Is adaptive gamification just a theoretical fairytale? An experiment in a text-based adventure game for data crowdsourcing

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Abstract

Gamification approaches are not always effective and vary in their success. Several studies suggest that unexpected results of effectiveness are related to a dearth of personalization of gamified systems following a one-size-fits-all (OSFA) approach. Although research indicates that gamification design that is dynamically adjusted to the preferences of the person using the system (i.e., adaptive gamification) can positively impact behavioral or motivational outcomes, there is still a gap in understanding the effectiveness of adaptive gamification. This work aims to advance our understanding on the impact of adaptive gamification on motivational and behavioral outcomes in the context of gamified crowdsourcing. To this end, an experiment (n=135) is conducted with a text-based adventure game that employs different versions of a narrative designed to address the specific needs of previously conceptualized distinct types of users (i.e., Hexad user types). The results show that adaptive gamification does not lead to higher behavioral outcomes, i.e., increased crowdsourcing participation, or motivational outcomes. Conclusively, this work challenges the common assumption of adaptive gamification based on player types being worth the effort. Moreover, the results show that general need satisfaction is associated with increasing motivational outcomes, independent of a user's player type. Therefore, this work suggests focusing on different perceptions of need satisfaction being required by individuals rather than focusing on player types which are abstractions of reality.

1. Introduction

Recent years have seen an emerging trend in using adaptive concepts for tailoring information systems to create more user-centric solutions. This trend has also become increasingly relevant for gamifying information systems. Over the past decade, it has become a common practice to utilize design elements from games outside of traditional game environments (Deterding, Dixon, Khaled, & Nacke, 2011) in order to invoke experiences, similar to those in games. This trend known as 'gamification' intends to foster psychological responses (i.e., motivation, flow experience, interest), and influence behavioral outcomes (i.e., engagement, system use, or contribution) (Hamari, Koivisto, & Sarsa, 2014; Koivisto & Hamari, 2019). While the benefits and potential of gamification have been consistently demonstrated, it is crucial to acknowledge that gamification approaches are not always effective and vary in their success (Krath & von Korflesch, 2021; Böckle, Micheel, Bick, & Novak, 2018; Morschheuser, Hassan, Werder, & Hamari, 2018). Often, unexpected results of effectiveness are related to the limitations of modest gamified systems following a one-size-fits-all (OSFA) approach (Morschheuser et al., 2018; Klock, Gasparini, Pimenta, & de Oliveira, 2015). Such systems lack the consideration of the diversity and individuality of users, their individual goals, needs, and values (Klock et al., 2015; Ferro, Walz, & Greuter, 2013). In particular, prior research has investigated three intrinsic needs posited by self-determination theory (SDT), namely relatedness, autonomy, and competence, and their effect on motivational outcomes, such as enjoyment, intention for future play, and immersion. For example, it has been shown that a game's narrative can support perceived *autonomy* (Bormann & Greitemeyer, 2015); challenges, badges, and leaderboards can partly support the feeling of *autonomy*, *relatedness*, and *competence* (van Roy & Zaman, 2019). Humans are inherently different and so are the aspects that motivate individuals to engage in a particular behavior. In consequence, there have been attempts to identify and categorize types of users based on their motives and needs. One popular typology in the gamification sphere is the User Type Hexad model by Marczewski (Marczewski, 2015). Such typologies indicate that designing a gamified system requires thoughtful consideration of the selected motivational affordances (i.e., gamification design elements) to accommodate specific user needs and to achieve the system's goal. Thus, besides consideration of generally suitable motivational affordances, it is essential to consider the individual user of the system (Klock et al., 2015; Ferro et al., 2013). By doing so, a

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standard gamification system can be turned into an adaptive gamification system.

However, designing individually tailored systems is complex (Morschheuser et al., 2018; Klock et al., 2015; Klock, Gasparini, Pimenta, & Hamari, 2020; F. Tondello, 2019) and we lack sufficient empirical support on whether tailored gamification approaches are in fact more effective and preferable compared to more generic (i.e., OSFA) gamification approaches. Often, random or only simple, superficial game elements and mechanics are implemented into the software, primarily represented by the most common gamification elements, namely points, badges, and leaderboards (Rodrigues et al., 2021; Morschheuser, Hamari, Koivisto, & Maedche, 2017; Hamari et al., 2014). On other occasions, designers opt to integrate as many design interventions as possible to ensure that all users can find features they appreciate (Hassan, Dias, & Hamari, 2019; Klock et al., 2015; Schöbel, Söllner, & Mishra, 2017). Many designers underestimate the complexities and various challenges involved in gamifying a system. For example, it cannot simply be assumed that game elements are generalizable or transferable into new contexts, and still induce the same effects (Huotari & Hamari, 2016; Rigby, 2015; Deterding, 2015). Scientific work highlights the importance of considering the users' individuality when designing a gamified tool as it makes a significant impact on the users' performance (Krath & von Korflesch, 2021; Lopez & Tucker, 2021; Böckle et al., 2018; Passalacqua, Senecal, Fredette, Nacke, & Pellerin, 2021). Nevertheless, few empirical studies exist that explore the adaptation of game elements, or mechanics (Klock et al., 2020). The bottom line is that there is an overwhelming amount of OSFA approaches, which are consequently better understood whereas adaptive gamification approaches are still sparse, which prevents us from understanding the effects associated with tailored approaches better. Hence, it remains elusive whether it is worth the economic investment, time, and effort to design more complex tailored gamification over more generic design interventions.

