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Exploring the influence of gamified learning on museum visitors' knowledge and career awareness with a mixed research approach

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In recent years, museums have become valuable venues for students to develop career awareness outside of school. However, optimizing the educational potential of museums and improving learners' outcomes presents a significant challenge in museum learning design. This study integrates three main game elements—goals, stories, and role-playing—into museum visits to design a Gamified Learning Activity (GLA). To verify the effectiveness of the GLA, we conducted a quasi-experiment with 66 elementary school students at the Handicraft Museum. Using a mixed-methods approach with convergent parallel design, we collected quantitative data from knowledge tests and qualitative data from DAST (Draw-a-Scientist-Test) and interviews for a comprehensive analysis. The results showed that learners who participated in the GLA paid more attention to the details of the handicrafts, appreciated the craftsmen more, and eliminated stereotypes about the age of craftsmen. This indicates that the GLA not only enhances learners' acquisition of museum knowledge but also has a profound impact on their non-cognitive aspects, such as career awareness.

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Introduction

Career development begins during childhood and continues throughout a person's life (Hartung et al., 2008; Super, 1990). Researchers emphasize the importance of "one's talents and interests or understanding the opportunities and requirements of various career fields", a concept known as career awareness(Braverman et al., 2002; Hartung et al., 2005). This has always been a hot topic of research and practice (Kier et al., 2014; Hartung et al., 2008). In the U.S., employment and entrepreneurship education courses are widely offered from elementary schools, integrating basic education with vocational education (Shen and Zheng, 2009). In Japan, "employment and entrepreneurship education" has been implemented in elementary schools since 1998 to cultivate students' psychological awareness and willpower for employment and entrepreneurship(Cai and Zhang, 2009).Some studies and practical experiences have shown that career awareness evolves with changes in environment and personal experiences(Kong et al., 1998; Losh et al., 2008). Suitable learning formats and environments are crucial conditions for these changes to occur (Wu et al., 2010). Informal learning venues, such as museums, can offer authentic and reliable information resources (Ramey-Gassert et al., 1994). Students can deeply observe and experience these resources through direct engagement or role-playing exercises. This provides a conducive space for students to cultivate career awareness in a relatively realistic setting outside of school (Wang and Tu, 2017; Kaplan et al., 1993; Hilke, 1988).

However, the design of the museum environment and exhibits is only the foundation for learning; it does not guarantee learning effectiveness (Bao, 2013). In recent years, museums have explored various design strategies to enhance engagement and interest in their exhibits (Anderson, 2004). Some researchers have noted that the physical environment can be designed to promote learning experiences by using mobile technologies, such as multiple-choice visitor manipulation (Humphrey and Gutwill, 2005) and synchronized visitor manipulation (Gutwill, 2005). Other researchers have suggested that learning activities can be designed without altering the museum exhibits and environment (Bao et al., 2011). These activities serve as mediating tools to bring museum resources closer to visitors. Appropriate learning activities not only provide new ways for learners to construct meaning and emotional connections, but also offer crucial support and guarantees for learning to occur and for students' overall development (Zhou et al., 2019; Zheng and Li, 2015; Xia and Zhang, 2015). Regarding the design of learning activities, some researchers have focused on worksheets. For example, Bao et al. (2011) designed sheets for home groups, where participants visited exhibits to complete the tasks on the worksheets. In addition, the design or planning of the tour routes and learning activities can be based on concept maps (Andritsou et al., 2018), electronic guides(Bieszk-Stolorz et al., 2021), etc. However, dull and monotonous worksheets can make learners feel bored, leading to counterproductive learning outcomes. Given that venue-based learning emphasizes active exploration by learners, it is essential to design learning activities that can maximize students' interest to achieve better learning results.

So, what kind of learning activities can maximize students' interest? Gamification may be one of the answers. "Motivation, participation, and achievement" are the three dimensions of learning in the museums, with motivation and participation being the key outputs (Perry, 2012). In recent years, gamification has been recognized as an effective way to promote motivation and engagement in student learning (Hu, 2020; Karagiorgas and Niemann, 2017; Manzano-León et al., 2021). It involves using game elements and mechanics in non-game environments to motivate desired behaviors (Werbach and Hunter, 2012). Gamification can make otherwise bland activities more engaging and motivating (Chou, 2015), and has unique educational advantages when integrated with museum learning (Chen and Chen, 2018). For example, Ha et al. (2021) found that users were significantly more likely to participate in group discussions when using gamified mobile question-asking app compared to a non-gamified one. Bieszk-Stolorz et al. (2021) found that gamified e-guides could lead to positive attitudes and increased willingness to visit the museum. The gamification of museum learning activities to enhance learning outcomes and experiences has been a research focus since 2015 (Johnson et al., 2015), yet it has not been widely implemented until recently (Miluniec and Swacha, 2020). Additionally, existing research mainly focuses on optimizing knowledge acquisition. The practical processes for promoting the development of non-cognitive aspects, such as students' career awareness, still require further exploration.

Therefore, in present study, we designed educational content for a Handicraft Museum, incorporating gamification elements to create gamified learning activities (GLA). To validate the effectiveness of it, we selected 66 students for a quasi-experiment at the Handicraft Museum. Recognizing that relying solely on quantitative or qualitative data would be insufficient (Tashakkori and Teddlie, 1998), this study adopted a mixed-methods approach with a convergent parallel design (Maxwell, 2016; Onwuegbuzie et al., 2007). This allowed for a comprehensive analysis by cross-verifying quantitative and qualitative data to address the research questions. The quantitative research component focused on assessing students' knowledge acquisition through knowledge tests. The qualitative research involved two parts: first, using DAST (Draw-a-Scientist-Test) to examine changes in students' perceptions of craftsmen; and second, conducting semi-structured interviews to gather students' impressions of the visit. By this way, the expectation was to enhance students' learning experiences during the museum visit and thereby promote their learning outcomes at both cognitive and non-cognitive levels.

