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Article

The Influence of Visual Recognition and Preference in Serious Games: A Pilot Study in Nepal

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Abstract

Understanding players' diverse visual recognition and visual preferences, especially in cross-cultural contexts, is critical for the creation of effective serious games. This study aimed to examine how varying levels of fidelity affect players' visual recognition, visual preference, and overall experience in serious gaming, using a mixed-method case study in the Bhaktapur district, Kathmandu, Nepal. Forty-four participants, aged 13 to 16 years, were enrolled in an A/B gameplay test. Fourteen students participated in in-depth interviews, thirty-six completed a questionnaire, and twenty-two provided valid telemetry data. We found that higher fidelity led to more positive affect, better recognition, stronger preference, higher familiarity, and positive emotional response from players. However, challenges were encountered regarding the identification of local food items. This highlights the key role of visual literacy, as adolescents are more influenced by familiar media than by real-life experiences in terms of visual recognition and preference. Effective visual communication in serious games should consider individual differences and the playing environment. This study contributes to serious game research by providing insights into an underrepresented demographic and demonstrating the importance of cultural context in visual communication. Findings offer practical guidance for game developers to design more inclusive and effective serious games.

1. Introduction

Games are typically multimodal texts [1] meaning that the creation of serious games (SGs) involves a challenging interdisciplinary approach [2]. A broadly recognized component of this complexity is the difficulty of merging entertaining game mechanics with accurate subject

matter representations. From a game visual development perspective, the challenge of effectively communicating a message while engaging players and maintaining focus on key issues is central to designing mechanics and systems for SGs. We argue that creating game graphics presents a similar challenge. Graphics must be visually appealing while also accurately and responsibly representing content. Visual literacy—the ability to interpret and make meaning from visual information [3]—is a critical factor in how players engage with and understand these visuals.

There has been limited research on how the fidelity of game graphics influences player experience, especially when game mechanics remain constant. When discussing simulation games, Alklind Taylor [4] describes fidelity as "a continuum from low to high fidelity", i.e. in such a continuum a low-fidelity system bears little or no resemblance to the real world or situation, while a high-fidelity system closely mirrors reality. Furthermore, visual fidelity directly affects how players perceive and interpret game elements. According to Berlyne's (1974) aesthetic theory, adjusting visual complexity to an optimal level enhances viewers' enjoyment of an object. Stimuli with moderate visual complexity are typically perceived as pleasant, while both overly simplistic or overly complex stimuli tend to be less enjoyable. This concept aligns with the objectives of our research, which aims to optimize visual communication in SGs. Earlier studies suggest that abstract or cartoon-like visuals are more effective than realistic styles in improving user experience [5], [6], [7].

Another challenge is understanding the characteristics of the game's target audience. Zagal [8] defines game literacy as having the ability to play games, having the ability to understand meanings with respect to games, and having the ability to make games. Different players have varying levels of game literacy influenced by factors such as age, upbringing, and technology access. These variations lead to different experiences for each player, making the design of SGs for diverse audiences more complex. Research outside the field of game studies and SGs has explored how cultural contexts influence people's preferences and interpretations of shapes, styles, and colors [9], [10], [11]. For example, a cross-cultural study on visual preferences in website design demonstrates that gender, socio-cultural contexts, and education levels affect preferences for colorfulness and visual complexity [12]. Given that games, particularly SGs, are highly visual media with specific learning objectives, understanding these individual differences is essential when creating games for multi- or cross-cultural play contexts.

Moreover, in the development of SGs, limited budgets often mean there are no funds available to hire professional game designers or artists [13]. This financial constraint creates challenges in balancing the educational content with engaging gameplay, making it difficult for development teams to produce games that are both attractive and effective in achieving their intended educational or training goals. For teams with restricted budgets, understanding how players respond to different levels of graphical fidelity can help prioritize resources effectively.

In this paper we used *Happy Heart* as a case study in our broader exploration of visual communication in SGs. *Happy Heart* is a serious game for Android devices, developed by us for the purpose of cardiovascular health promotion in Nepal. The case study involved Nepalese adolescents aged 13-16 years in grades 8-10. We explored their visual recognition and visual preferences of different levels of visual fidelity, as well as their visual literacy through an A/B test, using interviews, questionnaires, and telemetry for analysis. The novelty of our work lies in its focus on an underrepresented demographic, Nepalese adolescents, and the exploration of how cultural context shapes visual perception, offering new insights into game design for diverse audiences thereby contributing to the development of a more inclusive game design.

2. Methods and Material

2.1 Design and Development of *Happy Heart*

The burden of cardiovascular diseases (CVDs) in Nepal is rising with CVDs contributing to 24% of total deaths and 12% of total disability-adjusted life years [14]. Cardiovascular risk factors are common among adolescents [15]. Targeting adolescents in their formative years for building habits related to diet and physical activity could eventually decrease the burden of CVDs. Since adolescents are a technologically inclined group, gaming could be a possible way to create awareness among them.

Happy Heart is designed as supplementary digital teaching material for promoting a healthy lifestyle for Nepalese adolescents in grades 8-10. The game was developed 2022 - 2023, part of the Heart-related Research Intervention with Digitalization Among Young Adolescents (HRIDAYA) trial (ClinicalTrials.gov Identifier: NCT06668675).

The game comprises a series of seven levels, each functioning as a mini-game focusing on various aspects of cardiovascular health. These levels are centered around critical topics such as the content of sugar, salt, fat in different food items, physical activities, balanced diet, and nutrition groups. This selection of topics, as well as the learning goals connected to these, were based on the content of the manual used in the The Heart-health Associated Research, Dissemination, and Intervention in the Community (HARDIC) trial (ClinicalTrials.gov Identifier: NCT03639402) [16]. The HARDIC trial was conducted in the Bhaktapur district, Kathmandu, Nepal and applied peer education among mothers to improve the diet of their children [16]. Additionally, the knowledge gaps identified from our survey among 649 adolescents were also mapped into the game mechanics of *Happy Heart*.

