EXPLORING THE APPLICATION OF THE DIGITAL GAMIFICATION MECHANISMS TO THE EXPERIENCE OF PHYSICAL ARCHITECTURAL EXHIBITIONS

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Abstract. This study aims to respond to the 'human-centred' theme of digital heritage and visualisation by exploring a new approach to applying gamification mechanisms to design physical architectural exhibitions. This paper analyses the current exhibition's gamification design in three parts-core drivers, defining characteristics and development models. Then constructs a design model for "digital gamification". The history museum of Harbin Institute of Technology (Shenzhen) is selected as an example to conduct an empirical investigation. Finally, future experiments are proposed to evaluate the design process's effects on improving the platform's design. It is expected that the demonstration of this study will enrich the exploration of the application of the emerging design method of digital gamification mechanism in exhibition design. On the one hand, it attempts to construct the relationship between the influence of digital gamification mechanisms on the tangible and intangible information in the audience's cognitive space, thus providing new ideas for designing cultural experiences in future exhibition spaces. On the other hand, it gives new vitality to the exhibition design and enhances the audience's motivation to interact, which helps to expand cultural communication's influence.

Keywords. Exhibition Space, Experiential Mechanism, Digital Interaction, Gamification, Extended Reality

1. Introduction

In the new era, the transformation of the function of exhibition space has facilitated the exploration of innovative ideas for its design. Traditionally, the primary role of exhibition space was to collect and research and the collection is the centre of its attention. As a result, the spatial planning and design often differentiate and cluster exhibits according to their country, theme, age and other attributes. Spatial elements such as lighting and scale serve to give a better picture of the exhibits in their entirety. Visitors are also encouraged to follow the design routes to view the exhibits. However,

HUMAN-CENTRIC, Proceedings of the 28th International Conference of the Association for Computer-Aided Architectural Design Research in Asia (CAADRIA) 2023, Volume 1, 717-726.

as the social roles and functions of exhibition space have gradually diversified, maximising social value has become a primary objective in the design of exhibition spaces.

Recent research trends have found that entertainment and games can support the learning and educational mission of exhibition space as a place of informal learning, enhancing the cognitive efficiency and experience of people in the space. On the one hand, digital interactive technologies are used to enrich the presentation of cultural information and increase the sensory engagement of the audience. On the other hand, playful elements stimulate the audience's behavioural motivation and promote spontaneous learning and exploration based on personal interests in the spatial experience. However, gamification mechanisms are often combined with virtual technologies for building online platforms for displaying interactive experiences, with less research on the combination and application of physical environments.

For this reason, this paper uses digital technology and gamification as tools to explore a new exhibition experience design model for visitors to interact with space offline. Firstly, based on the literature study, we analyse the gamification design in current exhibition design applications regarding core drivers, defining characteristics and development models. Combine extended reality technology and gamification mechanisms to build a new design method to explore interactively in natural spaces. The design model of "digital gamification" was developed. Based on the design model, an empirical study of the "Objective-Analysis-Design" process was completed by taking the School History Hall of Harbin Institute of Technology (Shenzhen) as an example. The digital gamification design guides and stimulates audience interaction and continuous participation, thus enhancing the audience experience and promoting their participation and sharing (Figure 1).

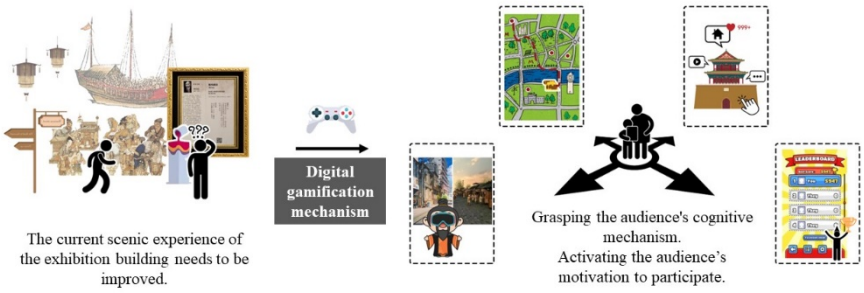

Figure 1. Digital gamification mechanisms to enhance the exhibition experience

2. Overview of gamification's concept and its application

The definition of 'gamification' varies somewhat between scholars. However, Deterding provides a more widely accepted concept of gamification as a mechanism for using game design elements in non-game contexts to improve user experience and engagement(Deterding, S., 2011).

