

## Assessing Virtual Art Museum Experiences in Elementary Education: Developing Children's Critical Thinking Skills

Eslam Nofal<sup>a,b\*</sup>, Doha H. Soliman<sup>a,c</sup>, Nevine N. Zakaria<sup>d,e</sup>, Priscilla Van Even<sup>f</sup>, Joelle Martin<sup>g</sup>, Seham M. Nofal<sup>b</sup>, Monther Jamhawj<sup>a,h</sup>

<sup>a</sup> Department of Architectural Engineering, University of Sharjah, UAE

<sup>b</sup> Department of Architectural Engineering, Assiut University, Egypt

<sup>c</sup> Department of Architecture, Faculty of Fine Arts, Alexandria University, Egypt

<sup>d</sup> Museology Department, Würzburg University, Germany

<sup>e</sup> Museum Exhibition Affairs, Ministry of Tourism and Antiquities, Egypt

<sup>f</sup> Meaningful Interactions Lab, KU Leuven, Belgium

<sup>g</sup> Academy of Architecture, Zuyd University of Applied Sciences, The Netherlands

<sup>h</sup> Department of City Planning and Design, Jordan University of Science and Technology, Jordan

---

### Abstract

This study investigates the impact of virtual art museum experiences on fostering critical thinking among elementary school students. Conducted in a formal school setting in Sharjah (United Arab Emirates), the research employs an experimental design to compare the development of critical thinking skills in students exposed to virtual museum environments versus traditional art education methods. Drawing on Bloom's revised taxonomy of cognitive processes and Falk and Dierking's contextual model of learning, the study evaluates six critical thinking skills: observation, interpretation, evaluation, analysis, association, and creation.

Findings reveal that virtual museum experiences significantly develop lower-order skills such as observation, interpretation, and evaluation skills, allowing students to interact more deeply with artworks. However, a decline is noted in higher-order skills involving synthesis, analysis, association, and creation, suggesting that certain critical thinking skills require more open-ended and exploratory engagement than most virtual platforms may typically provide. The study underscores the importance of balancing structured and exploratory learning approaches in virtual museum programs to optimize educational outcomes. These findings contribute to the broader discourse on digital learning in museum education and provide practical insights for educators and museum professionals seeking to integrate virtual learning tools effectively into art education programs.

**Keywords:** art museums, critical thinking, virtual museum experiences, digital learning, elementary education, interactive learning, art interpretation

### Introduction

Advancements in digital technologies have significantly influenced museum education, fostering innovative learning strategies (Corich et al. 2006; Meirbekov et al. 2022; Poce 2021). The integration of online learning technologies, coupled with a growing emphasis on critical thinking, has helped learners develop essential cognitive skills while leveraging museums' educational resources (Ennes 2021; Zakaria 2024).

Recognizing critical thinking as an essential skill is particularly crucial in today's knowledge-based digital society (Corich et al. 2006; Meirbekov et al. 2022; T. Moore 2013). Defined as purposeful, self-regulated judgment involving interpretation, analysis, evaluation, and inference (Facione 1990: 2) critical thinking is increasingly positioned as a priority in both formal and informal education settings.

In parallel, museum education has moved beyond knowledge transmission toward approaches that emphasize inquiry, dialogue, and meaning-making with objects and artworks (Hooper-Greenhill 1994, 2007). Museums are widely understood as informal and non-formal learning environments that support free-choice learning shaped by prior knowledge, motivation, and social context (Falk and Dierking 2000, 2016; Hein 1998).

Within this context, art museums have emerged as important partners for schools in cultivating students' critical thinking. Programs increasingly prioritize visual literacy, discovery-based learning, and structured discussion over rote knowledge (Al-Radaideh 2012; Burchenal and Grohe 2007; Luke et al. 2007). Unlike conventional school settings, where learning is predominantly verbal and text-based, art museums provide informal learning environments that stimulate deeper cognitive engagement: strengthening students' observation, interpretation, and evaluative judgment, while supporting communication and self-expression (Burchenal and Grohe 2007; Luke et al. 2007).