Given that the project's game designers hailed from cultural backgrounds (Swedish and Chinese) distinct from the target users (Nepalese), it was important for the health researchers, who were either Nepalese themselves or had considerable experience with Nepalese culture, to contribute with their firsthand insights into the cultural aspects of the target audience and locale. This resulted in a two-step process of first drafting game concepts based on specific learning goals, followed by a step of identifying requirements in regards to culturalization needs, including those concerning game art.

Nikolopoulou [17] notes that educational software for younger children often remain relatively neutral on cultural issues. Such software often uses storylines and visuals based on more universal themes. This neutrality aids the culturalization process. Even when designed for older children, educational games about topics such as food and lifestyle typically avoid political or violent themes which are often critical considerations for culturalization [18]. However, even more mundane themes such as food and sports can cause confusion if users cannot relate to or recognize designs due to their cultural background. In games that emphasize lifestyle and habits, this is therefore an important consideration. We decided the list of graphical assets, such as food items and physical activities, during the culturalization phase [19]. This step also determined how to visually represent the items to match local customs. For example, in Nepal, single-serving sodas are usually in glass bottles, while in Sweden, they come in cans.

The graphic design for *Happy Heart* is built on the idea of recognizing real-world objects and learning facts through gameplay. Therefore, we used referent images, which directly depict the actual object in a recognizable and concrete form, rather than signified images which rely on the symbolic meaning associated with the object [20]. For example, a referent image of an apple closely resembles a real apple, while a signified image of an apple would be a symbol that conveys the idea of an apple rather than depicting the actual fruit.

2.2 Mixed method study in Nepal

2.2.1 A/B Study Design

An A/B test of two visually different versions of the game (version A and version B) was conducted in which the player experience of the game was in focus. The design of material for the A/B test was carefully developed through literature studies [21] and exploratory studies. Previous research [22] shows that abstract and symbolic game visuals are preferable for learning and providing an engaging experience. Human visual perception unconsciously ignores the least visible parts when presented with overloaded information [22], [23]. Thus, we framed the graphic style into an abstract style.

Our initial study in Nepal in 2022 demonstrated that version A (VA) was the most effecient regarding recognition and visual preference among Nepalese adolescents [24]. Version B (VB) was selected for comparison as it was frequently mentioned in interviews. Research shows that the outline of an object triggers neural processes [25]. Outlines are known to improve object recognition by providing clear boundaries between objects and their backgrounds, thus helping the brain distinguish shapes more quickly [26]. Research in visual perception also suggests that outlines help reduce visual complexity by highlighting essential features, which is especially important in fast-paced environments like games [27]. The distinct separation created by outlines makes it easier for players to focus on key game elements, allowing faster decision-making and better engagement. We selected both versions with production efficiency in mind, as higher visual fidelity requires more time and resources, which may not always be feasible for SGs with limited budgets.

Finally, we selected two levels of visual fidelity that aligned with the target group's preferences and recognition. VA which uses the simplest method for depicting volume with hard shading, was chosen for comparison against VB, which lacks volume information. Both versions were then prepared for A/B testing, as shown in Table 1.

Table 1. The variable of two versions of the visual fidelity.

	VA	VB
Example: Ice cream		
Variable:		
Shading	Inherent color with hard shading (a technique in art where shadows are added with sections of darker color that aren't blended in). The object's inherent color is supplemented with darker shades to represent shadows and lighter hues to indicate highlights, thereby illustrating the object's volume.	Depict only the object's inherent color, without shading. This style will give the object a flat appearance and only provide information on the height and width, without volume.
Outline	No dark outline.	The structure of the object is delineated using a dark outline. However, finer details of the object's texture are not represented with this outline.

The two versions of *Happy Heart* are identical in terms of game mechanics and sound. The variable under consideration is visual fidelity. VA exhibits higher fidelity with hard shading and no outline, providing volume information, while VB, with lower fidelity, features a dark outline without hard shading, resulting in a flat image without volume information (see Table 1). The background was excluded from the variables to avoid issues related to visual perception. These two visual fidelities were used in *Happy Heart* for A/B testing (see Figure 1).