Scholars cite different grounded theories from cognitive and social psychology to reveal the effects of gamification, with self-determination theory (SDT) and mind-flow theory being the most commonly used theories. Self-determination theory is

commonly used in gamification to derive the effects of game design (Wee, S. C., 2019) . It analyses human behaviour in terms of its intrinsic and extrinsic motivational components. Although the positive effects of extrinsic motivation are short-term, they can be combined with, or even transformed into, intrinsic motivation when fully internalized or conscious(Ryan, R. M., 2020) and thus enhance the user's perception of experience and behavioural autonomy more sustainably. Flow is a psychological concept that means "the experience of forgetfulness that occurs when people complete a difficult task that matches their skills" (Csikszentmihalyi, M., 1991). When there is a balance between personal skill and challenge, people enter a state of mind flow where they are highly focused, and their behaviour and consciousness are integrated. Clear goals and immediate feedback in the game elements can positively affect the maintenance of this state.

The concept of gamification has formed a complete theoretical research framework in terms of validity, game elements, intrinsic motivation and impact assessment. It is currently focused on specific application strategies and design frameworks. In the exhibition design, specific applications of gamification mechanisms include electronic guided tours, digital interaction of cultural heritage, virtual exhibition galleries, awareness-raising and education, and cultural exchange. Interactions include fully online virtual game interactions, virtual interactions based on extended reality technologies (VR/AR/MR) and fully offline physical prop interactions. In terms of interactivity, the amount of information presented, and the enhanced perception of the physical environment (Figure 2), the interaction forms based on extended reality technology are better able to enhance the audience's connection to the actual environment while increasing the fun of the experience. The physical presence and atmosphere of the actual environment enhance the embodied nature of the audience's experience. This paper, therefore, explores the mechanics of digital gamification based on extended reality.

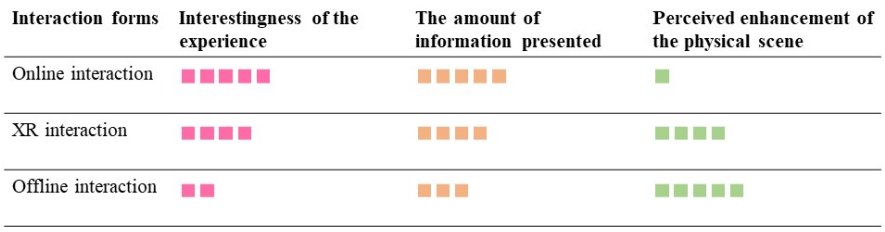

Figure 2. Comparison of interaction forms of gamification mechanisms

3. An application framework of digital gamification platforms in the design of exhibition spaces

3.1. THE DRIVERS AND DEFINING CHARACTERISTICS OF GAMIFICATION

Based on theoretical research, Jane summarised four defining characteristics of gamification: goals, rules, feedback systems and voluntary participation (McGonigal, J., 2011). (1) goals are used to focus the user's attention on a point so that a specific outcome is achieved, i.e. to provide the user with a purpose for their behaviour. (2) rules are used to guide the player into the story situation set by the game. By setting certain constraints to limit the user's goal attainment, the user gains a sense of achievement and engagement in overcoming obstacles. However, the difficulty setting of the rules needs to consider the individual ability differences of the participants to avoid forming a participation threshold. (3) the feedback system can prompt the difference between the player's current progress and the overall goal, which helps the user to control their behaviour during the experience. (4) voluntary participation means that the player can consciously and voluntarily choose the game tasks or goals. These four factors - goals, rules, feedback systems and voluntary participation - work together to achieve the four primary purposes for which users play the game - to be satisfied with their work, to experience success, to build social interaction and to participate in ambitious endeavours (Figure 3). In line with the laws of behavioural psychology theory, the user experience is enriched, enhancing the game's appeal and the user's willingness to participate. This fits with the objectives of the exhibition design experience that this study aspires to achieve and is also applicable to the design of this digital gamification mechanism.

