information creation tasks asked by a game agent called a gopher. Next, *PhotoCity* (Tuite, Snaveley, Hsiao, Smith, & Popovic, 2010) is another example whose purpose is to collect photos of real-world locations for constructing 3D models. Players are asked to collect as many flags as possible by capturing the photos of buildings identified by flags. A player who accumulates the most flags will own the building. *EyeSpy* (Bell et al., 2009) generates useful photos and texts of geographic locations for map navigation, and players are tasked to take pictures of locations and share them with others. Points are earned only if other players can make correct guesses about the location of these contributions.

Further, *CityExplorer* (Matyas et al., 2008) employs the concept of a board game to encourage players to contribute geo-referenced photos and texts. To conquer a city segment, players must place as many markers as possible on a particular segment, achieved through contributing photos of the locations of their chosen categories such as food, cafés, and so on. Finally, *Indagador* (Lee et al., 2010) incorporates gaming elements into content-sharing activities. Players can share and browse media rich location-based content, and earn points by rating and creating content. Using these points they can play mini-games, lay traps, and obtain treasure.

2.2. Introducing *SPLASH*, The HCG used in the study

For the purposes of this research, we employed a custom-developed application called *SPLASH* (Seek, PLAY, SHare), a type of HCG in which players generate geo-referenced information as by-products of playing it on their mobile phones. Studying a mobile HCG is useful and appropriate because of the rapidly increasing number of mobile users and their role in information sharing. For instance, Facebook has 751 million monthly mobile users as of 2014, an increase of 34 percent year-on-year (Popper, 2014).

SPLASH is a location-based information sharing HCG that runs on the Android mobile platform. In particular, through gaming elements, *SPLASH* allows players to share location-based information, known as "comments" comprising title, tags, descriptions, media elements (e.g. photos), and ratings. *SPLASH*'s content model is comprised of two levels: "Places" and "Units". "Places" represent an arbitrary geographic area, and examples include buildings, parks, points of interest, and so on. Places may also be further divided into "units". Both places and units hold associated comments. For example, a library in a school (place) may be considered a unit which attracts comments. Fig. 1 shows an example *SPLASH*'s comment.

SPLASH adopts a pet-based game genre in which players "feed" location-based information to virtual pets which live in mushroom houses. In line with *SPLASH*'s content model, "virtual pets" represent "units" and "mushroom houses" signify places. The mushroom houses are visualized on the map interface for navigation

and access to the respective content as shown in Fig. 2. Tapping on a mushroom house will retrieve a list of pets inside, and players can select their desired pet to view comments fed (see Fig. 3).

Further, SPLASH provides facilities for mobile information retrieval and discovery by visualizing user-generated information using different attributes, and serves to help players ascertain output quality. In particular, the appearances of the pet and mushroom house are influenced by the type of content fed. Specifically, a pet's size varies according to the amount of content fed, while content quality as measured by ratings, affects its color. Next, new content would make a pet look younger while older content would cause pets to age. Finally, pets fed with content that is generally positive in sentiment are happier, while those fed with content that is negative will appear sadder. Like pets, mushroom houses change in appearance according to the amount (size), quality (wall color), recency (roof color) and sentiment (weather) of content. Figs. 4 and 5 show the different appearances of the pet and mushroom house respectively. By allowing players to control the appearances of the pet and mushroom houses through information contributed, a sense of freedom in the game is facilitated (Przybylski, Rigby, & Ryan, 2010).

To promote socializing, SPLASH also provides virtual rooms inside the mushroom houses to represent each pet's apartment (see Fig. 6). Players can represent themselves with their own customizable avatars which appear in the virtual room (refer to Fig. 7). Players can decorate these rooms with items purchased from a virtual game store. Some of these items are mini-games which can be casual for pure entertainment, information-based that harness surrounding content to provide awareness to one's vicinity, or mini-HCGs for players to perform useful tasks during gameplay. A comment board can be found inside the virtual room, enabling players to contribute comments while socializing. Overall, these features are expected to create an environment which allows players to accomplish in-game goals together, and in turn, a sense of connectedness among players (Yee, 2006).

To publicize players' accomplishments, SPLASH offers a reward system that includes in-game currency (called gold), awards, and

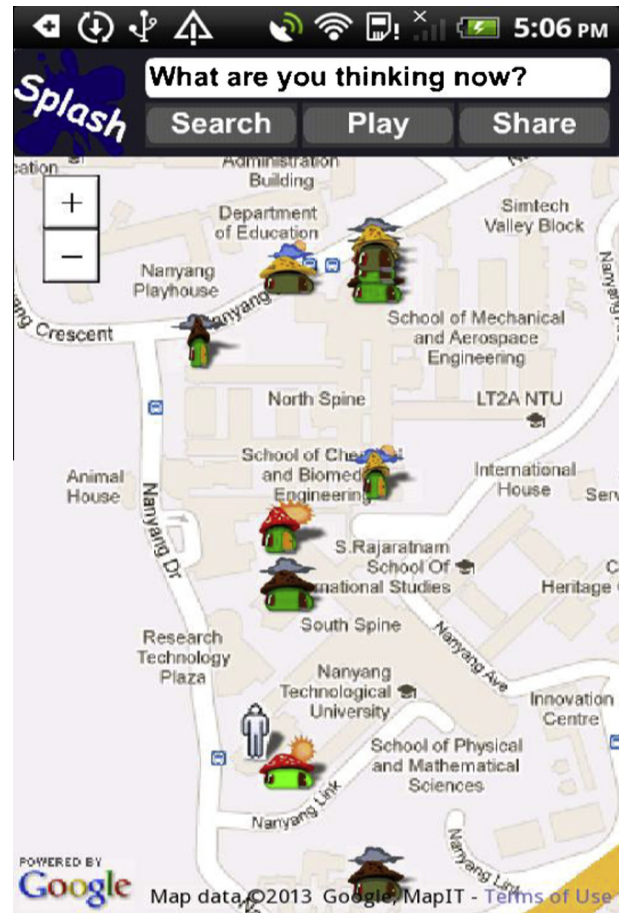


Fig. 2. SPLASH's map view.