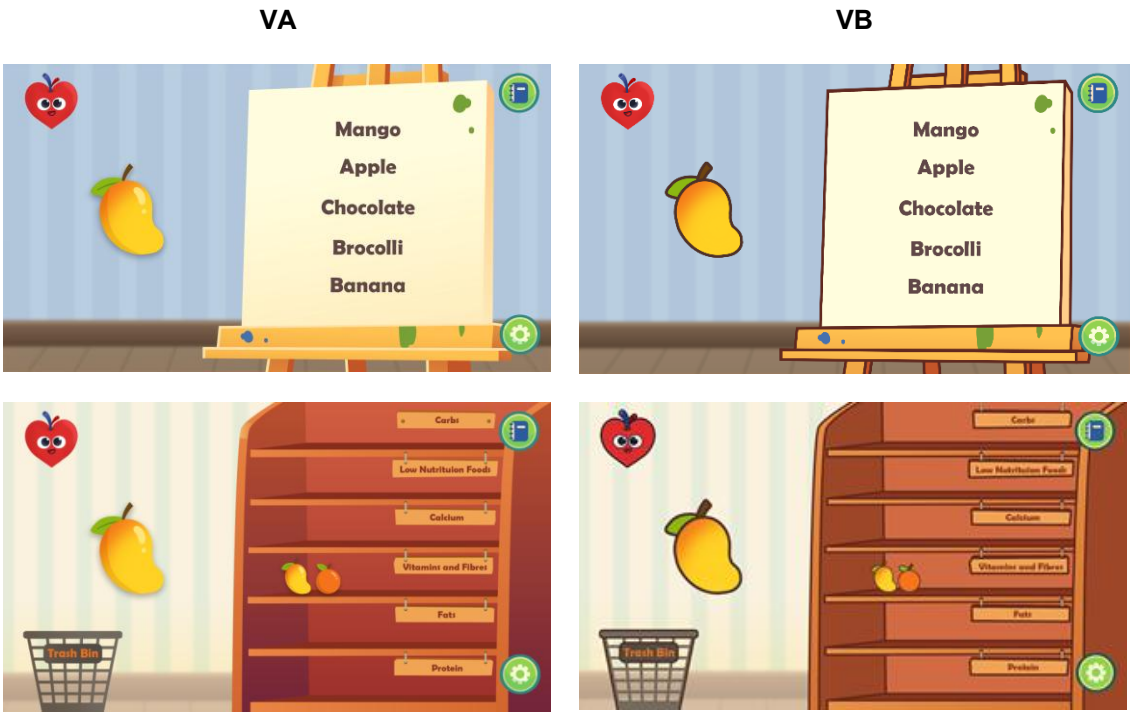

Figure 1. Mini games *Name the Food* and *Sort the Food* of *Happy Heart* with different levels of fidelity.

2.2.2 Participants and study setting

The study was conducted in a government school in the Bhaktapur district, Kathmandu, Nepal. Participants were included if they were (1) Adolescents studying in grades 8-10, (2) had access to a smartphone with internet access. Written informed consent was obtained before adolescents were enrolled in the study. Adolescents signed an assent form and a parental consent form was also obtained. In practice, most participants lacked personal smartphones and had to borrow a parent's device. Moreover, several parents expressed concerns about excessive screen time. We ultimately completed the game playtest with 44 participants.

Since the playtest was conducted in real-world settings, participants used personal Android smartphones (4.7–6.5 inches, Android 6.0+). Scalable 1920×1080 assets and pretest validation ensured consistent visual fidelity across devices. Telemetry and participant feedback revealed no screen size–related issues.

2.2.3 Data Collection

A mixed-method study was conducted, integrating both qualitative (interviews) and quantitative approaches (telemetry data and questionnaires). As our primary focus was understanding player experiences and perceptions, we used qualitative methodology to capture rich, in-depth insights that could not be fully explained by quantitative measures alone. Therefore, purposive sampling was used to ensure that participants had engagement with digital games and were willing to participate in the study. The quantitative findings are used primarily to complement and contextualize the qualitative analysis. First, they support methodological triangulation, thereby strengthening the validity of our qualitative insights. Second, as a supportive tool, for example,

recognition performance derived from the telemetry data assisted in selecting participants for the interviews.

- ***Game playtest***

The study commenced with a week-long gameplay test. Participants were randomly assigned to either VA or VB, with group A (GA) playing VA and group B (GB) playing VB. Age and gender were considered during the randomization process to ensure balance between the groups. Participants played the game at home as an additional educational content. They were instructed to play for at least 10 minutes per day over the course of a week. Regular reminders were sent to reinforce these guidelines and ensure compliance.

- ***Telemetry data***

Telemetry data tracking participants' playing patterns was stored in log files. In the first level, *Name the food*, participants were tasked with recognizing food items. A food item was displayed on the left, and the player was asked to match it with the correct English name from a list of five options on the right (Figure 1). One point was awarded when the player correctly matched the food item with its corresponding name, and no points were awarded for incorrect matches.

Tracking playing patterns provided valuable insights into how effective the visual communication of the game was. Considering that the playtest occurred in the participants' homes, this data may include external elements (noise) such as friends or siblings using their phones. To minimize the noise, the analyses focused exclusively on the first-time play of the first level.

- ***Questionnaire***

The questionnaire, developed and refined through two studies related to game experience measurement [28], [29], and reviewed by experts in game design and human-computer interaction to ensure validity, was conducted immediately after participants had played for a week and consisted of three parts. Initially, we asked three questions about media habits (e.g., What access do they have to digital media, how often do they play games, and what types of games do they prefer to play?). Subsequently, a 5-point Likert scale with 14 items was used to assess:

1. recognition (2 items on players' recogniton of visual elements),
2. aesthetics (4 items on players' perception of the visual appearance),
3. emotional response (3 items on players' feelings of the game),
4. perceived usability (3 items on usability of the interface), and
5. endurability (2 items on holisitc response to the experience, reflecting whether participants would use it again or recommend it to others).

These five subscales were adapted from Wiebe et al. [29] with six constructs more aligned with game graphics. Finally, participants answered three open-ended questions about their overall game and game graphics experience. Additionally, given participants' lack of smartphone access, we opted for paper-based questionnaires instead of online surveys.

- ***Interview***

To gain deeper insights into participants' preference of visual fidelity in games, as well as their ability to interpret different visual fidelity, semi-structured interviews were conducted . To facilitate for the participants during the interview, all questions were both asked verbally and shown on a laptop screen for them to read at their own pace. Each interview took approximately 30 minutes, was audio recorded and thereafter transcribed. During the interview, field notes were also recorded on a notepad.

To ensure the collection of rich and diverse data, participants were selected equally from GA and GB based on gender (with an equal split of male and female) and their gameplay performance, as recorded in the log files, as well as their resoponse to the questionaire. A Nepalese research

assistant acted as interpreter during the interviews to accommodate for the varying levels of English proficiency among participants.

The interview was divided into three different sections. First, we asked questions about participants' recognition and visual preference of the game version they played. Second, the participants then played the other version of the game for five minutes. We thereafter asked questions regarding comparison between the two game versions. Thus, a participant who played VA during the actual playtest played VB during the interview to see if there was any immediate perceived difference between the games and if players could identify the differences that existed. Third, we asked questions about participants' media habits and game experience.