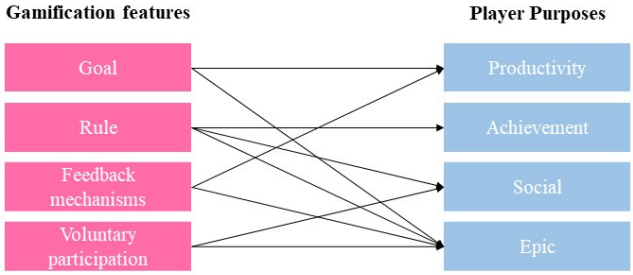

Figure 3. Gamification defining features and player purpose

3.2. GAMIFICATION DEVELOPMENT MODEL

The MDA model is widely accepted for explaining game design from a systems perspective. It divides the game system into three distinct components: Mechanics, Dynamics and Aesthetics. Mechanics are the underlying logic at the algorithmic and data level the designer has set up for the game. Dynamics is the interaction between user behaviour and the game. It serves as the interface between the designer's mechanics and the aesthetics of the player's experience, on the one hand showing the player the feelings the designer wishes to convey and, on the other hand providing user feedback to the designer to make adjustments to the game mechanics. Aesthetics, on the other hand, describe the emotional changes that occur as the user moves through the dynamic process and include eight core descriptions: Sensation, Fantasy, Narrative, Challenge, Fellowship, Discovery, Expression, Submission(Hunicke, R., 2004). The MDA model enables a two-way interaction between the designer's goals and the user's experience, which constitute the game's use and entertainment value.

As a model with a high degree of abstraction, MDA reflects the underlying logic of

gamification design but is not a sufficiently concrete and clear approach suitable for guiding practical design. It is a multidisciplinary process involving psychology, design and computing. How can this series of processes be effectively linked? Based on this question, Benedikt reviewed the literature on gamification design methods. They found that most gamification developments follow seven similar main stages: "project preparation - pre-analysis - gamification conception - concrete design - platform building - evaluation of success - monitoring and management" (Morschheuser, B., 2018).

On this basis, combined with the characteristics of the exhibition building space and the above analysis, the digital gamification design process built in this paper is shown in the following diagram

(1) Objectives. Collect the objectives of each stakeholder. Validate the reasonableness of the objectives under the basic principle of achieving mutual benefits for the organisational side and the stakeholders. As multiple objectives can blur the user's attention in the gamification experience, 1-2 objectives need to be selected as the most worthwhile to achieve based on the priority of the objectives.

(2) Analysis. Analysis refers to sorting out and analysing existing conditions within the space. Firstly, it summarises the tangible information (spatial scale/function, exhibits) and intangible information (stories, legends, customs, etc.) that needs to be conveyed within the exhibition design; secondly. It builds a logical network of relationships between all the information and classifies the level of importance according to its cultural value.

(3) Design. Using the rules as a thread, string together the ideas from the first two stages to form an abstract conceptual prototype. The prototype is refined through feedback.

(4) Development. Development can be divided into two phases: content development and technical development. Content development enriches the abstract game prototype into a complete interactive script guided by the objectives defined in the early stages and designs appropriate plot contexts and gamification mechanisms. At the same time, combined with real space, the five elements-"spatial nodes - cultural information - plot settings - interaction modes - gamification elements" are linked to building an implementable script content.

After content development, technical development begins, including asset library creation - application development - interaction deployment. Firstly, the creation of the asset library includes 2D assets (UI interface, icons) and 3D assets (live scans, tasks, actions, effects, digital exhibits). Secondly, a gamification application is developed using the Unity platform, guided by a script. Finally, the application is imported into XR devices such as Hololens to complete the interactive deployment and achieve an immersive experience for visitors.

(5) Evaluation. Quantifying the user experience in terms of both objective and subjective data. Objective data includes eye movement data (visual heat map, visual dwell time, visual transition state) and behavioural data (walking trajectory, dwell time, interaction behaviour). Subjective data include questionnaires, interviews and personal perception mapping etc.

Through the evaluation of subjective and objective data, on the one hand, the effect

of the digital gamification mechanism on visitors' experience enhancement and knowledge learning can be derived through their subjective experience feelings and mapping. On the other hand, grasping visitors' cognitive behaviour patterns in the process of gamification experience can provide data reference for the subsequent optimisation and improvement of the digital gamification mechanism.

4. An empirical exploration of digital gamification platforms

4.1. OVERVIEW OF RESEARCH SUBJECTS

The History Hall of Harbin Institute of Technology (Shenzhen) is located inside the Shenzhen Campus of Harbin Institute of Technology in Nanshan District, Shenzhen, Guangdong, China. It is a permanent thematic exhibition intended to introduce the long history of the university, its structure, its work and its outstanding research achievements to the university's staff, students and foreign visitors.