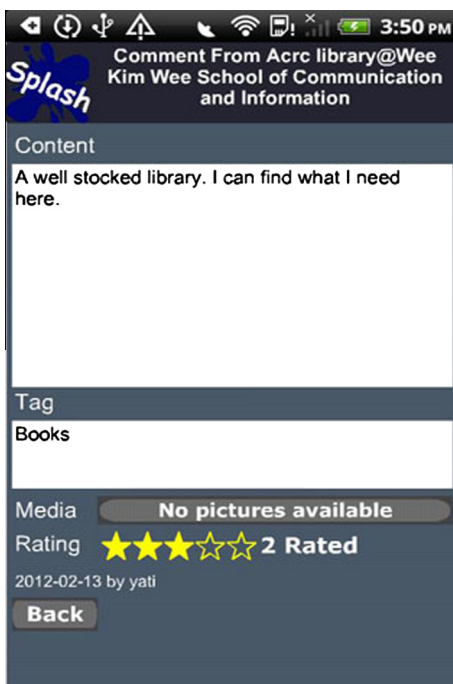


Fig. 1. SPLASH's comment.

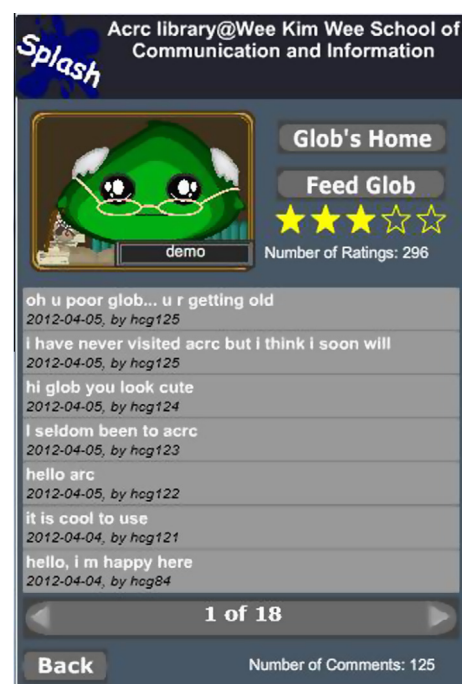


Fig. 3. SPLASH's virtual pet.

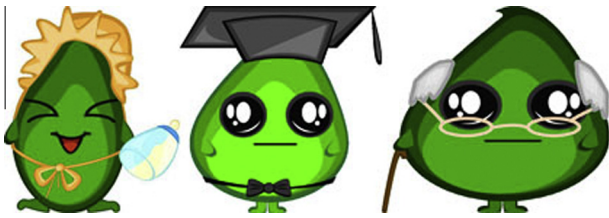


Fig. 4. Different appearances of a pet.



Fig. 5. Different appearances of a mushroom house.

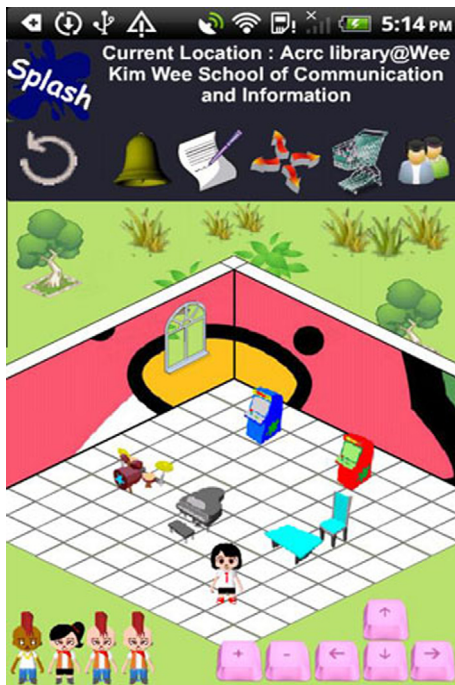


Fig. 6. SPLASH's virtual room.

leaderboards. The reward system is used to inform players about how proficient they are in the game, and what they have achieved so far (Christou, 2011). Players earn gold by viewing, creating, and rating comments, as well as playing mini-games inside virtual rooms. Awards are won by completing their specified missions (e.g. creating a certain number of comments). Leaderboards show the top players of the game such as those with the most gold and most rated comments, or those contributing the most number of comments.

There were a number of reasons for using SPLASH in this study, as opposed to using other information sharing HCGs currently available. First, it was chosen for its notable design features, described above, and has been relatively well-received by users in prior work (Goh, Lee et al., 2011). Next, with our developed game, we had a better control over its look-and-feel to ensure a

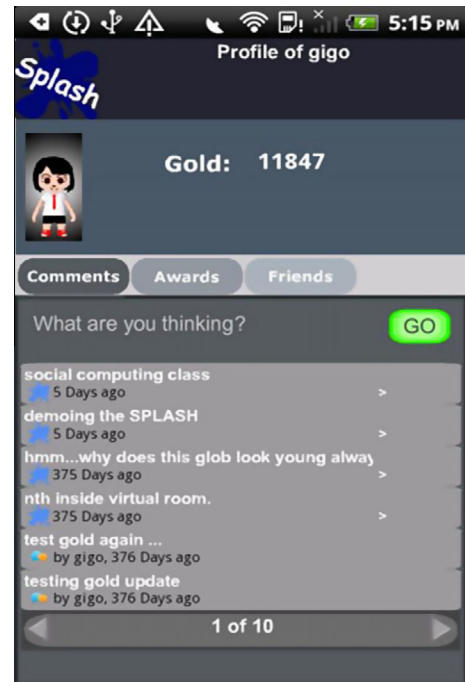


Fig. 7. SPLASH's avatar personalization page.

more consistent user experience during the study. Finally, using SPLASH, the content created by users could be easily accessed for analysis. The main features of SPLASH are summarized in Table 1.