2.2.4 Data Analysis

The qualitative data were analyzed using the software MAXQDA, following the six-step process outlined by [30]. The quantitative data were analyzed with the Statistical Package for Social Sciences, (IBM SPSS Statistics 152 version 27). We used Mann-Whitney U test to compare the Likert-type questions between the two groups, as it is appropriate for ordinal data and small sample sizes where normality cannot be assumed. A significance level of $p < 0.05$ was used. Considering the sample size, we also reported effect sizes to complement p-values and provide a measure of practical significance.

3. Results

3.1 Participants

Forty-four adolescents aged 13 to 16 years participated in the study, of whom 24 and 20 were assigned to VA and VB, respectively. After excluding eight respondents who had not completed the questionnaire, data from 36 participants were analyzed.

As for the characteristics of the participants, Table 2 shows that the study population had some extent of interacting experience on digital devices, but varying levels of gaming interests. The variation in playing frequency among participants contributed to a more comprehensive and realistic analysis of the study's objectives, allowing for a broader understanding of different user experiences.

Table 2. Participants' characteristics.

Characteristic	Overall (n=36)	GA (n=21)	GB (n=15)
Age Mean, Std Deviation	14.53, 0.736	14.62, 0.805	14.4, 0.632
Access to digital device, n (%)			
Internet	33 (91.7%)	20 (95.2%)	13 (86.7%)
Smartphone	35 (97.2%)	21 (100%)	14 (93.3%)
Tablet	2 (5.6%)	2 (9.5%)	0 (0%)
Computer	5 (13.9%)	1 (4.8%)	4 (26.7%)
Other	2 (5.6%)	2 (9.5%)	0 (0%)
The frequency of playing games in the last 6 months, n (%)			
More than 10 hours	4 (11.1%)	3 (14.3%)	1 (6.7%)
5-10 hours	4 (11.1%)	1 (4.8%)	3 (20%)

1-2 hours	15 (41.7%)	9 (42.9%)	6 (40%)
No more than 1 hour	10 (27.8%)	6 (28.6%)	4 (26.7%)
Hadn't played any games at all	3 (8.3%)	2 (9.5%)	1 (6.7%)
Favorite game type (multiple choices), n (%)			
Casual game	8 (22.2%)	5 (23.8%)	3 (20%)
Role-Playing game	8 (22.2%)	5 (23.8%)	3 (20%)
Puzzle game	16 (44.4%)	8 (38.1%)	8 (53.5%)
Multiplayer Online Battle game	20 (55.6%)	13 (61.9%)	7 (46.7%)
Strategy game	9 (25%)	6 (28.6%)	3 (20%)
Adventure game	19 (52.8%)	11 (52.4%)	8 (53.5%)
Simulation game	5 (13.9%)	3 (14.3%)	2 (13.3%)
Others	4 (11.1%)	2 (9.6%)	2 (13.3%)

3.2 Questionnaire

We summarized questionnaire data from five subscales:

- Recognition: GA demonstrated better recognition ($d = 0.519$) and a stronger familiarity with the food items ($d = 0.451$) in the game compared to GB.
- Aesthetics: GA found the game's graphic style more similar to other games they usually play, and this difference was statistically significant ($p = 0.031$, $d = 0.692$). However, both groups showed similar levels of enjoyment of the graphics, with minimal differences in how well the graphics matched the gameplay, suggesting overall graphic preference was comparable between the groups.
- Emotional Response: GA reported higher levels of happiness while playing the game ($d = 0.467$), though feelings of boredom and confusion were largely the same across both groups.
- Perceived Usability: Both groups found the game equally easy to navigate, with identical mean ranks for ease of movement and minimal differences in menu navigation. There was also no significant difference in the perceived level of challenge, suggesting that the game's usability was consistent across groups.
- Endurability: There was a trend that the satisfaction with the overall game experience and the likelihood of recommending the game to others was rated somewhat higher by GA. The moderate effect sizes suggest that GA may have had a marginally better overall experience. However, these differences were not statistically significant.

Further details on these findings are provided in Table 3.

Table 3. Comparison of participant responses in the questionnaire: Mean Ranks, P-values, and Effect Sizes Between Groups, categorized into five subscales. The color coding in the table is based on Ellis's [31] interpretation of effect sizes: Orange = Large, yellow = medium to large, green= medium, blue = small to medium, grey= small, white = below small.

	Subscale	Mean Rank		P value	Affect size (Cohen's d)
		GA	GB		
I felt happy when I played the game.	Emotional Response	20.52	15.67	0.110	0.467
I felt bored when I played the game.	Emotional Response	18.75	17.00	0.575	0.170
I felt confused when I played the game.	Emotional Response	16.98	20.63	0.277	0.347
I felt challenged when I played the game.	Perceived Usability	16.53	18.73	0.497	0.221
I found it easy to move things around in the game.	Perceived Usability	18.50	18.50	1.000	0.000
I found it easy to click things on the menu.	Perceived Usability	17.58	17.39	0.955	0.018
I could recognize most of the food items.	Recognition	18.33	13.46	0.136	0.519
The food items in the game are common in my daily life.	Recognition	19.45	15.03	0.178	0.451
The game's graphic style is similar to what I usually play.	Aesthetics	20.39	13.83	0.031	0.692
I enjoyed the graphics and imagery of the game.	Aesthetics	18.88	16.83	0.523	0.198
I think the game graphics matched the game.	Aesthetics	17.44	16.47	0.750	0.101
I was interested in the Heart character in the game.	Aesthetics	16.71	17.39	0.819	0.070
My game experience was rewarding (satisfying).	Endurability	18.61	15.07	0.241	0.371
I would recommend this game to my friends and family.	Endurability	18.06	15.73	0.463	0.241

3.3 Telemetry data

We analyzed data from players' first attempts at the initial level of Name the food. Players who did not complete the game were excluded from the analysis, seven from GA and six from GB. Additionally, one outlier from GB was removed because their number of mistaken answers was significantly higher than the group average, falling outside our predefined criteria for acceptable performance. This extreme deviation likely reflects a misunderstanding of the task, and its inclusion would distort the overall analysis. The final dataset includes two groups of participants: GA (N=14) and GB (N=8).