The exhibitions in the exhibition hall are rich in content, spanning a wide range of periods. At the same time, the exhibition information is presented mainly in the form of graphic panels, partially supplemented by digital media technologies such as panoramic video roaming and interactive projections. People often need to visit and learn on their own in the exhibition hall without a conventional guided tour. There is much room for improving their cognitive experience, so this space is an object of empirical evidence for exploring digital gamification mechanisms.

4.2. APPLICATION OF DIGITAL GAMIFICATION MECHANISMS

4.2.1. Objective

The nature of the exhibition is a single propaganda function, with a clear and fixed theme and a small number of stakeholders, including the school administration, staff and students, and external guests. Therefore, the museum aims to introduce the history and achievements of the school in a systematic way and to promote the school spirit.

4.2.2. Analysis

By sorting out the information within the space, a logical relationship diagram of the exhibition content can be constructed from two dimensions: the object to which the information belongs and the information hierarchy (Figure 4). After overlaying the different coloured information layers with the current flow of the exhibition, it can be found that the current flow generally follows the sequence of information narration from macro to micro, from cause to effect. However, there is still a localised mix of colour blocks in the overall space (Figure 5). This reflects the intersection of different layers of information in the arrangement of the existing spaces (Figure 6). It also reflects, to some extent, the difference between the traditional, object-centred layout

logic and the human perception-centred logic of gamified layout.