The present paper aims to close this gap by investigating the impact of adaptive versus OSFA gamified applications in a narrative-based adaptation approach on crowdsourcing participation. Specifically, we pose the question of whether adaptive gamification, i.e., adaptation of the game's narrative, compares more favorably as opposed to an OSFA approach when it comes to inducing motivational and behavioral outcomes. To this end, an experiment in a text-based adventure game for collecting handwriting data is conducted. The adaptation is realized based on the Hexad player types of users, with a particular focus on three intrinsically motivated player types that can be directly derived from SDT (Deci, Eghrari, Patrick, & Leone, 1994; Ryan & Deci, 2000a; Marczewski, 2015). Thereby, the adaptation affects the narrative of the text-adventure, resulting in the users playing different storylines, either selected based on their Hexad player type or randomly chosen.

2. Theoretical foundations and related work

2.1. Adaptive gamification

Gamification intends to afford systems, services, and activities with elements known from games to produce positive, i.e., 'gameful' user experiences, thereby generating motivation and meaningful engagement that is both enjoyable and instrumental (Hamari et al., 2014; Deterding et al., 2011; Koivisto & Hamari, 2019). Standard gamification concepts (i.e., OSFA-approaches) commonly lack the consideration of the diversity of users: their individual motivators, goals, and needs (Klock et al., 2015; Ferro et al., 2013). To overcome the shortcomings of OSFA gamification approaches, a research stream has formed called adaptive or tailored gamification. The basic idea is to adapt the system to the individual user preferences with the aim to achieve superior outcomes over generic gamification approaches. The concept of adaptation is already reflected in game development. For example, Bakkes et al. (Bakkes, Tan, & Pisan, 2012) suggest eight components of games suitable to manipulate for adaptation: space, mission/task, character, game mechanics, narrative, music/sound, player matching (multiplayer), and difficulty scaling. Several studies have exploited adaptation in the area of gamification based on various factors such as demographic aspects, e.g., gender and age, gamer type, or the consideration of player typology (F. A. Orji, Oyibo, Orji, Greer, & Vassileva, 2019; Klock et al., 2020). The latter distinguishes motivations based on user types.

However, a lot of research is conducted about user modeling, e.g., analyzing user preferences for different game elements to realize future adaptation, but not measuring the actual impact of adaptive gamification (Klock et al., 2020). Past research provided first insights into the effect of adapting a gameful system, leading to increased user engagement, having a positive effect on user performance, and more efficiently achieving the system's goal (F. Tondello, 2019; Lopez & Tucker, 2021; R. Orji, Tondello, & Nacke, 2018; Rozi, Rosmansyah, & Dabarsyah, 2019; Tondello & Nacke, 2020; Schwarz et al., 2021). In general, when talking about tailored or adaptive gamification, two concepts need to be differentiated: *customization* and *personalization* (F. Tondello, 2019). *Customization* refers to the user taking action, i.e., choosing preferred game elements

from a predefined list, also referred to as bottom-up gamification (Tondello & Nacke, 2020). Studies comparing OSFA to customized gamification approaches have revealed a positive effect on behavioral outcomes (Tondello & Nacke, 2020; Lessel, Altmeyer, Müller, Wolff, & Krüger, 2017). However, even if the benefit of tailoring a system to personal preferences might primarily rely on terms of freedom of choice, prior research could not determine an effect on autonomy (Schubhan, Altmeyer, Buchheit, & Lessel, 2020). Moreover, Schubhan et al. (Schubhan et al., 2020) could not find an effect on other aspects, such as enjoyment, competence, and pressure either. Thus, it is questionable whether positive effects on behavior are related to the adaptation of a system or other determinants, such as user contingent commitment (Rodrigues et al., 2021; Schubhan et al., 2020). In contrast, *personalization* refers to the system, respectively designer, taking action, i.e. adapting to the individual user's information. Thus, it requires users to indicate their gamification preferences before using the system. A particular theory that has been deemed appropriate to explain user behavior based on their motivational needs and preferences is SDT.