3. Research model and hypotheses

This study aims to investigate how motivational needs and perceived output quality influence perceived enjoyment of HCGs for information sharing. Thus, the following sections review related literature and propose relevant hypotheses.

3.1. Perceived enjoyment

According to Davis, Bagozzi, and Warshaw (1992), enjoyment can be regarded as “the degree to which performing an activity is perceived as providing pleasure and joy in its own right, aside from performance consequences”. It is considered to be a focal aspect of entertainment media because individuals consume it mainly to seek fun or pleasure (Sweetser & Wyeth, 2005; Vorderer, Klimmt, & Ritterfeld, 2004). As being an important factor, perceived enjoyment of pure entertainment games has been extensively examined and its influence on players' attitudes and behaviors has been reported by multiple studies (Hsu & Lu, 2007; Wu & Liu, 2007). Beyond entertainment context, perceived enjoyment was also found to have a substantial impacts on users' attitudes toward task-oriented applications such as online information sharing (Kim & Han, 2009; Li, Chau, & Lou, 2005).

As HCGs are built upon individuals' desire to be entertained, it is essential to maximize their enjoyment in order to maintain their attention (Bostan, 2009) which in turn necessary to understand its driving forces. Further, understanding what factors drive HCG enjoyment could promote the knowledge necessary for better user-centered game design. In a prior study, perceived HCG enjoyment was evaluated through affective, cognitive and behavioral dimensions (Pe-Than, Goh, & Lee, 2012), but results were inconclusive in showing multidimensionality of enjoyment. This suggests that perceived HCG enjoyment is a complex construct consisting

Table 1
Summary of *SPLASH*'s features.

Features	
Customization	<ul style="list-style-type: none"> – Change the appearances of the pets and mushroom houses – Change the appearance of players' avatars – No restriction on types of content shared (e.g., factual or emotional)
Visualization	Reflect the output quality on the pets and mushroom houses Quality Attributes → Visualization Amount → Pet's size / House's size Rating → Pet's color / House's wall color Recency → Pet's age / House's roof Sentiment → Pet's mood / House's weather
Virtual room	<ul style="list-style-type: none"> – Play mini-games – Have casual discussion on the comment board
Reward system	<ul style="list-style-type: none"> – Earn points – Win awards – Position in leaderboards

of different forms of enjoyment which are interrelated, and hence may not need to be differentiated. Thus, following prior research (e.g., van der Heijden, 2004; Wu & Liu, 2007), we adopt a holistic view of enjoyment. Drawing on relevant literature, this study proposes motivational needs and perceived output quality as potential factors that may exert influence on HCG enjoyment. These are discussed in the following sections.

3.2. Motivational needs

Games are recognized as an intrinsically motivated activity in which individuals participate to yield pleasurable experiences (Deci & Ryan, 2000). Therefore, player motivations have become one of the main concerns of entertainment-oriented games because they could serve as the contributors of enjoyment. Following the grounded theory approach, a line of research identified motivations for playing games for pure entertainment (e.g., Kellar, Watters, & Duffy, 2005; Yee, 2006). These include achievement, socializing, immersion, competency, and control. Another line of research on players' motivation in games examined the roles of psychological needs, which are considered to be essential for personal growth and well-being (Deci & Ryan, 2000). Research in this area consistently found that perceived needs for autonomy, competence, and relatedness had an impact on players' enjoyment and preference of entertainment-oriented games (Reinecke et al., 2012; Ryan et al., 2006). Furthermore, in task-oriented contexts such as performing work-related activities and exercises, individuals' attitudes and behaviors were found to be influenced by the satisfaction of these three needs (Boezeman & Ellemers, 2009; Peng, Lin, Pfeiffer, & Winn, 2012).

Given the entertainment-output generation duality of HCGs (Goh & Lee, 2011), individuals' enjoyment may be affected by the fulfillment of these three needs: autonomy, competence, and relatedness. First, perceived autonomy is regarded as the extent to which players perceive a sense of freedom in their actions within the game (Ryan et al., 2006). Multiple studies in entertainment-oriented games have indicated that players who perceived higher levels of free will in games were more likely to experience higher levels of enjoyment (Tamborini, Bowman, Eden, Grizzard, & Organ, 2010). In task-oriented context, Kaufmann, Schulze, and Veit (2011) have found that the fulfillment of autonomy need impacted workers' performance and enjoyment. Next, the competence need refers to the extent to which players perceive feelings of effectiveness while dealing with encounters in the game (Ryan et al., 2006). To enhance this, games include features which allow

players to acquire new skills and abilities and provide positive and immediate feedback to (Peng et al., 2012; Przybylski et al., 2010). Furthermore, Klimmt, Hartmann, and Frey (2007) found that players who experienced a greater fulfillment of competence need in games were found to enjoy the games more than those who experienced less fulfillment of this need.

Finally, the relatedness need is defined as the extent to which players perceive feelings of being connected to other players or feelings of socially involved in the game world (Peng et al., 2012). This need is more likely to be attained when the game offers social interactions among players, thereby enhancing their feelings of social connectedness with others, which in turn increases enjoyment (Przybylski et al., 2010). Moreover, socializing was found to be one of the gratifications obtained from playing an content sharing HCG (Lee et al., 2010).