Literature review

Gamification in museums learning. Gamification is"the use of game design elements in non-game context" (Armstrong and Landers, 2017; Landers, 2014; Deterding et al., 2011). In education, this concept is known as gamified learning. There are 39 game elements that can be incorporated into gamified learning such as badges, leaderboards, story, goals, and rewards (Garris et al., 2002). These elements aim to increase student engagement(Werbach and Hunter, 2012). In museum learning, the contextual characteristics of the environment provide great possibilities for gamified learning. For example, Jeon et al. (2020) combine story elements with museum exhibits to enhance the comprehensibility and interest of the content. Learners could personalize their gamified learning experience by selecting different stories. Related research has demonstrated that the use of simple game elements and mechanics in museum visitor applications can have a strong positive impact on visitor engagement with museum content. For example, Nelson et al. (2020) found that learners in a gamified environment asked almost twice as many questions as those in a regular environment in their study on the impact of gamification on learner effectiveness in science venues. Additionally, studies by Annetta et al. (2009) and Clark et al. (2009) have also demonstrated similar positive results. It is evident that the integration of gamification with museum learning can enhance student engagement and optimize the learning process to a certain extent. However, the effectiveness of its application depends on the careful selection and appropriate use

of game elements (Bellotti et al., 2013). In museum learning, context is a crucial characteristic, learners are the primary participants, and museum exhibits constitute the learning content. In this study, we selected three game elements based on the characteristics of the museums visited: stories, role-playing, and goals. Stories correspond to the museum's learning environment, role-playing aligns with the visitors, and goals relate to the museum exhibits. These elements were integrated into the museum learning activities to design the GLA.

Worksheets. Worksheets, also known as an activity sheets or learning guide sheets, are commonly used in museums as learning mediators (Bao, 2013). The museum learning environment is an open, contextual setting where learners have significant autonomy. Worksheets are created to structure learners' activities and minimize unnecessary wandering and distractions. Several studies have utilized worksheets to design learning activities that further exploit the educational value of museums, resulting in improved visitation outcomes (Burtnyk, 2004; Canizales de Andrare, 1990; Mortensen and Smart, 2007). These studies highlight the potential of well-designed worksheets to enhance the educational experience by providing structured learning pathways and clear objectives for students. However, other studies have not seen such improvements. Some researchers argue that worksheets may restrict students' exploration and lead to a negative learning experience (Griffin, 1999; Lucas, 2000). Overly prescriptive worksheets may stifle curiosity and limit the organic discovery process that is central to museum learning. When students feel constrained by rigid tasks, their engagement and enjoyment can diminish, counteracting the intended educational benefits. In contrast, gamification has long been considered a effective way to enhance student engagement and immersion (Landers, 2014; Deterding et al., 2011). It promotes active exploration rather than passive reception. Therefore, integrating gamification into worksheet design holds the potential to improve their effectiveness and application (Karagiorgas and Niemann, 2017; Manzano-León et al., 2021). By making worksheets more interactive, gamified worksheets will guide visitors to actively learn, which has the potential to lead to better outcomes in museum learning.

Career awareness. Career awareness, career exploration, career interests, and career aspirations, which begin to develop during childhood, are core skills for future career building (Hartung, 2015; Watson and McMahon, 2005). Among these, "career awareness" can be developed through short-term interventions (Carvalho et al., 2018). For example, students' impressions of individuals in certain professions and their understanding of the corresponding job responsibilities can be influenced by education (Wu et al., 2010). Some studies have embedded career education content in middle school science classes, positively impacting students' science career awareness and aspirations (Kang et al., 2023). Other studies have incorporated courses in off-campus venues, where museum learning not only involves the exhibits but also allows students to observe the real working conditions of various professions. For example, Melber (2003) had elementary school students visit a natural history museum every two weeks to work with scientists and experience the life of a researcher firsthand. Similarly, Finson et al. (1995) had an experimental group of students collaborate with museum researchers during the summer, while the control group received regular school instruction. Both studies found that students who participated in museum learning significantly reduced their stereotypes about scientists. Engaging in such learning experiences more frequently can provide students with opportunities to develop their interests and abilities, as well as help them envision potential social roles for themselves.

In this study, we chose a Handicrafts Museum where learners could learn about traditional Chinese craftsmen and their handicrafts. They can develop career awareness by observing or role-playing the work of people engaged in different craft occupations. The researcher divided learners career awareness of craftsmen into two dimensions: comprehensive occupational perceptions and occupational stereotypes. And the differences between learners on these two dimensions were explored through experiments.

Research questions. Building upon the literature review presented above, the present study used a worksheet as a vehicle to integrate three game elements of role-play, story and goal, into the museums learning activities, and designed GLA. The role-play corresponds to the visitor; the story corresponds to the learning environment in the museum; and the objectives correspond to the museum exhibits. To investigate its impact on visitors' learning outcomes, 66 participants were selected to conduct a quasi-experiment in a Handicraft Museum. And seek to answer the following research questions:

RQ1: Can the GLA have an impact on learners' handicrafts knowledge learning compared to non-gamified learning activities(NGLA)?

RQ2: Can the GLA have an impact on learners' occupational perception on craftsmen compared to NGLA?