2.2. Self-determination Theory

SDT posits human behavior to differ in grades of internalization on a scale from internal to external engaged behavior. A simple approach to distinguishing motivations is the differentiation between intrinsic and extrinsic. Intrinsic behavior occurs out of inherent interest and enjoyment. The individual is motivated by the perception of the activity being enjoyable itself. In contrast, extrinsic-driven behavior is not inherent and the reason for engagement is external to the activity itself. Extrinsic motivation can be perceived in the form of tangible as well as intangible rewards (Deci & Ryan, 1985; Deci, Vallerand, Pelletier, & Ryan, 1991; Ryan & Deci, 2000a, 2000b). If an individual is intrinsically motivated, creativity increases, positive emotions are shown, and persistence is higher. Furthermore, intrinsically motivated behavior is more likely to be continued while performance is experienced as optimal (Reeve, 2018; Ryan & Deci, 2000a). Therefore, evoking intrinsic motivation is more favorable. The basis for intrinsic motivation is the support of three basic human psychological needs as suggested by SDT, namely *social relatedness*, *autonomy*, and *competence*. *Social relatedness* is the need to experience a sense of belonging to others, being connected, and caring for others. *Autonomy* represents the need of feeling in control of the own behavior and goals, being self-initiating, and engaging in self-regulating activities. *Competence* summarizes the need of experiencing mastery and learning skills while understanding how to attain possible internal and external outcomes by efficiently performing necessary actions (Deci et al., 1991). Overall, SDT has consistently proved reliable in explaining the underlying motivations of human behavior, which makes it a valuable source for designing information systems whose aim is to adapt to the specific motivational needs of users.

2.3. Player types

Comprehensive approaches to understanding users' individual preferences in the context of games and gamification are player types or user typologies. One popular typology in the gamification literature is the User Type Hexad model. Besides its focus on gameful design instead of game design, it is not tailored to a specific domain, enabling general applicability. Studies have shown promising results pertaining to the effects of adapting a system based on individuals' Hexad player types, including increased user acceptance and system usage (Böckle et al., 2018) or user performance (Lopez & Tucker, 2021). The Hexad scale proposes six different player types, which are either derived from intrinsic or extrinsic motivations, as defined by SDT (Ryan & Deci, 2000a). Derived user types can be understood as personifications of motivations, whereby the three intrinsic motivations from SDT, namely *relatedness*, *autonomy*, and *competence*, are extended with a fourth, that is *purpose* (Deci et al., 1994). The model was later empirically validated by Tondello et al. (Tondello, Mora, Marczewski, & Nacke, 2019). In summary, Marczewski (Marczewski, 2015) distinguishes user types by the degree they are motivated by either intrinsic or extrinsic factors. They are defined as follows (Marczewski, 2015; Tondello et al., 2016). *Philanthropist*: This player type is driven intrinsically by a sense of *purpose*, being motivated by altruism or the feeling of serving a higher purpose with their actions; *Socializer*: Socializers are motivated by *relatedness*, looking for interaction with others and creating social connections; *Free Spirit*: The primary motivation factor of this player type is *autonomy*, i.e. seeking for the freedom of self-expression without external control; *Achiever*: The main motivators for achievers are *competence* and *mastery*. Driven by challenges to overcome and being the best in completing tasks, they seek to prove themselves; *Player*: Motivated by the pursuit of extrinsic rewards, e.g., points and badges, this type of user always expects something in return; *Disruptor*: Disruptors are driven by change. Either positively or negatively disrupting a system, they are acting to force changes, testing the system, its boundaries, and trying to push them further.

Understanding the effects of adaptive gamification, classifying game elements, or investigating the fit be-

tween game elements and player types are components of various research work in the last years (F. Tondello, 2019; Klock et al., 2020; Böckle, Novak, & Bick, 2017; Hallifax, Serna, Marty, Lavoué, & Lavoué, 2019; Krath & von Korflesch, 2021). However, there is still a gap in understanding the role of users' individuality and the resulting sensitivity to the impact of gamification affordances (Koivisto & Hamari, 2019). A lot of research centers around user modeling, e.g. analyzing user preferences for different game elements to realize future adaptation, whereas attempts to measure the impact of adaptive gamification remain meager (Klock et al., 2020). Research provides conceptual frameworks on adaptation, but no or only little results on real-world adaptation (Böckle et al., 2018, 2017; Klock et al., 2020; Lopez & Tucker, 2021). Conclusively, there is still a lack of understanding of whether adaptive gamification in real-world applications can increase motivational and behavioral outcomes to the extent that it justifies the design efforts associated with the adaptation. It is also notable that most of the research about adaptive gamification is dedicated to the domain of education, which makes it challenging to transfer context-dependent findings to other fields (Rodrigues et al., 2021; Klock et al., 2020; Hallifax, Serna, Marty, & Lavoué, 2019). Importantly, to the best of our knowledge, personalized adaptive gamification has not been investigated in a crowdsourcing context. This work aims to extend research in the field of adaptive gamification to explore its effects in the context of gamified crowdsourcing in a real-world application.