Collectively, these studies indicate that needs for autonomy, competence, and relatedness have positive influences on perceived enjoyment both in entertainment- and task-oriented contexts. Since HCGs are meant to be fun while producing outputs, enjoyment could be attributable to the satisfaction of needs for autonomy, competence and relatedness as in entertainment-oriented games. We thus expect players to be motivated by the satisfaction of the three needs described above which in turn influence their perception of HCG enjoyment, and we put forward the following hypotheses:

H1: Motivational needs in terms of (a) need for autonomy, (b) need for competence, and (c) need for relatedness are positively associated with perceived enjoyment of a HCG for information sharing.

3.3. Perceived output quality

According to Davis et al. (1992), perceived output quality can be regarded as a judgment "by observing intermediate or end products of using the system". Prior research has shown that users' perceived quality of outputs has an effect on their enjoyment of and attitudes toward online task-oriented applications, for example, sharing and seeking information online (Kim & Han, 2009; Lee, Park, & Widdows, 2009). Similarly, as HCG players involve in outputs generation through gameplay, their perceived quality of these outputs may influence their enjoyment. Prior studies on HCGs have found support for the importance of output quality. For instance, players have expressed concerns for quality of outputs generated by a mobile HCG (Goh, Razikin, Lee, & Chua, 2012; Lee et al., 2010).

Research on output quality has indicated that users employ various aspects in assessing the quality of outputs encountered in task-oriented applications (Lee, Strong, Kahn, & Wang, 2002; Wang & Strong, 1996). Moreover, Fichman (2011) found that users' perceived importance of various quality dimensions varied according to the types of outputs (e.g., social or objective). This finding has been supported in the context of online information sharing and seeking as studies have shown users' satisfaction to be more affected by their perceived relevance of online searches (Chen et al., 2014; Lee et al., 2002). Furthermore, Alkhatabi, Neagu, and Cullen (2010) have reported that users have paid much attention to the accuracy, completeness, relevancy, and timeliness of outputs in online context.

First, accuracy is commonly defined as the correctness of outputs appropriate to the context where it is represented (Nelson, Todd, & Wixom, 2005). It is also regarded as a core intrinsic quality of information, and includes attributes such as correctness, reliability, believability, and other related concerns (Wang & Strong, 1996). Prior studies have suggested that perceived accuracy of output impacted users' trust beliefs and playfulness of online

applications such as online shopping and knowledge sharing (Hwang & Kim, 2007; Kim & Han, 2009). The above studies did not explicitly examine the relationship between perceived output accuracy and enjoyment but, nonetheless, highlight its importance in online context.

Next, completeness represents sufficient breadth of scope and depth of detail of information contained in the outputs (Lee et al., 2002). Perceived completeness of outputs was found to be associated with users' satisfaction of online searches (Ho, Kuo, & Lin, 2012) and flow experience in the use of mobile social networking (Zhou, Li, & Liu, 2010). Next, relevancy is defined as the extent to which users perceive outputs to be applicable, relevant, usable, and helpful enough for the task at hand (Lee et al., 2002). Finally, timeliness refers to the age of the output, representing the degree to which content is up-to-date or current (Wang & Strong, 1996). In the context of e-health information seeking, users' satisfaction was found to be impacted by their perceptions of how relevant and current the e-health searches are (Lee et al., 2009).

These studies highlight the importance of the aforementioned quality dimensions in the online context. Given the fact that HCGs are designed to increase productivity, we deem that players who perceive higher levels of output accuracy, completeness, relevancy, and timeliness are more likely to experience a greater level of enjoyment. Hence, the following hypotheses are proposed:

H2: Perceived output quality in terms of (a) accuracy, (b) completeness, (c) relevancy, and (d) timeliness are positively associated with perceived enjoyment of a HCG for information sharing.

Given the factors discussed above, the research model is depicted in Fig. 8. This model suggests that motivational needs for autonomy, competence, and relatedness, as well as perceived accuracy, completeness, relevancy, and timeliness of outputs serve as antecedents of perceived HCG enjoyment for information sharing.

4. Method

4.1. Study procedure

A questionnaire was developed to elicit participants' perceptions of motivational needs satisfaction, output quality, and enjoyment of HCGs. In addition, this questionnaire collected participants' demographic data, mobile phone usage, as well as gaming experience. A pilot study was carried out with five graduate students prior to conducting the actual study to uncover the deficiencies in the developed questionnaire and study procedure. Generally, the entire questionnaire was found to be clear and comprehensive. A few suggestions were made such as wording and format used in the questionnaire, and these were incorporated in the revised questionnaire.

Participants were recruited through email invitations, placing posters in university campus, and advertising in school classes. Participation in this study was voluntary and anonymous, and it was conducted using the following procedure. First, participants were introduced to *SPLASH* and its features. Next, they were each provided with a HTC Desire mobile phone installed with *SPLASH* and asked to familiarize themselves with the application. The actual study then began and participants performed a series of tasks designed to cover all the features of *SPLASH*. The tasks included using *SPLASH* for (a) finding places on the map, (b) feeding pets and creating content, (c) rating comments, (d) visiting virtual rooms, (e) customizing avatars, and (f) viewing the leaderboard. Thereafter, the questionnaire described above was administered. The entire study took approximately 40 minutes to complete. Participants were also paid a modest incentive of \$5 for their effort.