RQ3: Can the GLA have an impact on learners' occupational stereotypes about craftsmen compared to NGLA?

Development of gamified learning activity. Based on activity theory (Nardi, 1996), this study divides the design of GLA into three parts: the selection of learning subjects, the selection of learning objects, and the design of learning mediating tools——worksheets.

Subjects and objects selection. The subject of the GLA in the museum include learners and learning guides. Learners were grade 3 students from W primary School, the learning environment for them is usually an indoor place with a podium and seats, which emphasizes a more rigid discipline, fixed roles and teaching patterns. "Moving" the classroom to an arena without podium and seats is a huge change for them. Learning guides include museum staff and school teachers. During the visit, they need to give a brief overview of the museum, such as relevant history, exhibit categories, exhibit distribution, etc., answer questions and solve problems for students who have doubts. In addition, they have to ensure the visit order and provide a good learning environment for learners.

Learning materials are the objects of learning activities. The object chosen for this study is Hangzhou Handicraft Museum (Fig. 1), which offers a variety of handicraft and creative handicraft experience programs for learners. Learners can experience the deep historical traditional crafts and intangible cultural heritage crafts with Chinese characteristics.

Worksheets design. Worksheets are an effective tool to integrate museum education and student learning without compromising the exhibition design of the museum (Meng, 2004). Its high accessibility and scalability make it a choice of researchers. The present study designed a gamified worksheet and a non-gamified worksheet, which is the main vehicle for this museums learning.

Gamified worksheet. This study uses the worksheet as a vehicle to integrate the three game elements of role-play, story, and



Fig. 1 Floor plan of the Handicraft Museum. This shows the experimental site for this study, which contains a variety of handicraft exhibits and experience programs Source: Own elaboration.

Table 1 Content on of game elements with the worksheet.

Game elements	Description
Story	We designed a letter of invitation to the students. It reads, "Hello children, you have been selected as the reserve army of Chinese intangible cultural heritage heirs! In order to select the best heirs, we have designed a number of hurdles in the Handicrafts Alive Museum. Next you will compete for the final successor of this selection!". This makes the whole handicraft pavilion scene and story background integration.
Role-play	From the time students receive the letter, the venue visit is transformed into a highly competitive challenge that requires students to observe and think, and students are transformed from being visitors to the venue to being challengers.
Goals	In each mission, a non-game player (NPC) will appear in the exhibit. The challenger can only pass this level by observing the exhibits and thinking before unlocking the next task.

goals into the learning activities. Table 1 demonstrates the specific ways in which each element was integrated.

The first page of the gamified worksheet is the cover (Fig. 3), which contains the words "Who is the final heir", "Challenger" and "Secrets of breaking through" to create a gamified situation for students. The other three pages contain four exhibits and six tasks, covering eight exhibits in the Handicraft Museum (Figs. 2 and 3). In each task, a non-game player (NPC) will appear in the exhibit and the challenger can only pass the level by observing the exhibits and thinking. For example, in the first level, the NPC greets the students and proposes the task - "Dear challenger, welcome to the first level, I am the gatekeeper of this level. Please find out the happiest and saddest people on this clay street". During the process, the NPCs in each level will guide learners to carefully observe the exhibits and exhibition sign information.

Non-gamified worksheet. The non-gamified worksheet are only used as a general tour guide for students (Figs. 4, 5). It covers the same exhibits as the gamified worksheets, but differ in the design of each question. To fill the worksheet, learners have to observe the features of the exhibits in every section and the content of the display boards. Also, learning guides in each section will help learners when they need.

Method

Participants. The researchers believe that the messages and values conveyed by the Handicraft Museum are consistent with the cognitive development of elementary school children. Therefore, we chose 66 third-grade students from W Primary School who were already able to read, write, draw and express their ideas clearly. And we confirmed through interviews that all the students had never visited the Handicraft Museum and divided them into the GLA group ($N = 33$) and the NGLA group ($N = 33$).

Procedure. The study consisted of three stages. A preparation stage in the classroom, a learning stage in the Handicraft Museum and a assessment stage (Fig. 6). However, only the assessment was the same in the experimental and control conditions.

In the first stage, teachers first introduced the activity to both groups of students. Then, they distributed a letter regarding the selection of the "final heir" to the experimental group. It reads "Hello kid,you have been selected as the reserve army of Chinese intangible cultural heritage heirs! However, in order to select the best heirs, we have designed many levels in the Handicraft Museum, which are incrementally more difficult. Next, you will compete for the final heir of this audition! Are you ready to