GA demonstrated a higher average success rate and a lower total mistake rate than GB. The lower standard deviation in GB suggests that the performance scores in GB are less variable, indicating more consistency in success rates among its participants. Further details on these findings are provided in Table 4.

Table 4. Descriptive Statistics of Success Rates per Person and Total Mistakes Rate for GA and GB.

Success Rate (%)	GA (N=14)	GB (N=8)
Mean (%)	95.71	93.50
Median (%)	96	92
Standard Deviation (%)	4.56	3.67
Mistakes Rate (%)	GA (N=14)	GB (N=8)
Total mistakes rate (%)	4	7

3.4 Interview data

Qualitative data was collected from 14 interviews, with an equal gender distribution. Seven participants were selected from each group. Each interviewee was assigned a randomly generated player ID during gameplay. The alias for each interview combines their player ID, gender, and the version of the game they played (e.g., A4M9E_M_VA).

3.4.1 Visual Recognition

- ***The importance of visual fidelity***

As mentioned above, participants who had played VA played VB and vice versa for five minutes during the interview. When asked which version they found easier to recognize, 12 out of 14 respondents (86%) preferred VA. Realism was the most frequently cited reason for their preference.

> *VA is easy to recognize because it looks natural. For example, 'Jery' (a traditional sweet dish) looks like a rope in VB, which makes it very difficult to recognize. VA looks more realistic.* (A6T9U_F_VA)

Three of them mentioned that the food items in VA resembled how they see in them in daily life.

> *The food we eat in our daily life, which we see in stores, is quite similar to the picture in VA.* (A4F1V_M_VB)

In the game, *mutton* meat is depicted as a piece of raw meat with a sheep symbol tag. One participant noted that the *mutton* meat item does not resemble what she usually sees, but it does not impact her ability to recognize it as *mutton*.

When fidelity is increased, providing more detailed depictions of objects can aid recognition. One girl from VB noted that *grams* and *dalmoth* were frequently confused due to their similar appearance. However, in VA, recognition was easier for her as she could distinguish between these two food items.

Out of 14 participants, 2 (14%) expressed a different opinion. They believed that less detail enhanced simplicity and aided recognition, contrary to higher fidelity. They expressed that the outline made the graphic easier to comprehend.

> *[...] in VA, there's no border, and it's quite shiny, making it difficult to understand. In VB, it's simple and easy to recognize the object* (A9G1N_M_VA)

- ***Recognition Challenges***

When asked if they could recognize most of the graphics while playing the game, all agreed that one or more food items were difficult to identify. Among these, certain food items were mentioned most frequently in both versions: *spirits* (10 times), *dhindo* and *dalmoth* (7 times each), *pulse* (6 times), *grams* (5 times), and *barfi* (3 times). Notably, the majority of the mentioned difficult-to-recognize food items are local to Nepalese culture. Additionally, *potato* and *butter* were each mentioned once in VB. Furthermore, when questioned about their emotional response to the difficulty of recognizing food items, eight participants expressed feelings of confusion.

We found that the *spirits* graphic item was the most frequently confused element among participants. Many adolescents perceived it as a water container. The interpreter identified the bottle provided in the game as a specific *spirits* container, *karuwa*, in Newari culture. One participant reported never having seen this type of bottle before, while another associated *spirits* with ghosts, hence not relating it to food.

Dhindo was identified as a stone twice in VA and once in VB, and as egg once in VA. One participant pointed out an incorrect color representation of *dhindo*, noting that corn flour should be yellow. Upon further inquiry regarding participants' prior visual encounters with *dhindo*, it was revealed that none of the 14 participants had encountered *dhindo* in an edited graphical depiction; rather, their exposure was limited to photographic representations.

In VB, *dalmoth* and *grams* were consistently mentioned together three times by participants when discussing confusing items which look similar.

Some participants mentioned that although they frequently encounter certain items, the manner in which these items are presented in the game differs from their usual experience.

> *I don't know the name of chayote either in Nepali or in English. My mother cooks it regularly. I couldn't recognize it because I only eat it. I have seen it in real, but I get confused when I see it in pictures. (A1G9D_F_VA)*
> *It should be in the package. So, it should have the name on the package, such as dalmoth and pulses, etc. (A4M9E_M_VA)*

In the sixth level, where players prepare meals for a day, food items are positioned on a shelf for selection and placement onto a plate. Three participants highlighted difficulties in identifying items swiftly due to their disproportionate size compared to other items.

> *I feel like it's incorrect because cookies are smaller than cabbages (A4C9K_F_VB)*
> *The roti I usually see is bigger than it, it's not the size shown in the game. This make me confused when I was playing the level Prepare Meals. (A9G1N _M_VA)*

In GB, six out of seven participants, and in GA, three out of seven participants, reported that difficulties in recognizing food items contributed to their confusion during the game.

- ***Game graphic assets familiarity***

When questioned about the familiarity of the food items in the game within their daily lives, nine participants indicated that most of the foods were common, while five mentioned some were familiar. Among these five, three were vegetarian, leading to limited exposure to certain meat products.

Additionally, in the sixth level, two participants said that the plate is not what they usually use, but they do not have a recognition problem to understand it.

The shape is similar to the one I used at home, but the difference is that it is made of steel and copper. (A1G9D_F_VA)

Further inquiries regarding participants' emotions upon encountering common food items demonstrated that two participants expressed feelings of confusion or disappointment upon encountering uncommon foods. Conversely, seven participants reported feelings of happiness. Some elaborated further on their positive emotions:

I feel good. Since all the food in the game is common, so I can learn which foods provide carbohydrates or protein, which I likes this way to learn. The knowledge is necessary in our daily life. (A2K3E_F_VB)

Two participants expressed a desire for additional food items to be included in the game, such as vegetables like *spinach* and fruits like *lychee*.