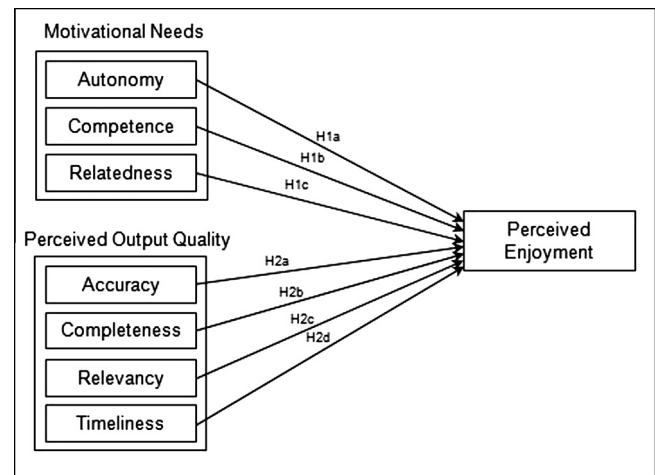


Fig. 8. Research model.

4.2. Sample

Our study was conducted on 205 undergraduate and graduate students from a local university with ages ranging from 19 to 41 with an average of 26.40 years. The sample consisted of 58% females and 42% males. Among our participants, 48.8% of them had a background in computer science, information technology or related disciplines, while the remainder was from disciplines such as arts, social sciences and business. Further, 67.3% of the participants indicated that they were online gamers. In addition, 50.7% of participants indicated that they had used the location check-in features of social networking applications, while 42.4% of them shared information about locations on social networking applications via mobile phones. Prior studies have shown that university students can represent an important age demographic of overall online game players (Kirriemuir, 2005; Wu & Liu, 2007). As such, the university student group in this study may reasonably represent the population that is involved in online games.

4.3. Operational definitions

In our study, the independent variables were perceived satisfaction of motivational needs for autonomy, competence and relatedness, as well as perceived output accuracy, completeness, relevancy and timeliness. The dependent variable was perceived enjoyment. Questions were rated on a scale of 1 (strongly disagree) to 5 (strongly agree). The questions were adapted from prior studies and described as follows:

- Perceived motivational needs satisfaction. Measurements of motivational needs satisfaction were adapted from the Players Experience Need Satisfaction question items (PENS) (Ryan et al., 2006) and Basic Psychological Need Satisfaction items (Deci & Ryan, 2000). The PENS scale has been utilized to assess players' in-game needs satisfaction in various game genres including shooting, action and adventure, simulation, and strategy and role-playing games (e.g., Przybylski et al., 2010; Ryan et al., 2006). A total of 12 question items were used to assess these motivational needs.
- Perceived output quality. This was assessed with 12 items that were drawn from previous studies (e.g., Lee et al., 2002), and modified to the current context. This scale set has been employed to evaluate users' perception of information quality in various online contexts including sharing and searching information (e.g., Goh et al., 2012; Kim & Han, 2009).

- Perceived Enjoyment. A total of 12 items were utilized to measure perceived enjoyment of HCGs, and these were formulated based on prior studies (e.g., Fang, Chan, Brzezinski, & Nair, 2010; Fang & Zhao, 2010) and adapted to suit the study's context.

5. Results

5.1. Factor and reliability analyses

To determine the potential groupings of the constructs used in this study, principal component factor analysis with Varimax rotation which yields orthogonal factors was run iteratively. We retained all factors whose eigenvalue was greater than one, as well as those with theoretical salience. Reliability was also assessed using Cronbach's alpha. Table 2 shows the factor analysis results of the motivational needs satisfaction construct. As expected, three motivational need factors were revealed, and they had good internal reliabilities with acceptable alpha values of 0.79 ($M = 3.41$, $SD = 0.62$) for autonomy, 0.77 ($M = 3.37$, $SD = 0.68$) for competence, and 0.79 ($M = 3.25$, $SD = 0.72$) for relatedness respectively. The descriptions of these constructs are articulated as follows:

- Autonomy need refers to people's perceived feelings of freedom while performing activities in the HCG.
- Competence need refers to people's perceived feelings of effectiveness while dealing with challenges encountered in the HCG.
- Relatedness need refers to people's perceived feelings of connectedness with others in the HCG.

Next, four factors emerged from the factor analysis of perceived output quality, and all of them had good internal reliabilities with alpha values of 0.96 ($M = 3.4$, $SD = 0.77$) for accuracy, 0.96 ($M = 3.2$, $SD = 0.78$) for completeness, 0.91 ($M = 3.3$, $SD = 0.75$) for relevancy, and 1.0 ($M = 3.6$, $SD = 0.81$) for timeliness respectively. The results are presented in Table 3, and the constructs are described in the following.

- Accuracy assesses the extent to which information generated by the HCG is correct, reliable, and accurate.
- Completeness assesses the extent to which information generated by the HCG contains sufficient detail to meet one's needs.
- Relevancy assesses the extent to which information generated by the HCG is appropriate, relevant, and useful for one's needs.

- Timeliness assesses the extent to which information generated by the HCG is current, timely, and up-to-date for one's needs.

With regards to perceived enjoyment construct, the factor analysis yielded a single category with Cronbach's alpha value of 0.89 ($M = 3.14$, $SD = 0.63$), and this single category was used in subsequent analyses. The results are presented in Table 4, and the construct is operationalized as:

- Perceived enjoyment measures players' emotional influences during gameplay, cognitive judgments of game tasks, as well as self-awareness of their actions during gameplay.

5.2. Hypotheses testing

Before testing the hypotheses, we examined the correlations among independent variables to ensure the absence of multicollinearity among them. The results showed that there were no high correlations among the independent variables (0.6 and above). After this, a multiple linear regression analysis was carried out. Specifically, the three motivational needs and four output quality dimensions were entered as independent variables, while perceived enjoyment was treated as the dependent variable. The model accounted for 44% of the variance of perceived enjoyment of HCG. The hypothesis test results are summarized in Table 5.