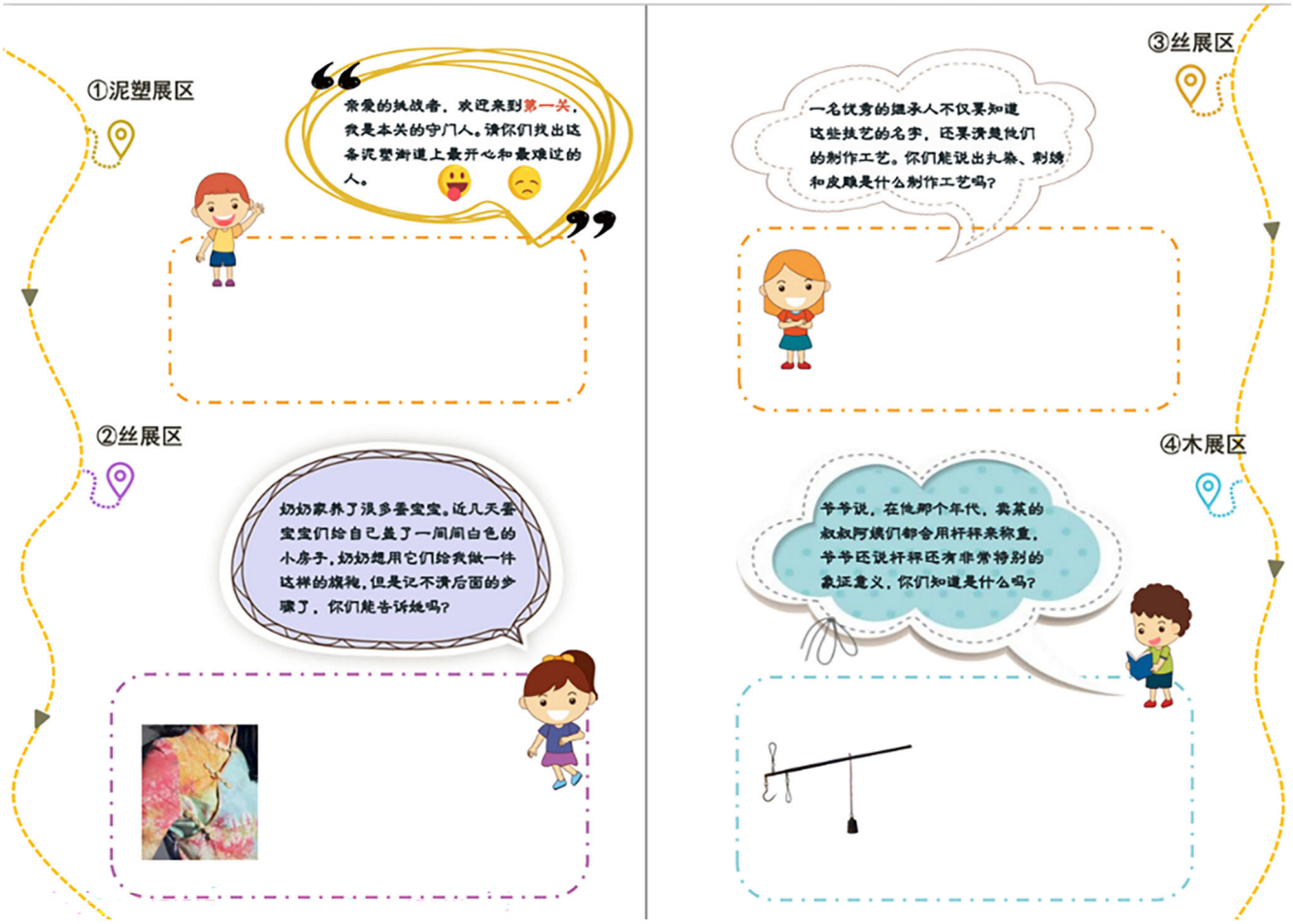


Fig. 2 Gamified worksheet (left: second page; right: third page). This shows part of the gamified worksheets we designed. Source: Own elaboration.

accept the challenge? From: Association for Intangible Cultural Heritage". From this moment, the visit to the Handicraft Museum is no longer simply a tour, but a competitive challenge that requires observation and reflection, and students are transformed from visitors to challengers. Subsequently, they distributed the gamified worksheets to the experimental group and the non-gamified worksheets to the control group.

In the second stage, the two groups of subjects participated in activities according to their own learning rules. The experimental group participated in museum learning with a gamified worksheet, while the control group with a non-gamified worksheet, and they were allowed to interact with each other. An experienced teacher and a researcher from each group observed the learners' performance throughout the process.

In the third stage, researchers will collect data. All students will complete a knowledge test, which will serve as the source of quantitative data. Following this, drawing tests and interviews will be conducted to gather qualitative data. In the drawing test, students will be asked to draw an craftsmen within a specified time. The interviews will be conducted online, with students responding via voice. This ensures that students do not interfere with each other, and the delayed test also examines how well students retain the results of their learning. At last, the students with the highest scores were given the title of 'Intangible Cultural Heritage Inheritor' and received a final prize.

Instruments. The results were analyzed using a mixed method combining quantitative and qualitative approaches. We used a knowledge test paper to measure learners' knowledge and a drawing test to measure learners' stereotypes and overall level of awareness of craftsmen. In addition, semi-structured interviews were used to supplement the measurement of learning about handicrafts and craftsmen.

Knowledge test. The knowledge test was designed by a museum learning researcher and a primary school teacher to examine students' knowledge of handicrafts. It consists of five main questions of 10 sub-tests, each of which carries 10 marks, for a total test score of 100. The questions covers knowledge of the handicraft exhibits mentioned in the worksheets and examines students' mastery of the learning content. Test questions are shown in Appendix A.

Drawing test. The drawing test is used to test students' general perceptions and stereotypes of craftsmen. The drawing test was first introduced by Chambers (1983), who argued that a drawing test is not just a 'drawing of a person' or 'drawing a picture', but a tool designed to reveal the subject's intelligence, self-image or certain emotional states or conflict projections. Since then, Chambers' drawing test has been used in a number of studies testing the image of scientists in the minds of students (Schibeci and Sorensen, 1983; Maoldomhnaigh and Hunt, 1988; Fort and Varney, 1989; Mason et al., 1991). In present study, the participants were mostly 3rd grade students, who did not have the advantage of verbal expression and preferred to express themselves in a non-written form of drawing.

Interview. The interview questions will be designed to be more open-ended than the specific questions in the knowledge test.