3. Methods

The research question was investigated using a text-based adventure game called *STABILO Dungeon*, which is a gamified crowdsourcing approach for collecting handwriting data (see Fig. 1) and was developed by us using Unity 3D. Gamified crowdsourcing systems aim at using motivational affordances to increase user participation and harness the power of the crowd for solving tasks or problems (Morschheuser, Hamari, et al., 2017; Morschheuser, Maedche, & Walter, 2017). The purpose of our crowdsourcing solution is to engage people in writing words with an IoT device called Digipen to collect data for further development of Digipen's machine learning algorithms. The approach is played on a tablet that is wirelessly connected with the Digipen, a classic ballpoint pen equipped with sensors to detect movement and pressure of a persons' handwriting. The Digipen is used to write on standard paper. The handwriting is then digitized, displayed on a digital device (e.g. a tablet), and used to interact with the gameplay.

The core game mechanism of the *STABILO Dungeon*

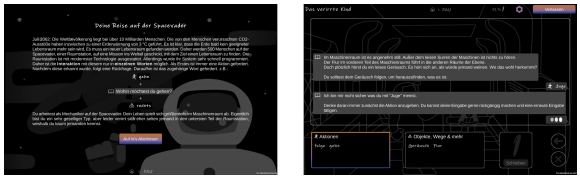

Figure 1: The *STABILO Dungeon* app. Left: storyline introduction. Right: gameplay using the Digipen.

is, as the key characteristic of an adventure game, primarily driven by a narrative. The player controls the main character of the narrative and can decide on the main character's actions at certain points of the story in order to decide on the further game progress (Cavallari, Heldberg, & Harper, 1992). A text-adventure as game frame was chosen as it, from our point of view, best fits the setup of an analog pen writing on paper interacting with a digital application running on a tablet. As a narrative framing, a spaceship has been selected on a journey to discover potential alternative planets for living, inspired by science fiction games.

Playing the game is simple. At predefined points in the story, users are invited to write down sequentially a combination of an action to execute, e.g., *go*, and a corresponding object, location, or expression, e.g., *left* or *kitchen*. The actionable activities a user can choose from are predefined and shown via the user interface. The character controlled by the player is moved in the environment to solve obvious or underlying tasks. While moving around, the character can not only interact with objects, but also Non-player characters (NPCs), which are part of the narrative.

3.1. Experiment design

For the experiment design, this work followed the framework for adaptive gamification proposed by Böckle et al. (Böckle et al., 2018). Böckle et al. (Böckle et al., 2018) suggest differentiating four main elements, namely purpose of adaptivity, adaptivity criteria, game mechanics and dynamics, and adaptive interventions. In this work, the purpose of adaptivity is to support participation in the crowdsourcing task and consequently increase the quantity of contribution. As an adaptivity criterion, the Hexad player types were decided to address the purpose, since it is one of the most relevant models to identify user preferences for game elements (Hallifax, Serna, Marty, Lavoué, & Lavoué, 2019). Finally, to decide what game mechanics, dynamics, and adaptive interventions are considered Bakkes et al. (Bakkes et al., 2012) was referred to. According to Bakkes et al. (Bakkes et al., 2012), different components of games can be considered as factors to tailor a game to its user. In this experiment, the adaptation of the game's narrative was chosen. Thereby, the present study extends research

on adaptive storytelling.

Beside the prior described development of the general application, three different narratives, further referred to as storylines, were designed. Thereby, the adaptive intervention manifests as personalized content. The storylines are constructed to especially satisfy intrinsic user needs, as inferred from SDT. Hence, the design corresponds specifically with the intrinsically motivated player types as of the Hexad model, namely *Achiever*, *Socializer* and *Free Spirit*, which are also among the most commonly observed types (Tondello et al., 2019; Krath & von Korflesch, 2021). In general, the focus for developing the adaptive storylines was on creating mechanisms for individual need satisfaction for the corresponding player types. For *Achiever* we considered features that give rise to *competence* perceptions (i.e., progress and challenge). Hence, the narrative was decided to focus on a quest to solve, including underlying challenges which can be mastered. Moreover, including feedback on mastery for succession is suitable for the narrative (Marczewski, 2015). In contrast, for *Socializer*, it is relevant to address the need for *relatedness*. As the experiment design does not allow for social interaction with other players, it was decided to focus on the integration of NPCs. Additionally, research shows that *relatedness* fulfillment is associated with having a meaningful role, taking care of others and feeling emphatic (Sailer, U.Hense, Mayr, & Mandl, 2017; Rigby & Ryan, 2011). Therefore, the narrative should include mechanisms for inducing empathy by taking care of somebody. Finally, for the *Free Spirit* the focus was on the need for *autonomy*. Prior research indicates that autonomy needs can be addressed by enabling freedom of decision and facilitating perceptions of task meaningfulness. (Marczewski, 2015; Rigby & Ryan, 2011; Ryan, Rigby, & Przybylski, 2006). Furthermore, *Free Spirits* are associated with *Easy Fun*. Therefore, it was decided that the narrative should not be restrictive, but that the users themselves can choose the sequence of a task. Moreover, the narrative should include possibilities for meaningful branching choices, meaning options for the user to influence how the narrative continues. Additionally, the narrative should support exploration and offer unexpected content. An overview of the designed storylines and main mechanisms for need satisfaction can be found in Tab. 1. The storylines are introduced in detail in the following, including practical mechanism examples.