When asked about the differences or similarities between *Happy Heart* and other media, all seven participants who played VB noted they had encountered similar styles either in books, games, videos, or cartoons. Meanwhile, six participants who played VA mentioned seeing similar styles either in books, posters or advertisements.

I have seen this type of graphic on TV, in textbooks, and in games. For example, I have seen something similar in a game my younger brother plays, where it is depicted in the environment. I have also seen items like mangoes and oranges, those fruits and vegetables, in anime. But I have never seen anything like dhindo in these medias. (A4F1V_M_VB)

Three participants from VB and two from VA noted that they had not encountered a similar style in other media. One participant mentioned that food items like *dhindo* had only been seen in photos, never in other graphic forms, and another participant made the same observation about *roti*.

3.4.2 Visual preferences

- ***Preferences of higher fidelity***

When asked which graphic style they preferred, 11 out of 14 indicated a preference for VA. Of those 11, 10 (91%) cited realism or authenticity as their main reason for choosing VA.

I prefer VA because it looks more realistic. VB looks like a painting, animation and cartoons. The two versions of the game look very different. VA is nicer than VB. (A1R1L_M_VA)

One participant mentioned that he and his friends typically play 3D games such as Free Fire and therefore prefer realistic-looking graphics in games.

With more specific questions asked, in a formal gameplay context, eight participants (57%) expressed a preference for playing VA, while six participants (43%) favored VB if given the chance to play in the classroom. However, in an informal gameplay context, nine participants (65%) chose VA, three (21%) chose VB, one (7%) liked both, and one (7%) chose not to play either.

Additionally, “realistic” has been mentioned the most with five out of nine (56%), while three out of those five mentioned that VA is easier to recognize.

> *Definitely VA. It's really clear to understand. I really like the animation and graphic design. The VA does not have outlines, which makes it more realistic.* (A4C9K_F_VB)

Further discussion is about VB which is more like a game for kids who are younger than the participants (13-16).

> *I prefer VA. The difference between VA and VB is the outline. VB is really good for my younger brother, who is 6 years old. It is more suitable for younger kids but not for me. Because this looks like the figures we teach to toddlers.* (A7W7E_F_VA)

In the informal gameplay context, one participant also mentioned that both graphic styles are designed for kids.

> *Both games are too simple and feel like they're made for kids. The graphics are easy and better for children, not older players like me. So, I don't want to play either game in my free time. (A9R7X_M_VB)*

Participants who prefer VB to play in the classroom and free time, provided the reason that they thought VB is easy to recognize.

> *I prefer VB to play in the classroom. Because in VB the graphic is good and everyone can understand it. But color and graphics are better in VA. (A2B7Z_M_VB)*

- ***Game preferences***

Thirteen out of fourteen participants expressed their favorite games (see Table 5), with one participant not expressing any particular preference. Most games are mobile games, although some, like Minecraft and Ark: Survival Evolved, are available on multiple platforms.

Table 5. Frequency of Mentioned Favorite Games.

Game Title	Times Mentioned
Garena Free Fire [32]	6
Candy Crush Saga [33]	5
Subway Surfers [34]	4
Temple Run [35]	3
puzzle game	3
Piano Tile [36]	2
Clash of Clans [37], driving truck, Ark: Survival Evolved [38], fashion game, Minecraft [39], Roblox [40], Hay Day [41], and Mini Militia [42]	1 each

In the responses to the reason for their favorite games, a recurring theme is the enjoyment derived from the mentioned games. Participants expressed positive sentiments towards their favorite games, whether for fun, entertainment, or relaxation. Seven participants also mentioned a preference for games with appealing graphics and animations, such as the high-level graphics found

in Garena Free Fire or the good animation seen in Subway Surfers, Ark: Survival Evolved and Mini Militia. Additionally, games like Candy Crush and COC were appreciated for their simplicity and their ability to provide entertainment during moments of boredom.

- ***Game graphical preferences***

In terms of graphic form (2D or 3D), six out of fourteen games were in 3D, while five out of fourteen are 2D games. As for Fashion Games, driving trucks, and puzzles, without specific information regarding their graphic styles, it is challenging to categorize them definitively. Four male participants and one female participant mentioned that they usually play or prefer 3D games.

> *3D games are one of the most popular types of games now, like Free Fire. Free Fire is one of the most popular games, so 3D graphics will help us play better. It is very interesting, enjoyable, and easy to play. (A4M9E_M_VA)*

Three participants stated that 2D games are not their preferred choice.

> *Seeing 2D graphics reminds me of things that are more like games for children. Since children enjoy playing such games. (A4F1V_M_VB)*

When considering graphic style, five games lean towards cartoon-stylized graphics featuring colorful and stylized visuals: Subway Surfers, Temple Run, Candy Crush, Clash of Clans, and Hay Day. In contrast, two games aim to create immersive virtual worlds utilizing more realistic graphics: Free Fire, and Ark: Survival Evolved. Four games like piano tile, Minecraft, Roblox and Mini Militia are more in line with abstract style.

- ***Cartoon Series Preferences***

Thirteen out of fourteen participants expressed their favorite cartoons and cited entertainment as the primary reason for favoring their chosen cartoons. Two participants mentioned a long-standing relationship with their favorite cartoons, having watched them since childhood but one participant stated a shift away from watching cartoons. Additionally, the characters are mentioned three times as a reason for preference.

Regarding graphic form (2D or 3D), eight out of eleven cartoons mentioned by the participants use 2D animation, while three out of eleven utilize 3D animation. In terms of country of origin, the majority, seven out of eleven, are from Japan, with three from India and one from France.