Fig. 3 Gamified worksheet (left: fourth page; right: first page). This shows another part of the gamified worksheets we designed. Source: Own elaboration.

This open-ended question design can lead students to state their own reflections on the visit. Questions 1–4 ask open-ended questions about the exhibitions in the clay sculpture, wood, silk and bamboo weaving sections respectively, aiming to find out which other exhibits students looked at closely during their visit to determine how learners learned during the visit in both learning modes. Question 5 was a more general question designed to guide learners through the learning process to find out if learners also noticed exhibits in other galleries during their visit. Question 6 asked students to talk about how they felt about the learning on the visit. The same interview outline was used by both groups of students. Interview outline are shown in Appendix B.

Data analysis. Data analysis in this study consists of two parts: quantitative data analysis based on the knowledge test and qualitative data analysis based on the drawing test and interviews.

Quantitative data. Quantitative data refers to the knowledge test data collected after the visit. A total of 66 test papers were distributed, and 66 valid responses were received, with 33 from the experimental group and 33 from the control group. Researchers used SPSS software to conduct an independent samples *t* test to compare the differences in the levels of knowledge about handicrafts between the two groups of students.

Qualitative data

Drawing test data: Based on the drawing test procedure proposed by Chambers (1983), two analytical methods, drawing evaluation and drawing classification, were used in this study. In addition, we drew on previous data analysis methods (Laubach et al., 2012) and developed indicators for evaluating and classifying craftsmen in the drawing test.

The purpose of the drawing evaluation was to determine the extent to which students knew about craftsmen. Student drawings were scored against five evaluation indicators, specifically characteristic clothing, working environment, tools, handicrafts and annotated descriptions, as shown in Table 2. A painting was scored as “1” if it demonstrated one of these aspects, otherwise it was scored as “0”. Thus, the highest score for a painting is “5” and the lowest score is “0”. The higher the score, the more comprehensive the respondent’s perception of the craftsmen’s image.

The purpose of the drawing classification was to identify the categories of craftsmen in students’ minds, including five perspectives: identity, age, gender, emotion, and social dimensions of craftsmen, as shown in Table 3. If a dimension is not represented in the drawing, it is recorded as “0”.

The five evaluation indicators of characteristic dress, working environment, tools, handicrafts, and annotated descriptions and the five dimensions of craftsmen’s identity, age, gender, emotion and social dimension together reflected the students’ stereotypes about craftsmen. After the test, the drawings of the students in the experimental and control groups were collected for coding and



Fig. 4 Non-gamified worksheet (left: fourth page; right: first page). This shows part of the non-gamified worksheets we designed. Source: Own elaboration.



Fig. 5 Non-gamified worksheet (left: second page; right: third page). This shows part of the non-gamified worksheets we designed. Source: Own elaboration.

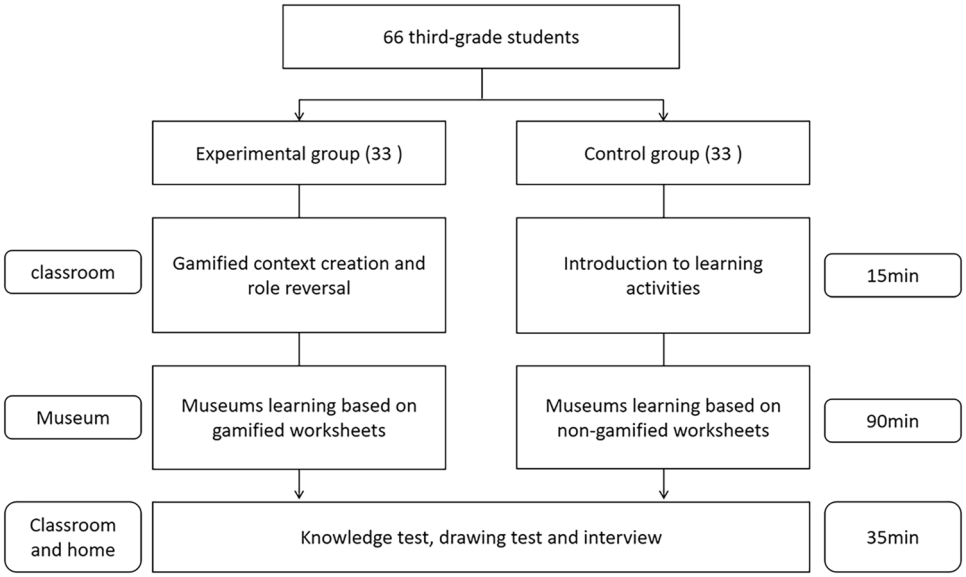


Fig. 6 Experimental procedure. This shows each stage and content of the experiment. Source: Own elaboration.

Table 2 Coding criteria for the evaluation of drawing tests.

Indicator	Example
Characteristic clothing	Woodworking clothes, cheongsam, etc.
Working environment	Main street, kitchen, pottery workshop, etc.
Tools	Hammer, needle and thread, etc.
Handicrafts	Pottery jars, embroideries, kites, etc.
Note descriptions	"Lu Ban, the originator of carpentry", "Wow, awesome!" etc.

Table 3 Coding criteria for painting test classification.

Dimension	Classification
Status	Silk skills1, Wood skills2, Clay sculpture skills3, Bamboo weaving skills4, Other skills (inside) 5, Other skills (outside) 6, Multiple skills7
Age	Juvenile1, Young2, Middle-aged3, Old4
Gender	Male1, Female2
Emotion	Happy 1, No expression 2, Unhappy 3
Social dimension	Individual 1, Group 2

analysis according to the above coding rules, and the scores of the students in the two groups were compared.