In the *Achiever* storyline, the user's character was introduced to serve as a night guard while a meteorite shower hits the spaceship. Consequently, the power supply of the spaceship is damaged and needs to be repaired immediately to save the rest of the crew. Therefore, the users' primary role is to identify the root cause of the power supply damage, find suitable tools for repairing, and finally fix the damage. Meanwhile, the user receives positive feedback about progression for every underlying challenge solved. Thus, the story aims to reflect a quest with underlying challenges and is enriched with motivating feedback of mastery - all serving to affect the need for *competence* (Marczewski, 2015).

Table 1: Developed adaptive storylines.

Player type	Mechanism for need satisfaction
Achiever	Quest, underlying challenges, Feedback of mastery
Socializer	Non-player characters for interaction, Meaningful role, Emphasis, Care taking
Free Spirit	Freedom of choice over sequence of tasks, Meaningful choices

The storyline developed for *Socializers* distinguishes as it introduces the users' character as trying to help a little girl who got lost to find her way back. This can only be achieved by interacting and being supported by other NPCs, e.g., asking for chocolate to calm the girl or being directed to where to find support. In contrast to the previously described story, the quest is structured to be subconscious, and the character is described as being driven by social aspects, i.e., empathy, and caretaking. Thereby, it is the only storyline where NPCs appear, as well as it aims to evoke empathy and transport a need for caretaking by taking on a meaningful role. Thus, this storyline presumes to satisfy the need for *relatedness* (Sailer et al., 2017; Rigby & Ryan, 2011; Marczewski, 2015).

Lastly, the storyline adapted to *Free Spirits* differs from the previously described as it does not require a fixed sequence of actions but gives the user the freedom of choice. The character is introduced to having the opportunity to explore the spaceship, visit different rooms, and interact with different things. In the story, exploration is encouraged, and choices regarding how the story continues are available, e.g., whether the user wants to plant tomato or pepper seeds or whether the user wants to send out a rover to explore another planet or keep it. Thus, it aims at satisfying both aspects of *autonomy*, namely *autonomy* in regards of freedom of decision and *autonomy* in regard to task meaningfulness - offered through the possibility to make branching decisions (Marczewski, 2015; Rigby & Ryan, 2011; Ryan et al., 2006).

3.2. Experiment procedure

The research follows an experimental between-subject design. In Fig. 2 a summary of the experimental procedure can be found. Before the randomized experiment, the participants were introduced to the application's aim to collect handwritings to train the writing recognition of the Digipen. However, they were not instructed to the experiment being about adaptive gamifi-

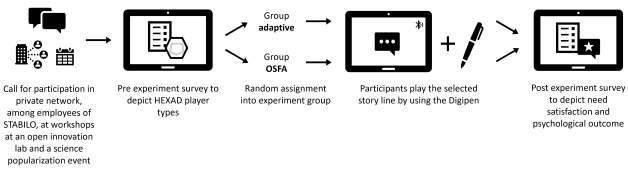

Figure 2: Experimental procedure.

cation. Participants are asked to provide demographic information, e.g., year of birth, gender, and handedness, when starting the application. Furthermore, they are asked to rate the Hexad scale items on a seven-point Likert scale presented in a randomized order. However, no information about if and how the rating affects the game is given. Next, the participants are randomly assigned to one of the experiment groups, namely OSFA or adaptive. Based on the experiment group, the storyline is selected. Afterwards, the participants play the chosen storyline by using the Digipen. The users can either play the story until it is finished or can leave the game at any time. Finally, after leaving the game, the user is asked to fill out a final questionnaire. The items of the post-experiment questionnaire intended to measure need satisfaction and motivational outcomes. Items are presented in a randomized order and are rated on a seven-point Likert scale. The experiment was presented on two consecutive weekends at an open-innovation laboratory in the city-center of Nuremberg, as well as at a science popularization event in Nuremberg. Further, several participants were recruited in private networks and among employees of STABILO. The experiment was conducted between the end of January and the end of May 2022. All users received STABILO pencils worth €1-5€ for their participation. The experiment groups differ in whether participants are exposed to the - based on the Hexad scale - best fitting storyline (adaptive) or to a randomly selected storyline (OSFA). The storyline is the independent variable manipulated in the between-subject design.

3.3. Participants

In total, 157 participants completed the experiment. Of those 19 were excluded due to detected patterns in the survey results. Patterns are referred to as either all items rated the same way, or consequent descending or ascending item rating. Additionally, the handwriting recognition is only trained for right handed people which is why three participants were excluded as they are left handed. In summary, this concludes in 135 participants which are considered in the evaluation.