First, hypotheses 1a, 1b, and 1c were supported. Our findings showed that the needs for autonomy ($\beta = .24$, $p < .001$), competence ($\beta = .12$, $p < .05$), and relatedness ($\beta = .23$, $p < .001$) were significantly positively associated with perceived enjoyment of *SPLASH*. Put differently, the more that freedom was perceived in the game, the more likely a player experienced enjoyment in playing it. Next, players who saw themselves as being skilled in *SPLASH* were more likely to enjoy playing it. Finally, the more the game was perceived to support social interaction, the more likely a player enjoyed playing it. According to the strength of association which the beta regression coefficients provide (Nicola, Kemp, & Snelgar, 2006), perceived autonomy was found to have a stronger relationship with perceived enjoyment, followed by perceived relatedness and competence.

Second, Hypothesis 2c was supported but hypotheses 2a, 2b and 2d were not. Our results showed that perceived output relevancy was significantly positively associated with perceived enjoyment ($\beta = .19$, $p < .01$), indicating that players were more

Table 2
Measurement and factor analysis of perceived motivational needs.

Scale items	Factors			Alpha
	1	2	3	
<i>Autonomy need</i>				.79
I felt controlled and pressured to be a certain way	.072	.062	.79	
I did things in this application because they interested me	.23	.25	.75	
This application provides me an opportunity to express my ideas and opinions freely	.14	.28	.74	
This application provides me with interesting options and choices	.33	.28	.62	
<i>Competence need</i>				.77
I felt that I was making progress on the activities I did throughout the use of application	.11	.80	.12	
I felt that I could do activities in this application very well	.16	.78	.28	
I felt competent at using this application	-.026	.77	.20	
This application kept me occupied but did not overwhelm me	-.028	.63	.12	
<i>Relatedness need</i>				.79
I felt connected with the people I played with	.84	-.037	.15	
I felt that I was part of a group who shared similar goals	.80	.072	.19	
I felt comfortable with other people I played with	.77	.015	.11	
This application allows me to create an open channel of communication with other people that share similar interests	.65	.13	.13	
Variance explained (%)	36	17	8.9	
Eigenvalue	4.3	2.1	1.1	

Table 3
Measurement and factor analysis of perceived output quality.

Scale items	Factors				Alpha
	1	2	3	4	
<i>Accuracy</i>					.96
This application provides accurate information	.24	.90	.21	.16	
This application provides correct information	.23	.90	.15	.20	
This application provides reliable information	.19	.90	.24	.16	
<i>Completeness</i>					.96
This application provides information that covers sufficient breadth and depth for my needs	.18	.23	.87	.28	
This application provides information that includes all necessary details	.22	.23	.87	.24	
This application provides information that is sufficiently complete for my needs	.29	.19	.85	.28	
<i>Relevancy</i>					.91
This application provides information that is relevant to my needs	.16	.15	.25	.89	
This application provides information that is appropriate for my needs	.29	.20	.23	.81	
This application provides information that is useful for my needs	.26	.19	.28	.79	
<i>Timeliness</i>					1.0
This application provides information that is sufficiently up-to-date	.91	.24	.23	.25	
This application provides information that is sufficiently current for my needs	.91	.23	.24	.25	
This application provides information I need in time	.90	.25	.23	.24	
Variance explained (%)	60	13	11	8.4	
Eigenvalue	7.2	1.5	1.3	1.0	

Table 4
Measurement and factor analysis of perceived enjoyment.

Scale items	Factor loadings	Alpha
<i>Perceived enjoyment</i>		.85
I felt attracted to this application (or feature)	.81	
I felt emotionally attached to this application (or feature)	.75	
I felt emotionally involved in this application (or feature)	.75	
I think this application (or feature) is an effective way of sharing information	.72	
I was able to easily use the application (or feature) to accomplish my designated tasks	.70	
I felt emotionally affected while using this application (or feature)	.69	
I think this application (or feature) is an interesting way of sharing information	.69	
I think it is worthwhile to use this application (or feature)	.66	
I think this application (or feature) is a good way of sharing information	.66	
I was able to quickly choose appropriate actions for my designated tasks in this application (or feature)	.64	
I lost track of time while using this application (or feature)	.59	
I became less aware of my surroundings because I was engrossed in using this application (or feature)	.52	
Variance explained (%)	47	
Eigenvalue	5.7	

Table 5
Summary of results.

	Hypotheses		Standardized β	t-Values	R ²	Results
<i>Motivational needs</i>						
H1a	Autonomy	→ Perceived enjoyment	.24	3.4*	.44*	Supported
H1b	Competence	→ Perceived enjoyment	.12	1.9*		Supported
H1c	Relatedness	→ Perceived enjoyment	.23	3.6*		Supported
<i>Perceived output quality</i>						
H2a	Accuracy	→ Perceived enjoyment	.046	.71		Not supported
H2b	Completeness	→ Perceived enjoyment	.015	.21		Not supported
H2c	Relevancy	→ Perceived enjoyment	.19	2.5**		Supported
H2d	Timeliness	→ Perceived enjoyment	.13	1.7		Not supported

* $p < .05$.** $p < .01$.+ $p < .001$.

inclined to enjoy playing *SPLASH* when they encountered more relevant outputs in the game. However, no significant relationships existed between perceived output accuracy, completeness, and timeliness, and perceived enjoyment of *SPLASH*. Put differently, players' perceived accuracy and completeness of outputs generated by HCGs had no impact on their perceived enjoyment. It also seemed that the provision of timely outputs did not promote players' perceived enjoyment of *SPLASH*.