Interview data: A total of 191 valid interview responses were received, including 83 for the experimental group and 108 for the control group. Thematic analysis was conducted on these interview data to serve as an important supplement to the knowledge test data and drawing test data. Researchers first annotate meaningful phrases in each interview transcript, generating initial labels such as "number of handicrafts" and "a great experience". Next, they search for and identify themes within these recurring initial labels. After initially identifying themes, the researchers review and refine the themes and their subordinate labels. They then determine the theme names and their included sub-dimensions. Finally, the researchers compare the frequency of mentions of each theme and its sub-dimensions between the two groups of students in the interviews.

Table 4 Results of the independent samples t-test on handicrafts knowledge for the two groups.

Variance	Group	*N*	Mean	SD	*t*	*p*
Knowledge	GLA	33	61.21	13.86	0.33	0.74
	NGLA	33	60.00	15.81		

Results

Handicrafts knowledge. To answer RQ1, an independent samples t-test was conducted to investigate the effect of museums GLA on the students' handicrafts knowledge. As shown in Table 4, the handicrafts knowledge scores of the experimental group ($M = 61.21$, $SD = 13.86$) was higher than that of the control group ($M = 60$, $SD = 15.81$). However, there was no significant difference between the GLA and NGLA groups on knowledge ($p = 0.74 > 0.05$). This indicates that the two groups of students had a similar level of knowledge acquisition related to handicrafts during the museum visit. However, since the knowledge tests consisted entirely of objective questions, the scores may not fully reflect the students' understanding of handicrafts. Subsequent data will supplement these results.

Occupational perception on craftsmen. In order to answer RQ2, participants' 66 paintings were first coded and analyzed according to the coding rules of the drawing test. The Cronbach's alpha for the two sets of coded data is 0.922. This indicates that Cronbach's alpha condition for reliability of the coding data is satisfied. Then, the difference of students' perception on craftsmen in two groups was compared through an independent samples t-test. As shown in Table 5, there were significant differences between the two groups in both the working environment ($p = 0.02 < 0.05$) and handicrafts ($p = 0.01 < 0.05$) dimensions. And the drawings of students in control group were more involved in the working environment and handicrafts compared to the experimental group. In addition, there were no significant differences between the two groups on the dimensions of characteristic costumes ($p = 0.81 > 0.05$), tools ($p = 0.36 > 0.05$) and annotation ($p = 0.33 > 0.05$). The drawings of students in experimental group were less presented than the drawings in control group on characteristic costumes and tools, but more so than the control

Table 5 Results of the independent samples t-test on perception on craftsmen for the two groups.

Dimension	Group	Mean	Mean Difference	95% Confidence		t	p
				Lower	Upper		
Characteristic costumes	GLA	0.45	−0.03	−0.28	0.22	−0.24	0.81
	NGLA	0.48					
Work environment	GLA	0.18	−0.27	−0.50	−0.05	−2.45	0.02*
	NGLA	0.45					
Tools	GLA	0.76	−0.09	−0.29	0.11	−0.92	0.36
	NGLA	0.85					
Handicraft	GLA	0.39	−0.37	−0.59	−0.13	−3.17	0.01*
	NGLA	0.76					
Annotation	GLA	0.55	0.13	−0.13	0.37	0.98	0.33
	NGLA	0.42					

*$p < 0.05$.

Table 6 Results of independent sample t-test on stereotype about craftsmen.

Dimension	Group	Mean	Mean difference	95% Confidence		t	p
				Lower	Upper		
Identity	GLA	3.55	−0.39	−1.35	0.56	−0.82	0.41
	NGLA	3.94					
Age	GLA	1.88	−0.54	−1.07	−0.03	−2.10	0.04*
	NGLA	2.42					
Gender	GLA	1.36	0.12	−0.14	0.38	0.94	0.35
	NGLA	1.24					
Mood	GLA	1.48	−0.07	−0.39	0.27	−0.37	0.71
	NGLA	1.55					
Social characteristics	GLA	0.97	−0.27	−0.44	−0.11	−3.34	0.01*
	NGLA	1.24					

*$p < 0.05$.

group on the dimension of annotation. It is evident that, overall, the control group students have a higher level of comprehensive understanding of craftsmen compared to the experimental group students. Specifically, the experimental group students' understanding of the work environment and handicrafts is not as thorough as that of the control group students. In the discussion, we will interpret these results and supplement the findings with interview data for further validation.

Occupational stereotype about craftsmen. The five indicators of characteristic costumes, working environment, tools, handicrafts and annotation and the five dimensions of craftsmen identity, age, gender, mood and social characteristics together reflect the learners' stereotypes about craftsmen. For RQ3, to examine the effect of GLA in museums on learners' stereotypes about craftsmen, independent samples t-test was adopted to compare of both groups. The results of the t-tests for the first five indicators have been described above, and this part focuses on the last five dimensions.

As shown in Table 6, the students in GLA group did not differ significantly from the students in NGLA group on the three dimensions regarding the identity ($p = 0.41 > 0.05$), gender ($p = 0.35 > 0.05$) and mood ($p = 0.71 > 0.05$) of the craftsmen. And the majority of the drawings showed positive emotions of the craftsmen. There were significant differences between the two groups in both the age ($p = 0.04 < 0.05$) and social characteristics ($p = 0.01 < 0.05$). It is worth noting that the craftsmen painted by students in the experimental group was significantly younger than that in the control group. Moreover, the craftsmen in the drawings of the GLA were mostly alone, while in the drawings of the NGLA were mostly found in groups. This to some extent reflects the social image of craftsmen in the minds of the two groups of students.