Among the participants, more than half were female and the average age is 35.4. An overview of the participants' demographics can be found in Tab. 2. The

Table 2: Participant demographics.

Gender	**n**	**%**	**Age**	**n**	**%**
male	56	41.5 %	less than 20	17	12.6 %
female	74	54.8 %	20-29	47	34.8 %
unknown	5	3.7 %	30-39	24	17.8 %
			40-49	12	8.9 %
			50-59	23	17.0 %
			higher than 60	7	5.2 %
			unknown	5	3.7 %

experiment differentiates between two groups, namely adaptive and OSFA. Assignment of experiment group happened randomly. 69 participants were assigned to the adaptive group and 66 participants were assigned to the OSFA group. In the adaptive group the participants played the storylines designed for its main player type out of the SDT based player types. In contrast, in the OSFA group, participants were randomly assigned to one of the storylines. As a result it can occur that participants, even if assigned to the OSFA group, are playing the potentially best fitting storyline. However, the assignment was performed randomly as the proposed design reflects how practical realization would look like when designing one approach for all user.

3.4. Measures

To realize the experiment and evaluate its results, different measures were used.

Pre-experiment questionnaire The pre-experiment questionnaire surveyed for the users' Hexad types. The Hexad survey was presented in German (Krath & von Korflesch, 2021). Items were operationalized via a seven-point Likert scale and presented in a randomized order.

Behavioral outcomes To investigate the gamification conditions' effects on behavioral outcomes, the users' *crowdsourcing participation* was measured. Crowdsourcing participation is operationalized as whether the participant has finished the storyline. The number of handwritten words per user was not considered, due to methodological considerations. The amount of handwritten words is confounded with the algorithm's performance, not allowing to obtain them independently. Additionally, participants may execute actions not directly related to the successful completion of a task.

Post-experiment questionnaire The post-experiment questionnaire surveyed for perceived intrinsic need satisfaction and motivational outcomes. Table 3 provides a detailed overview of the survey constructs, a description, and from where they were adopted. All items were derived from previously published sources and measured along a seven-point Likert scale presented in a randomized order. For items with no German translation available in literature, three native speakers with C1 English proficiency provided

Table 3: Post experiment survey constructs. UPEQ by Azadvar and Canossa (2018), PENS by Ryan et al. (2006), and GAMEX by Eppmann et al. (2018).

	Construct	Adapted from
Intrinsic need satisfaction	*competence*	UPEQ
	autonomy	PENS
	relatedness	UPEQ
Motivational outcomes	*future play*	Ryan et al.
	absorption	GAMEX
	enjoyment	GAMEX

independent translations, which were refined by considering a consensus and closest word equivalence (Brislin, 1976).

For measuring perception of intrinsic need satisfaction, items of PENS and UPEQ were utilized. Both scales find their theoretical background in SDT. Moreover, UPEQ was developed as a transformation of existing SDT based surveys, including PENS. Besides the similarities, UPEQ offers a larger validation sample and more importantly involves in the contextualization of *relatedness* sociality with NPCs. Thus, UPEQ was used instead of PENS for the *relatedness* and *competence* constructs in this work.

As motivational outcomes in this work, *enjoyment*, *absorption*, and *future play* were assessed. *Absorption* and *enjoyment* both were measured by items derived from GAMEX. GAMEX was explicitly designed for gamification instead of games and is generalizable to different gamification contexts, or applications (Eppmann et al., 2018). Lastly, evaluating the player's *future play* intention was assessed by items adopted from (Ryan et al., 2006). Testing the post-experiment survey model and constructs was realized using component-based PLS-SEM in SmartPLS 3.

Convergent validity was assessed via Cronbach's α (> 0.7), Average Variance Extracted (> 0.5), and Composite Reliability (> 0.7) (Fornell & Larcker, 1981; Nunnally, 1978). All constructs' convergent validity metrics were met, as they are higher than the thresholds given. Discriminant validity of the post-experiment questionnaire was assessed by confirming that each items' loading is highest with its corresponding construct and comparing the square root of each constructs' AVE with inter-correlations of the other constructs. Besides the construct of *competence*, where the inter-correlation between *competence* and *enjoyment* exceeds the square root of the AVE, discriminant validity was met according to the Fornell-Lacker criterion.

4. Results

In summary, playing the *STABILO Dungeon*, 8,563 crowdsourced handwritten words were collected.

Motivational outcomes As Fig. 3 shows, the distributions of the motivational outcomes, perceived *enjoyment*, perceived *absorption* and *future play* intention, show no clear difference between the experiment groups. This is reiterated by the result of a one-sided Mann–Whitney U test (see Tab. 4), where no significant difference is evaluated. Deepening the analysis to the storylines, it can be found that in fact some motivational outcomes are higher for the adaptive group. However, performing a one-sided Mann–Whitney U test, no statistical significant greater results can be found. A Mann–Whitney U test is performed due to the non-parametric nature of the Likert scale used to assess the outcomes.