6. Discussion

Focusing on HCGs for information sharing, this study has examined how motivational needs for autonomy, competence, and relatedness, as well as perceived accuracy, completeness, relevancy, and timeliness of outputs influence individuals' perceived HCG enjoyment. The findings are discussed in detail in the following sessions.

6.1. Effects of motivational needs

In terms of motivational needs, our findings indicate that the autonomy need has a positive effect on players' perceived enjoyment of HCG for information sharing such as *SPLASH*. This means that HCG players obtain enjoyment from being able to perform in-game activities in their desired ways, fulfilling the need for autonomy. This finding is consistent with the findings from task-oriented contexts such as organizations (Boezeman & Ellemers, 2009; Millette & Gagné, 2008) and games for pure entertainment contexts (Peng et al., 2012; Ryan et al., 2006), where it has been found that individuals who perceive a greater sense of enjoyment are shown to be more motivated by the amount of control over the tasks. In our study, *SPLASH* provides flexibility in information sharing activities, offering no restriction on types of content shared (e.g., factual or emotional content) and multiple modes of sharing (e.g., feeding the virtual pet or posting on the comment-board). *SPLASH* also allows players to choose a particular award of interest and perform the specified tasks to win it. Arguably, these features could have provided the right amount of freedom required by players with high autonomy need. Our results therefore suggest that the provision of autonomy in HCGs should transcend that of entertainment-oriented games, highlighting the necessity to cater to autonomy over assigned computational tasks for HCG enjoyment.

Next, the significance of the relatedness need indicates that people achieve enjoyment in HCGs through a fulfillment of social belongingness. *SPLASH* supports socializing through its virtual rooms where players' avatars can interact and communicate with others. This feature could have assisted players to encounter other individuals who share common interests with them, thereby forming a sense of relatedness. In this sense, this finding could potentially indicate that HCGs such as *SPLASH* facilitate the formation of weak social ties among players by which they can acquire useful information beyond those gained from their close friends (Granovetter, 1983). While many existing HCGs do not have social features, this study underlines the need to assess possible ways to incorporate these features to promote a deeper engagement in such games. This study extends the prior work of Lee et al. (2010), which found that HCGs for mobile information sharing allow players to create and maintain social relationships, by providing some evidence that the fulfillment of relatedness need is the origin of enjoyment.

Further, the competence need was identified as a significant predictor of perceived enjoyment, demonstrating that players experience enjoyment through being skilled in performing their given tasks. This finding concurs with prior research on entertainment-oriented games that identified the relationship between individuals' perceived ability to cope with game challenges and their enjoyment (Przybylski et al., 2010; Reinecke et al., 2012). As HCGs uniquely require players to have relevant skills to tackle assigned computational tasks in addition to those required for games for pure entertainment, perceived enjoyment of HCGs could have stemmed from the feeling of being able to contribute useful outputs. From the perspective of competence–performance distinction (Miller, 1975), this finding suggests that players are more likely to enjoy HCGs when they are competent at performing computation tasks encountered in gameplay. This finding is supported by a previous study (Pe-Than et al., 2012) which demonstrated a relationship between players' perceptions of being skilled in HCGs and their attitudes toward such games. Here, *SPLASH* provides various indicators to promote players' perception of competence in content contribution. For instance, the more information with positive sentiment is fed, the happier the pet will become. This indicator could have led to the perceptions of competence, ultimately affecting their enjoyment.

6.2. Effects of perceived output quality

Interestingly, perceived output relevancy was found to have a significant positive influence on perceived enjoyment of HCG for information sharing. A possible explanation is that playing these games provides players with an opportunity for serendipitous information discovery (Foster & Ford, 2003), meaning that players encounter new content that is relevant to, but not anticipated by them. The chance of encountering relevant information further determines players' HCG enjoyment. In our work, *SPLASH* presents places on its map interface where user-generated content is located. While visiting places in *SPLASH*, players may encounter content created by others that they might not have known before and find them relevant. These situations highlight serendipitous information discovery that in turn, create a sense of enjoyment. This study therefore extends the work of Lee et al. (2010), which reported that content-sharing HCGs are able to facilitate information discovery, by providing a more nuanced perspective of the role of relevant outputs, and how that leads to players' HCG enjoyment. This finding further suggests that individuals play HCGs not only to seek fun, but also to discover relevant outputs, providing evidence that people appreciate the dual nature of these games (Goh & Lee, 2011; von Ahn & Dabbish, 2008), and also underlines the importance of creating situations that facilitate information discovery in HCGs.

The non-significance of perceived output accuracy, completeness, and timeliness suggests that players are not concerned about these issues while playing HCGs like *SPLASH*, which diverges from the findings of prior work (e.g., Kim & Han, 2009) where users expressed concerns over the accuracy and completeness of outputs in online knowledge sharing contexts such as Yahoo! Answers. However, in a study of blogs, which is a type of online information sharing application, the relationships between users' perceived accuracy of information and their perceived enjoyment could not be established (Chen et al., 2014). Therefore, it could be speculated that individuals view accuracy differently for user-generated content, and such perceptions were found to be influenced by cultural backgrounds and individual differences such as personality and prior experience with social information (Lee et al., 2002; Watts, Shankaranarayanan, & Even, 2009). Accordingly, players' evaluation of output accuracy in *SPLASH* might have been affected by their familiarity with, and belief and attitudes toward social information (Flanagin & Metzger, 2013). Furthermore, Fichman (2011) argues that accuracy and completeness quality aspects are more important for informational and objective content than opinion and social content. Thus, it could be speculated that *SPLASH* attracts more of the latter content types, thus diminishing the roles played by accuracy and completeness of outputs on perceived enjoyment. A prior work suggests that different genres of HCGs for image tagging generated different types of outputs (Lee et al., 2010). Thus, the types of outputs encountered in HCGs may impact perceived output quality, and future research should empirically investigate this relationship.