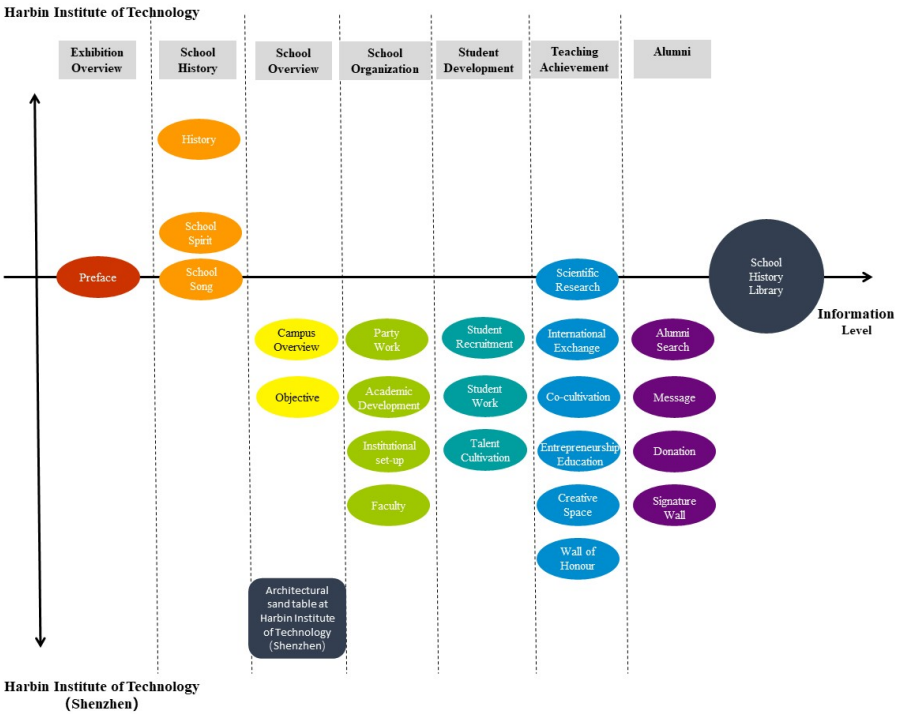

Figure 4. A logical diagram of the exhibition content

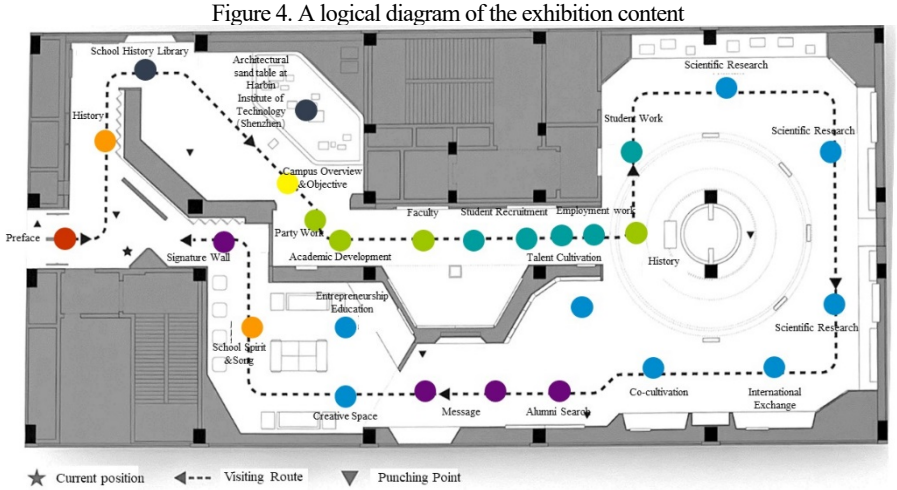

Figure 5. Projection of gamification logic in real physical environment

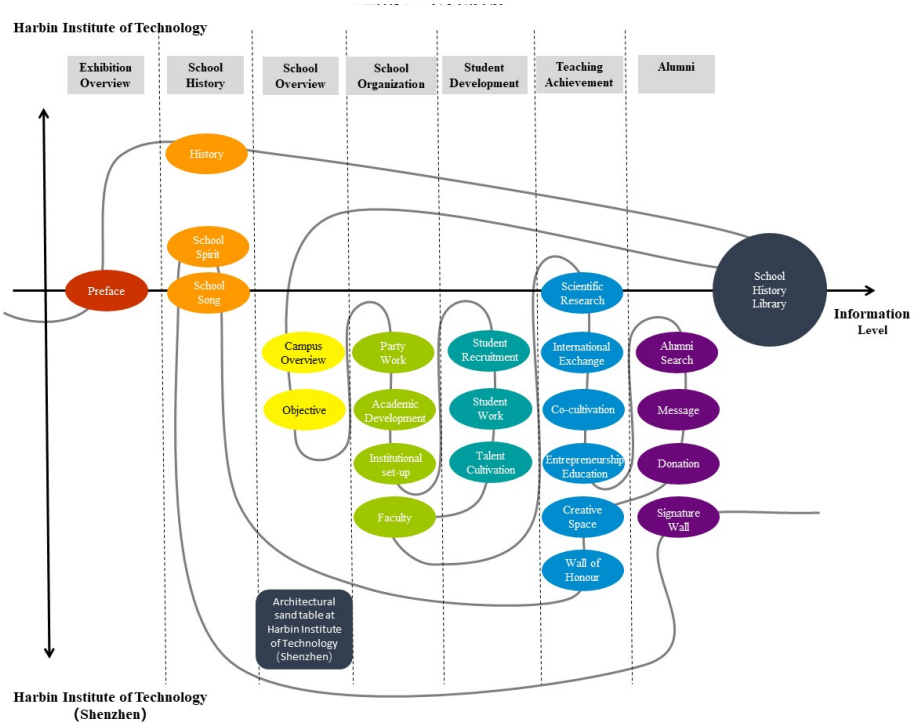

Figure 6. Current layout logic

4.2.3. Design

Considering the limited cognitive energy of the audience, it is not easy to experience the completion of all sections of the exhibition content. It is, therefore, necessary to