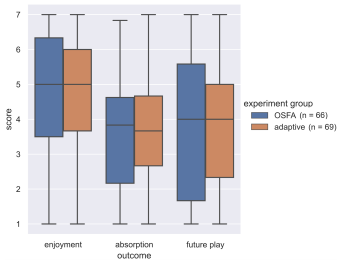

Figure 3: Motivational outcomes per experiment group.

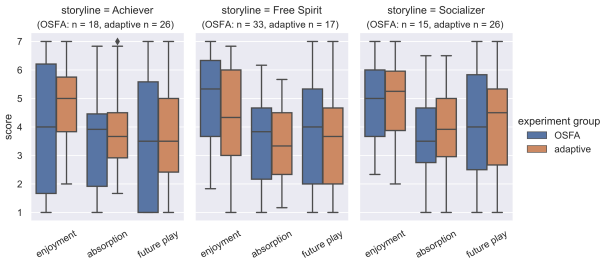

Figure 4: Motivational outcomes per experiment group and per story.

To assess the relationships between the independent and dependent variables, a correlation analysis between the intrinsic need satisfaction and motivational outcomes is performed. As the Likert scale is of non-parametric

Table 4: One-sided Mann–Whitney U test results of motivational outcomes adaptive to OSFA group.

outcome	storyline	Δ mean	p
enjoyment	Total	0.10	0.47
	Achiever	0.85	0.17
	Free Spirit	−0.58	-
	Socializer	0.10	0.39
absorption	Total	0.15	0.31
	Achiever	0.27	0.31
	Free Spirit	−0.19	-
	Socializer	0.24	0.28
future play	Total	0.05	0.42
	Achiever	0.38	0.24
	Free Spirit	−0.38	-
	Socializer	0.04	0.49

Table 5: Kendall's τ correlation between perceived satisfaction of individual intrinsic needs or general need satisfaction and motivational outcomes (*** p<.001).

	enjoyment	*absorption*	*future play*
autonomy	0.65***	0.53***	0.63***
competence	0.69***	0.47***	0.57***
relatedness	0.45***	0.51***	0.52***
intrinsic need satisfaction	0.68***	0.57***	0.66***

Table 6: Δ Crowdsourcing participation adaptive to OSFA group and two-sample proportions z-test results.

storyline	**Δ proportion**	**p**
Total	8.70%	0.1326
Achiever	24.79%	0.0501
Free Spirit	0.89%	0.4740
Socializer	-2.05%	-

nature, Kendall's τ was utilized for the analysis. Tab. 5 presents the correlations of the perceived intrinsic need satisfactions and the motivational outcomes. Overall, the correlation results reveal highly significant correlations between the perceived intrinsic need satisfactions and all motivational outcomes. Deepening the analysis to individual correlations, *relatedness* shows the lowest correlation with *enjoyment*, whereas *competence* shows the highest correlation with *enjoyment*. Next, with *absorption*, *competence* and *relatedness* show both similar correlations, which are slightly exceeded by the correlation between *absorption* and *autonomy*. Finally, for the correlation with the intention for *future play*, *autonomy* shows the highest correlation. Relatedness shows the lowest correlation with *future play* intention, which is however still high. Moreover, as SDT posits as basis for intrinsic motivation the support of all three basic human psychological needs, also the perceived intrinsic need satisfaction as a combination of the three factors *competence*, *relatedness* and *autonomy*, and its relation with the motivational outcomes is explored. As seen in Tab. 5 the sum of perceived intrinsic need satisfaction and the motivational outcomes are all strongly correlated and highly statistically significant.

Behavioral outcomes Measuring the effect of adaptation on behavioral outcomes is realized by investigating the *crowdsourcing participation*, operationalized as whether a storyline has been finished by the participant or not. Table 6 summarizes the Δ proportion of finished storylines between the experiment group.

The *crowdsourcing participation* is higher in the adaptive group compared to the OSFA group. Deepening the analysis to the individual storylines, especially the *Achiever* storyline shows a great difference between the proportion of participants who finished the story in the adaptive group versus the ones in the OSFA group. Contrary, for the *Socializer* storyline, the proportion of participants who finished the storyline of the OSFA group is slightly higher than the one of the adaptive group. Analyzing whether the differences between the proportions are significant, a two-sample proportions z-test did not reveal significant results.

5. Discussion

This research explored the effectiveness of adaptive gamification in comparison to OSFA approaches in the context of a gamified crowdsourcing use case for collecting data on people's handwriting. The experiment (n=135), which followed a between-subject design, revealed no significant effects on psychological and behavioral outcomes when using adaptive gamification designed to address the prevailing motives and needs of *Achiever*, *Socializer*, *Free Spirit* Hexad player types. Importantly, the outcomes of personalizing the experience were not significantly higher than in the OSFA group (here a randomly selected gamification design).