Table 7 Themes drawn from interviews with two museum learning styles.

Themes	Dimensions	GLA	NGLA
Handicrafts knowledge	Number of handicrafts	103	115
	Handicraft Production Process	23	13
	Handicraft Details	30	24
	Imagination	17	20
Learning experiences	Enjoyable learning experience	4	3
	A rewarding experience	5	4
	Looking forward to future visit	3	7
	Hope to do my own handicraft	2	3
Attitudes	Enjoyment of handicrafts	7	11
	Admiration and recognition of craftsmen	11	2

Interview data. After conducting thematic analysis of the interview data, the content can be categorized into three themes, including handicrafts knowledge, learning experiences, and attitudes, as shown in Table 7. The first theme reveals differences in students' acquisition of handicraft knowledge, including their recollections of the number of handicrafts, the handicrafts production process, handicrafts details, and their imagination. The second theme highlights differences in students' learning

experience, such as finding the experience enjoyable, feeling that it's a rewarding visit, looking forward to future visits, and hoping they could try handicraft making. The third theme reveals students' attitudes towards handicrafts and craftsmen. By observing the frequency of mentions within each sub-dimension, we can identify differences between the GLA and NGLA groups.

In the first theme, students recalled the number of handicrafts (GLA: 103 times; NGLA: 115 times), mentioned the production process (GLA: 23 times; NGLA: 13 times), detailed the intricacies of the handicrafts (GLA: 30 times; NGLA: 24 times), and expressed their imaginations about handicrafts (GLA: 17 times; NGLA: 20 times).Overall, the NGLA group showed more interest in the quantity and imagination of handicrafts, whereas the GLA group focused more on the crafting process and details of the handicrafts. Through similar comparisons, it is observed that in the second theme, the GLA group reported a more satisfying learning experience than the NGLA group. In the third theme, the NGLA group expressed a greater appreciation for handicrafts, while the GLA group showed more admiration and fondness towards the craftsmen themselves.

Discussion

This study integrated three game elements—stories, role-playing, and goals—into museum learning to design GLA. To validate its effectiveness, a quasi-experiment was conducted with 66 elementary school students at the Handicrafts Museum. The study primarily utilized a parallel mixed-methods approach, combining quantitative and qualitative data to analyze the differences between the GLA and NGLA groups in terms of their knowledge of handicrafts and their career awareness of craftsmen. The results indicated that learners in the GLA group observed the details of handicrafts more closely than those in the NGLA group. Additionally, the GLA participants expressed greater admiration for craftsmen and showed reduced stereotypes towards them. This finding indicated that GLA in museums help to enhance the learning outcomes at the non-cognitive level of learners.

The GLA group paid more attention to the details of the handicrafts due to their deep engagement in play. Regarding handicraft knowledge, although there was no significant difference between the GLA group and NGLA group in terms of the knowledge test. This indicates that both groups of students were able to identify and acquire key knowledge about handicrafts during the museum visit. However, since the knowledge tests consisted entirely of objective questions, they did not provide an opportunity for students to express their subjective understanding. As a result, the tests may not fully reflect the learners' comprehensive knowledge of the handicrafts.

From the interview responses, we found that while the NGLA group mentioned the handicrafts more frequently, the GLA group provided more detailed descriptions and made more references to the crafting process and complexity of the handicrafts. For example, when describing the West Lake silk umbrella, one student noted, "The maker made the umbrella out of bamboo, which is unique to the suburbs of Hangzhou, and Hangzhou silk, with a design of the West Lake". He not only highlighted the materials used to make the West Lake silk umbrellas, but also described their structure. When answering the question of why the miniature kite is so small, one student said, "The upper half and the tail are made separately and then pasted together, so when it is flown, the miniature kite dances in the air like a real butterfly". This shows that he has carefully observed and thought about the kite-making process. These findings indicate that the GLA group paid more attention to the details of the handicrafts than NGLA. The results are consistent with a study showing that museum visitors who used a gamified mobile questioning app slowed down in galleries and spent more time closely examining the exhibits (Ha et al., 2021). The possible reason for this phenomenon is that students in the GLA group were able to immerse themselves in the story context and their roles during the visit, leading to more active learning. This immersion heightened their desire for self-exploration, allowing them to observe more details that were not included on the worksheets. In contrast, students in the NGLA group lacked the engaging context of "competing for cultural heritage heirs" and relied more on the relatively dull worksheets or explanations, which did not motivate them to explore additional details. Therefore, the story contexts we create in the museum environment allow visitors to engage deeply in the learning activities. At the same time, these context allows them to reach a state of self-regulation while playing their corresponding role (Vygotsky, 1978; Barab et al., 2012).

The GLA group had a less comprehensive perception on craftsmen than NGLA group, but they showed more admiration for craftsmen. The analysis indicates that students in the NGLA group addressed four key aspects—characteristic costumes, work environment, tools, and handicrafts—more frequently in their drawings. Although students in the GLA group also addressed these aspects, they did so less often compared to the NGLA group. However, the drawings from the GLA group included more annotations, which suggests that to some extent, the students in GLA did not have as comprehensive a perception of the craftsman as the NGLA. This finding is inconsistent with previous studies (Liu and Idris, 2019; Nofal et al., 2020). There are two possible explanations for it. First, in terms of drawing requirements, some students may misunderstood the drawing test, believing that they only needed to draw the mental image of the individual scientist and ignored elements such as the working environment. It is worth noting that GLA students added more annotations to their drawings, using text to supplement what the drawings lacked. Since the pre-test of drawing skills was not conducted, the possibility of differences in drawing skills between two groups cannot be excluded.