With regards to timeliness, its influence in the literature is mixed. For example, timeliness of outputs was found to have an effect on users' satisfaction in goal-oriented activities such as dealing with e-health, e-government, and organizational information (Chen et al., 2014; Lee et al., 2009). However, its influence on users' attitudes toward online question and answer applications was not significant (Kim & Han, 2009). As output generation and enjoyment are intertwined in HCGs, players could have perceived creating and seeking information in *SPLASH* as an enjoyable activity rather than achieving certain goals, consequently weakening the perceived importance of information timeliness. Furthermore, Kim and Han (2009) also explicated that users often underemphasize the

timeliness of information in the online context because of the provision of current information by its very nature. Due to the mobility of *SPLASH*, players are more likely share information about current events, causing the currency of information to be understated, resulting in its non-influence on perceived enjoyment.

6.3. Limitations and future research

Although this study has yielded valuable insights, the findings should be interpreted with caution for several reasons. One, as this study was conducted using a single HCG genre in a specific domain of information sharing, the findings may not be generalizable and need to be replicated in other contexts. Therefore, it would be instructive to carry out investigations using different HCG genres across different human computation domains to better establish the relationships found in the present study. Two, as this study was conducted with a single group of participants who were primarily undergraduate and graduate students, it is not possible to evaluate if these findings are generalizable to other user population. Therefore, replicating this study with diverse age groups and educational backgrounds would provide evidence that corroborates or contradicts previous findings, and even uncover other factors that may be important for HCG enjoyment. Three, the present study employed a cross-sectional survey method, and players' perceptions were collected based on given scenarios. Conducting a longitudinal study with repeated use, as well as observing players' behaviors in an actual context of use would be beneficial in validating our results.

Several avenues for future work remain. First, this study did not consider all possible motivational needs, instead opting for a single model of motivation, albeit one that has been shown to be relevant in the gaming literature. Future research should examine other possible motivational factors that might affect perceived HCG enjoyment, such as needs for achievement and information (Ines & Abdelkader, 2011). Second, given our results that highlight an impact of motivational needs satisfaction on perceived HCG enjoyment, it would be interesting to investigate other individual differences on such as perceived self-efficacy and personality traits (Fang & Zhao, 2010), and their relationships to perceived HCG enjoyment. Third, an experimental study with HCGs and non-game-based applications could also be conducted to reveal concrete evidence of whether embedding computational tasks into games is enjoyable as well as effective in solving computational problems. Finally, it would be worthwhile to consider designing different HCG genres because elements of different game genres were found to satisfy different levels of motivational needs (Johnson & Gardner, 2010), and evaluate players' enjoyment, efficiently and performance of these games.

7. Conclusion

This study advances the literature on enjoyment of games that are not purely meant for entertainment by exploring its antecedents through the lens of motivational needs and perceived output quality. The following implications may be derived from our findings. First, HCGs for information sharing will be enjoyable as long as they are able to fulfill individuals' motivational needs and assure output relevancy. These relationships could be used to identify effective strategies to maximize individuals' HCG enjoyment. Secondly, games could be employed to facilitate individuals' information sharing and seeking behaviors. Our findings suggest that players not only use HCGs for entertainment, but also utilize them to meet their informational needs as evidenced by the significance of output relevancy. Thirdly, our work suggests that it would be

possible to make boring or everyday tasks more engaging if we understand the factors that influence individuals' perceptions of enjoyment. Hence, our findings could be applied to a number of real-world environments to promote user engagement. Examples include providing employee training in organizations, enhancing children's educational experience, collecting customers' feedback on products and services, and getting people to contribute user-generated content on various platforms. Finally, our work serves as a springboard to explore other possible factors that might affect enjoyment of HCGs. The knowledge of these factors provides a deeper understanding of HCG players' behaviors.

Our work also suggests design implications for HCGs and applications that are not just for pure entertainment:

- Features that support user empowerment are vital to facilitate players' need for autonomy in HCGs. Individuals should be allowed to perform activities in HCGs in ways that they desire. To facilitate this, multiple ways to accomplish assigned computational tasks, customizable goals and informational feedback that indicates how far players' reach their goal could be offered. Situations that curb autonomy in HCGs should also be identified and alleviated. However, HCGs offering too much freedom may create a burden of responsibility on task completion, especially to players who seek fun. Thus, designers need to strive for a balance between the need for task autonomy and enjoyment.
- HCGs should cater for individuals with different skill levels. Thus, it is important to assign tasks that are cognitively appropriate to players (Alkhatabi et al., 2010). One way of achieving this is by detecting and classifying the player's level of involvement with the game such as infrequent or frequent player, and thereafter allocating appropriate tasks to them. Another possibility is having two explicit gameplay modes in HCGs: learning and computing. Here, the learning mode allows players to acquire required skills to perform computations while the computing mode enables them to contribute outputs.
- Social interaction among players is important in HCGs. Therefore, mechanisms that foster meaningful and purposeful social interactions should be incorporated into HCGs (Jegers, 2007). Examples include virtual game spaces, liking and rating, and finding friends of similar interests. Since socialization has become ubiquitous, it is also important to include features that enable opportunities to create location-based social networks and to bridge a gap between virtual and real social ties.
- HCGs should consider incorporating mechanisms that promote the relevancy of outputs. In particular, personalization mechanisms are vital to retrieve information that is more likely to be of interest to players. In this regard, mechanisms to filter out irrelevant information effectively based on the needs of players' are required to be implemented. Besides, game design elements which could encourage the creation of relevant content for others should also be investigated. Here, reward and punishment strategies such as adding or deducting scores may help to achieve this (Christou, 2011).

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