In more detail, the approaches designed for *Achievers* and *Socializers* resulted in motivational outcomes that are higher when played only by these player types in the adaptive group compared to the OSFA group. However, testing for empirical evidence, no significant differences could be observed. Contrary, for the *Free Spirit* approach, motivational outcomes of the OSFA group even exceed the adaptive group. Further, analyzing the relation between individual, i.e., perceived *competence*, *autonomy* and *relatedness* need satisfaction, or overall need satisfaction with the motivational outcomes reveals more interesting findings that need to be considered (see Tab. 5). Not only the perceived satisfaction of every individual need was significantly correlated with every outcome, independent of a users' player type, but also the overall perceived need satisfaction. These results are consistent with other research (Ryan et al., 2006; Ijaz, Ahmadpour, Wang, & Calvo, 2020; Huotari & Hamari, 2016; Rigby, 2015; Reeve, 2018; Ryan & Deci, 2000a) and generalize the tenacity of SDT in gamification research. Taking this into account, it can be argued, that even if player types, such as the considered Hexad player types approach, classify users in categories based on their prevailing motives and needs, it is necessary to not only focus on the fulfillment of those individual needs but instead consider offering mechanics to satisfy needs on a broader scale. Our results indicate, that independent of the user's player type, opportunities to satisfy multiple psychological needs are required, as also posited by (Ryan et al., 2006).

5.1. Practical implications and future research

First, in line with our result that users should be provided with the possibility to satisfy multiple psychological needs, system designers are advised to implement

gamification features that can satisfy a wider spectrum of intrinsic needs rather than focusing on a very limited array of features that only target specific needs of a single player type. However, these features need to be carefully selected to align user motivation and behavior with the goals of the system, rather than including as many features as possible, as this can otherwise result in unintended consequences, such as motivational interference or distraction (Riar, Morschheuser, Hamari, & Zarnekow, 2020; Riar, 2020). A possible solution to selecting only a limited but targeted set of features while at the same time provide users with a multitude of motivational outcomes, may involve designing a narrative in which users can go through different phases or even cycles of need satisfaction (e.g., address competence needs for initial fun and onboarding, then shift to socialization to bind users, e.g., emotionally, and incrementally give users room for exploration and freedom of choice to strengthen autonomy).

Second, our research indicates that the source for satisfying a specific psychological need (e.g., competence) may vary in conjunction with the different player types. For instance, in the present experiment a *Free Spirit* might perceive competence because of having mastered to explore all rooms in the spaceship of the story. In contrast, an *Achiever* perceives competence because of the mastered challenge. This may explain how one gamification approach can satisfy the same psychological need of distinct player types and is in support of previous research that demonstrates that one gamification design can enable players to satisfy multiple needs (Xi & Hamari, 2019). We encourage future work to further investigate this assumption of different kinds of perceptions of needs for different player types.

Third, the results of the present study suggest that while adaptive gamification is an intriguing concept, questions remain whether and under what circumstances it may be effective and worth the effort, as it may not always lead to the desired outcomes in real-life contexts. This is in line with previous research that similarly found adaptive gamification to be non-significant e.g., (Lopez & Tucker, 2021; Tondello & Nacke, 2020; Schubhan et al., 2020; Mora, Tondello, Nacke, & Arnedo-Moreno, 2018; Lavoué, Monterrat, Desmarais, & George, 2018; Monterrat, Lavoué, & George, 2017). Thus, this work challenges the assumption of the effect of adaptive gamification based on Hexad player types. To move the field forward, it is necessary to further explore the potential of adaptive gamification and what could lead to a breakthrough in terms of its effectiveness. In particular, prior research is highly invested in exploring adaptation based on human need and player type frameworks, as in the present study, whereas other potentially relevant aspects are largely overlooked. For example, players' needs can hardly be categorized once and are then set in stone. Rather they may be highly dynamic and dependent on other factors that need further exploration, such as player mood. In addition, there may also be other more stable factors that are underexplored in the literature stream on adaptive gamification, such as personal values. The roles of unstable factors (such as player mood) and more stable factors (such as personal values) could become intriguing future waypoints for advancing our knowledge regarding toward what end adaptive gamification needs to be designed. While this poses new challenges for designers it also offers new opportunities for research to further investigate the potential of adaptive gamification.

5.2. Limitations

A limitation of this study is that it was built on hardware, which has not yet reached market maturity. Thus, the possibilities for recruiting participants were restricted by the number of Digipens available to us. However, the missing market maturity should not have impacted the experiment results. Anyways, it is suggested to further extend the research with a bigger group of participants to substantiate the findings. Moreover, future research is recommended to investigate comparable approaches with other crowdsourcing applications and in other contexts in order to contribute to the generalizability of the results. Despite the limitation, the present study provides important insights into adaptive gamification, including practical implications and potential avenues for future research.

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