Additionally, GLA students mentioned various aspects of craftsmen multiple times in the interviews. Particularly in the "Admiration and Recognition of Craftsmen" dimension, GLA participants mentioned this aspect 11 times, while NGLA participants only mentioned it 2 times. This indicates that GLA students expressed more admiration and praise for craftsmen. For example, one student remarked, "I think the craftsmen are very skilled and great; their carved works are exquisite," and another said, "They have created culture and wealth for society, which is truly admirable. They are my role models. " This shows that the role-playing allowed learners to develop a deeper understanding of the hard work involved in handicraft making. Such admiration and recognition of craftsmen are crucial for the career development of learners and the transmission of traditional handicrafts.

The GLA group removed stereotypes about the age of craftsmen because of their immersion in role. The images of craftsmen in the minds of students reflect their stereotypes about craftsmen (Chambers, 1983; Steele, 2003). In our analysis of the paintings, we found significant differences between the two groups of students in terms of age and social dimensions of craftsmen. In the drawings by students in NGLA, craftsmen were predominantly portrayed as middle-aged or elderly individuals. In contrast, the craftsmen depicted by GLA students were mostly independent young adults. In studies on the image of scientists,

students often hold stereotypes, with most having a positive "impersonal" image of scientists and a negative "personal" one (Mead and Metraux, 1957). The participants in this study were all elementary school students. Students in the NGLA group tended to view craftsmen as traditional older craftsmen who seemed more distant from them. In contrast, GLA group students had a more personal and relatable view of craftsmen. This suggests that the GLA approach helped to dispel the stereotype that craftsmen belong predominantly to the "middle-aged and elderly" demographic. Instead, GLA group students saw craftsmen as primarily young people, reflecting a positive "personal" professional image, which is an important external factor influencing students' attitudes towards craft professions (Wu et al., 2010).

Researchers have noted that an individual's perception of things can change their cognition (Brown et al., 1989; Lave and Wenger, 1991). By introducing gamification into museum visits and allowing students to engage in role-playing and compete for the title of "ultimate heir," this approach helped them connect more closely with the craftsmen. Students were able to think from the craftsmen's perspective, developing a stronger sense of self-identification. This is potential to foster a positive development in their career awareness related to craftsmanship.

Conclusion and limitation

In this study, 66 elementary school students participated in a quasi-experiment at a handicraft museum to validate the effectiveness of GLA. We employed a mixed-methods approach with a parallel design, collecting knowledge tests as quantitative data and drawing tests and interviews as qualitative data. Through comprehensive analysis, we compared the differences between the GLA and NGLA groups in terms of handicraft knowledge and career awareness related to craftsmanship. The results showed that in terms of handicraft knowledge, there were no significant differences between the two groups on the objective knowledge test. However, interview data revealed that the GLA group paid significantly more attention to the details of the handicrafts. Regarding career awareness of craftsmanship, both groups had a relatively comprehensive understanding of craftsmen. The NGLA group provided more detailed depictions of craftsmen in the drawing test, while the GLA group supplemented their drawings with annotations. During the interviews, the GLA group expressed more admiration for the craftsmen compared to the NGLA group. Additionally, students in the GLA group demonstrated a reduced stereotype about craftsmen, viewing them as younger individuals closer to their own age. This reflects a positive "personal" professional image and has the potential to foster their positive development in their career awareness related to craftsmanship.

However, the results of this study should be viewed within its limitations. First, the experimental site chosen for this study is the Handicrafts Museum, so the results are certainly influenced by the particular site. Considering this effect, these results should be generalized with caution. More research is needed to investigate the impact of the intervention in other populations and contexts. Furthermore, this study used a combination of qualitative and quantitative research methods to collect experimental data, but the experimental conditions did not allow for the collection of enough learning data. So, we can not examine the impact and effect of GLA on learning outcomes at more non-cognitive levels. Therefore, in the future, more diverse evaluation approaches are needed to verify the impact of the GLA on affective aspects of learning. Finally, we included only three game elements in the design of the GLAs: role play, story, and objectives. Therefore, the conclusions drawn are far from sufficient to summarize the overall effect of gamified learning. In future research, we should focus on the inclusion of other game elements and mechanisms and explore the effects of different elements and combinations of elements on student learning outcomes in order to guide practice more comprehensively.

Data availability

Personal data was collected and analyzed in this study. The consent form states that all participants agreed to data confidentiality. The datasets are therefore private to protect participant privacy. The data generated or analyzed during this study is available upon request to the corresponding author for academic research purposes only.

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Author contributions

Wei Xu designed and carried out the research and conducted the data analysis and summary. Qian-Wen Xing, Yue Yu and Li-Ying Zhao conducted the research, and participated in the data analysis. All authors contributed to the article and approved the submitted version.

Competing interests

The authors declare no competing interests.

Ethical approval

All studies in this manuscript were approved by the ethics committee of the first author's institution (Approval Committee: Ethics Review Committee of the Institute of Applied Psychology, Zhejiang University of Technology ; Approval Number: 2024D001). All procedures were meticulously executed in accordance with the committee's recommendations.

Informed consent

The process and purpose of the study was explained in detail to all participants before the study began to ensure ethical compliance. All participants and their guardians signed an informed consent form before the experiment.

Additional information

Supplementary information The online version contains supplementary material available at https://doi.org/10.1057/s41599-024-03583-4.

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