4. Discussion

4.1 The influence of visual fidelity on visual recognition

Both our qualitative and quantitative data suggest that VA is more easily recognized compared to VB. Participants consistently identified realism as a key factor contributing to the clarity of VA. Enhanced visual fidelity allows for more detailed and accurate representations of objects, which aids in their recognition [43]. For example, participants who initially had difficulty distinguishing between *grams* and *dalmoth* were able to differentiate them more effectively in VA, demonstrating that higher visual fidelity supports clearer identification. This observation aligns with the general principle that more realistic visual elements facilitate more confident identification of objects. Telemetry data further supports this, showing higher success rates and fewer mistakes in GA. This can be attributed to the higher visual fidelity of VA, which likely provides clearer visual cues that better align with players' cognitive processes. This principle is consistent with findings in other SGs, though the relevance may vary by age group. Studies in medical training show that higher-

fidelity simulations improve diagnostic accuracy, decision-making, and procedural skills [44]. However, the effectiveness of such simulations depends on age-appropriate design, as younger players may engage differently with high-fidelity visuals compared to adult learners in medical training.

According to the questionnaire results, participants in GA who played the higher-fidelity version (VA), were more familiar with in-game food items than GB. This suggests that VA's higher fidelity visuals closely mirrored their real-world experiences. One participant noted, " I felt happy when I saw Nepali food on the screen like *Dhindo*," underscoring the emotional impact of familiar visuals. GA also reported higher levels of happiness and less confusion than GB, indicating that higher visual fidelity not only improves recognition but also enhances engagement and emotional connection.

4.2 The influence of game literacy on visual preference

Our findings demonstrate that game literacy significantly influences graphic preferences in games. Based on questionnaire and interview data, participants prefer VA with its graphic style perceived as more in line with the visuals they are accustomed to in other games. Other major reasons for the preference of this graphic style were realism and authenticity. According to the participants, VA has a more three-dimensional appearance, which aligns with the current popularity of 3D games. Notably, when asked about their favorite games, Free Fire (3D), Candy Crush (2D), and Subway Surfers (3D) emerged as the top choices, while 5 participants mentioned they usually play or prefer 3D games. The games varied in fidelity from medium to high and featured both realistic and stylized graphic styles. Most of the games are mobile-based, and none have been developed locally in Nepal, highlighting a reliance on internationally produced games. The popularity of 3D graphics among adolescents reflects a strong visual preference for realistic visual styles, which influences their ability to recognize and engage with similar visuals in SGs, as players are already familiar with such aesthetics in their everyday gaming experiences.

On the contrary, VB was described as resembling a children's game, with an outline that closely matched what younger siblings might play with. Participants therefore believed it was more appropriate for younger children. For older adolescents, more realistic graphics might be necessary to maintain engagement, while younger audiences may benefit more from simpler, more outlined visuals.

On the other hand, participants who favored VB appreciated its simpler graphics, which they found easier to recognize. As one participant noted, "everyone can understand VB's graphic." Two key factors likely contribute to this preference. First, the graphical style with outlines is commonly seen in other media, such as books and cartoons, making it familiar to the players [24]. Higher media literacy may enhance players' ability to appreciate specific graphic styles. For example, adolescents who read more frequently are likely to recognize and value graphic styles similar to those found in books and other familiar media. This familiarity can influence their preferences and perceptions of graphics in SGs. Second, As mentioned in the A/B study design section, outlines enhance object recognition by providing clear boundaries, reducing visual complexity, and helping players focus on key game elements. This improves decision-making and engagement in fast-paced environments [25], [26], [27]. Additionally, screen size can be a factor here as well. On smaller screens, clear outlines may become even more critical, as smaller objects require sharper boundaries to maintain clarity [45].

Using outlines can be a practical solution to optimize production time in game design. However, it is important to carefully consider the thickness of the outline [45] and, more importantly, ensure the objects maintain a sense of volume. Overly thick outlines can flatten the appearance of objects, diminishing the sense of depth, while thin outlines may fail to provide the clarity needed for quick recognition.

When discussing visual fidelity in game graphics, we do not differentiate between 2D and 3D graphic formats. However, from a technical and cost perspective, 2D graphics are generally faster and more affordable to produce. Even though 3D graphics are popular and align with current game trends among our target audience in Nepal, producing them at the same level of fidelity requires more investment in both time and resources. The challenge is to strike a balance, finding just enough visual fidelity for players without unnecessary complexity that inflates production costs.

4.3 Gameplay context: informal or formal

When considering more specific contexts, VA was the most favored in both formal and informal gameplay settings. However, the difference was less pronounced in a formal context, such as playing in the classroom.

Our results offer valuable insights for developers regarding graphics investment in SGs. In formal educational settings, where adolescents are required to engage with assigned materials, it may not be necessary to allocate significant resources to high-fidelity graphics. Moreover, adolescents may not focus heavily on visually appealing graphics, and simplicity could help direct their attention to key information. Overly complex visuals can increase extraneous cognitive load, potentially hindering learning [43]. As long as the graphics are sufficient to ensure clear recognition and effectively convey the intended message, lower fidelity may not be detrimental. On the other hand, in informal contexts, such as at home, where players have more entertainment options, investing in high-quality graphics could be crucial for capturing and maintaining attention. Javora [46] cautioned that restraint is necessary when developing appealing graphics, as overly complex designs can hinder learning by increasing cognitive load. Therefore, considering the gameplay context during development can help optimize resource allocation for graphics in SGs.

4.4 Local Food Recognition Challenges: Cultural vs. Global Influences

Identifying Nepalese local foods such as *dhindo, dalmoth, pulse, grams,* and *barfi* posed significant challenges. Although those are common foods in Nepalese daily life, they may not be common in daily media, such as games or books, in Nepal. For example, participants' exposure to *dhindo* primarily through photographs rather than other graphical representations affected their ability to identify it. Interestingly, visual literacy appeared to play a more influential role than lived experience in recognition, complicating the identification process for adolescents in our study.