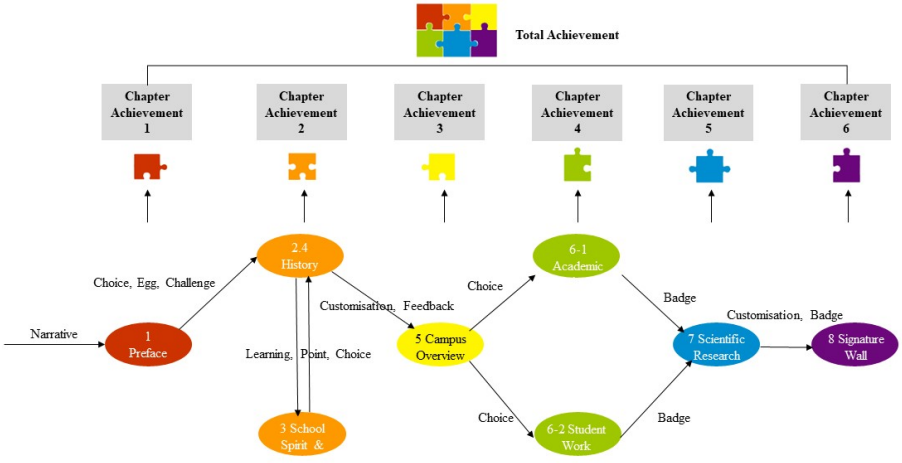

Figure 7. Prototype diagram for gamification design

classify information into two categories, "must complete" and "choose to complete", based on (1) effectiveness in terms of goal attainment and (2) importance of the information. "Must-complete" refers to the storyline experience that the user must participate in during the visit. "Opt-in" means the user can choose at least one of the same type of episodes to participate in and then move on to the next stage of the experience. After completing the information segmentation, appropriate gamification elements are selected to link the information content and build the game prototype diagram (Figure 7).

4.2.4. Content development

Considering that the exhibition's objective is to introduce the school's history and spirit systematically, the plot of this digital gamification mechanism is set in the context of a commission that "I" receive from a person who has lost his memory. "I" need to go back in time and help the amnesiac to recover his lost memories. The game's goal is to answer two questions posed by the amnesiac: 1. Who is he? ； 2. What did he do?

The game mechanic is: visitors follow the cursor to the plot points in the space and complete the plot exploration and tasks at each station to obtain the corresponding "memory fragments". The "memory shards" completeness is linked to completing the quest at that station. Once all the "fragments" have been collected, the visitor can retrieve the complete memory and complete the commission (Figure 8).

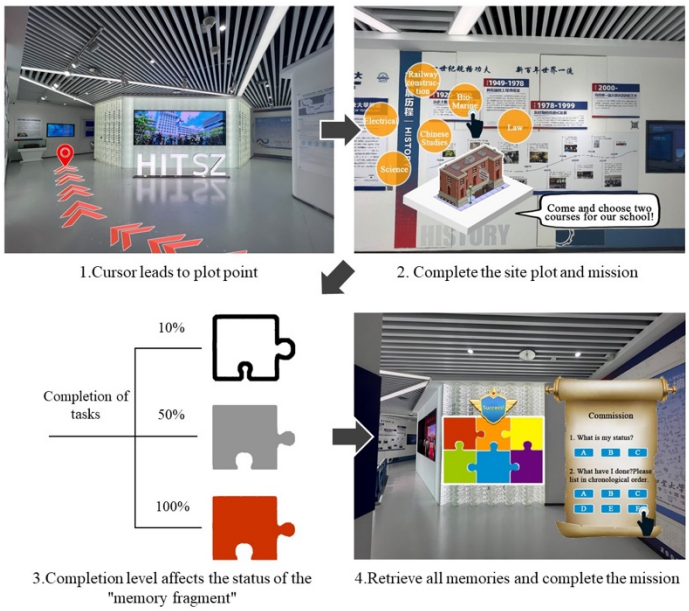

Figure 8. Diagram of the game mechanic

The plot points and the flow of the school history museum were identified based on the previous prototype game map. The design of the interactive script is based on this.

5. Conclusion

Theories on how gamification mechanisms affect people's motivation, behaviour and learning in different contexts are well documented. However, research into the integration of digital gamification mechanisms with the design of scenic experiences in natural exhibition spaces is still at an exploratory stage.

Based on the basic model and decisive characteristics of gamification, this paper constructs a digital gamification design model. In the specific application of the History Museum of HIT (Shenzhen), the content layout will show different logical states under the gamification design and the traditional design mechanism.

However, as the application process of "design-develop-implement-evaluate" for digital gamification mechanism is a longer-term process, this paper has only explored it to the content development stage. Further empirical research in real-life spaces is required to evaluate the effectiveness and impact of this design approach. In the future, the design approach can be improved and refined in light of practical experience. It is also necessary to determine the effectiveness of specific gamification elements in depth. This will enable the most appropriate elements to be selected for application in the design of future exhibition spaces, further enhancing the positive effects of digital gamification mechanisms.

Acknowledgements

This research is supported by the following funds: National Foundation for Philosophy and Social Science Late Grant Project (No. 19FXWB026); Science and Technology Plan Project of Guangdong Province (No. 2017A020220011).

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