Like traditional literacy, visual literacy is culturally specific, though some symbols and visual images are universally recognized [3]. Cultural backgrounds shape individuals' perceptions of common objects, as demonstrated in our study. Nepal's cultural diversity spans 125 distinct ethnic groups [47], each with its own influence on daily life. An extreme example in this study is the misidentification of *spirits*, viewed as a local *spirits* bottle by the Nepalese team due to Newari (a local ethic group predominant in Bhaktapur) cultural symbols. However, 10 out of 14 participants mistook it for a water container or had never seen it before. This demonstrates that the game's visual content related to cultural and social content can be interpreted differently across cultures. Notably, our participants were from Bhaktapur, a district deeply influenced by Newari culture. Age groups also played a significant role in the recognition of these items. Therefore, using an image of a common *spirit*s glass filled with *spirits* could be more easily recognized. Leaning towards more universal representations therefore may lead to quicker identification [19].

On a positive note, local foods play an important role in daily life and can enhance adolescents' understanding of nutrition. In the participants' own words, they mentioned being able to acquire knowledge about which foods contain more carbohydrates or protein. Moreover, they expressed delight in seeing these local foods featured in the game. This aligns with findings by Pyae, Zaw, and Khine [48], who observed that incorporating relevant cultural content in digital games, particularly for localization and culturalization, can make players more engaged in the game.

Choosing food items for SGs aimed at a specific cultural group requires careful thought. local food items could be a good culturalization for the target audience for game experience, but how to choose the representation is very important here to make sure it could communicate a message correctly. Difficulties in recognition can lead to negative emotions, such as confusion. Therefore, it is important to account for the visual literacy of the target group during the design process.

5. Strengths

The strength of this study is its mixed-methods approach. The integration of both qualitative and quantitative data offers a more comprehensive understanding of the subject matter. Another strength lies in our studies adoption of a transcultural perspective, integrating insights from both international and national researchers.

6. Conclusions

This study explores how different levels of visual fidelity influence visual recognition and visual preferences among Neplasese adolasents. The results show that higher visual fidelity enhances players' recognition, overall preferences, familiarity, and emotional responses in SGs. However, the difficulties participants faced in identifying local food items highlight the importance of visual literacy, suggesting that adolescents' recognition and visual preferences are shaped more by familiarity with popular media—such as games and cartoons—than by real-life experiences. Effective visual communication in SGs goes beyond understanding visual languages or semiotic properties; it requires a connection to adolescents' broader cultural knowledge and relevant experiences, grounded in the cultural and social contexts in which games are produced.

To minimize the risk of visual miscommunication in SGs, developers should consider factors regarding individual differences such as age, gender, visual literacy, game literacy, life experience, cultural context, religion, and educational level. Additionally, factors related to the playing environment, such as whether the study is formal or informal, pedagogical strategies, the type of equipment (e.g., Android phones, tablets), and screen size, should also be considered. By integrating these considerations into the design process, developers can create more inclusive and effective visual experiences in SGs, enhancing their overall impact.

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Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and publication of this article.

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Appendix

Game Graphics and Experience Questionnaire

The purpose of this tool is to evaluate players' game and game graphic experience. This questionnaire asks about your PERSONAL beliefs about the **educational game HAPPY HEART** you played during the last 2 weeks.

Your responses will be anonymous and will never be linked to you personally. Your participation is entirely voluntary. If there are items you do not feel comfortable answering, please skip them. Thank you for your cooperation.

Part 1: Basic information

1. Please write your player ID: _____

2. Please write your gender:	a.Male	b.Female	c.Perfer not to say	d.Other____
3. Please write your AGE:	a.13	b.14	c.15	d.Other____
4. Please write your Grade:	a.8	b.9	c.10	d.Other____

Part 2: Game habits

1. What access do you have to digital media? (You can select multiple choices)

   a. Internet
   b. Smartphone
   c. Tablet
   d. Computer
   e. other_____

2. How often did you play video games per week in the last 6 months?

   a. more than 10 hours
   b. 5-10 hours
   c. 1-2 hours
   d. no more than 1 hour
   e. hadn't played any games at all

3. What kind of game do you usually like? (You can select multiple choices)

   a. Casual game
   b. Role-Playing game
   c. Puzzle game
   d. Multiplayer Online Battle game
   e. Strategy game
   f. Adventure game
   g. Simulation game
   h. Other_____

Part 3: Your experience of the game Happy Heart

Please indicate how you felt while playing the game of each of the items, on the following scale:

Strongly disagree: 1; Disagree: 2; Neutral: 3; Agree: 4; Strongly agree: 5

What does "**game graphics**" mean?

It's the visual elements in video games – everything you see on the screen while playing, like characters, environments, objects, animations, and more.

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
		1	2	3	4	5
1	I felt happy when I played the game.	○	○	○	○	○
2	I felt bored when I played the game.	○	○	○	○	○
3	I felt confused when I played the game.	○	○	○	○	○
4	I felt challenged when I played the game.	○	○	○	○	○
5	I found it easy to move things around in the game.	○	○	○	○	○
6	I found it easy to click on things in the menu.	○	○	○	○	○
7	I could recognize most of the food items.	○	○	○	○	○
8	The food items in the game are common in my daily life.	○	○	○	○	○
9	The game's graphic style is similar to what I usually play.	○	○	○	○	○
10	I enjoyed the graphics and imagery of the game.	○	○	○	○	○
11	I think the game graphics matched the game.	○	○	○	○	○
12	I was interested in the **Heart** character in the game.	○	○	○	○	○
13	My game experience was rewarding (satisfying).	○	○	○	○	○
14	I would recommend this game to my friends and family.	○	○	○	○	○

15. What did you **like** about the **game graphics** of **Happy Heart**?

16. What did you **dislike** about the **game graphics** of **Happy Heart**?

17. Is there anything else you would like to say about **Happy Heart**?