The rise of digital platforms further extends these opportunities by offering interactive, accessible ways to engage with artworks. Virtual museum experiences can replicate or even enhance aspects of physical visits, providing tools for detailed observation, contextual interpretation, and inclusive access (Wu et al. 2023; Yow 2022). Yet, questions remain about how such experiences affect different dimensions of critical thinking, particularly for younger learners. While prior research highlights the potential of virtual environments to enhance motivation and engagement, their effectiveness in supporting higher-order synthesis skills such as analysis and creation remains underexplored.

Building on this gap, this study investigates the impact of virtual museum experiences on the development of critical thinking skills in elementary school students. Using Benjamin Bloom's revised taxonomy as the analytical framework for cognitive processes (Anderson et al. 2001), and informed by John H. Falk and Lynn D. Dierking's (2016) Contextual Model of Learning to situate how learners engage with artworks, we compare a conventional art engagement experience with three virtual experiences across six skills: observation, interpretation, evaluation, analysis, association, and creation. The sample comprised two third grade classes (N=55; ages 8-9) in an English-language school in Sharjah, United Arab Emirates. The findings extend museum education research in Arab contexts and offer evidence-based guidance for the design of virtual art museum programs in elementary education.

## **Theoretical Context**

### ***Learning Experiences and Pedagogy in the Museum***

Museums are important educational spaces that provide diverse learning experiences for visitors. In the museum domain, education extends beyond the acquisition of factual knowledge to encompass various aspects of free-choice learning, guided by individual motivations, interests, and prior knowledge (Falk and Dierking 2000, 2016). In literature, the terms informal and non-formal are commonly used to describe museum learning programs and activities (Falk and Dierking 2000, 2016; Hein 1998; Hooper-Greenhill 1994, 2007). In this paper, informal refers to self-directed, free-choice learning, and non-formal refers to structured programs outside formal schooling. Our school-museum collaboration is non-formal within a free-choice learning tradition.

Over recent decades, the educational role of museums has been increasingly framed within lifelong learning and experiential paradigms. Educational practice has shifted from mere knowledge transmission toward approaches that integrate learning with visitors' experiences, making inquiry, dialogue, and meaning-making central to the museum visit (Hooper-Greenhill 1994, 2007; Jeffery 2000; Kelly 2003) This evolution reflects a broader trend in pedagogy that prioritizes learner agency, engagement, and the co-construction of knowledge in informal

learning environments (Jeffery 2000; Kelly 2003).

Throughout history, children have been a key audience for museums, both as visitors and learners (Andre et al. 2017). Today, museum education practices integrate various learning theories, including behaviorism, constructivism, cognitive and developmental perspectives, humanism, and connectivism to inform the design of meaningful programs for school learners (Ebitz 2008; Zakaria 2024). These pedagogical approaches aim to create meaningful and engaging learning experiences for school students, connecting objects to students' prior knowledge and supporting progressive skill development (Andre et al. 2017).

Current museum education practices emphasize student-centered learning, where students explore collections through guided discussions using inquiry-based dialogue rather than didactic lectures (Golding, 2009; Gómez-Hurtado et al., 2020).<sup>1</sup> Visual Thinking Strategies (VTS) are widely applied, encouraging careful observation and dialogic interpretation through structured questioning (Yenawine 1999). Studies of art-museum programs report measurable improvements in students' abilities for close observation, interpretation, and evidence-based evaluation (Burchenal and Grohe 2007; Luke et al. 2007). In parallel, engagement with artworks and interpretative media activates play, sensory perception, and emotion- factors associated with deeper learning and heightened awareness (Golding 2009; Gómez-Hurtado et al. 2020).

As lifelong learning and accessibility for children and students have become central priorities for museums (Zakaria 2024), digital technologies have played an increasingly significant role in supporting museum education (organized programs) and learning (students' cognitive processes) through synchronous and asynchronous virtual experiences, as well as interactive tools that encourage participation and knowledge production (Hawkey 2002; Marty 2008; Moore, 2015). High-resolution platforms and curated digital resources expand opportunities for close looking and contextual understanding, with growing interest regarding the potential of such tools to foster critical thinking skills in children (Poce 2021).<sup>2</sup>

Within this evolving pedagogical landscape, the present study examines how different types of virtual art-museum engagement relate to specific critical-thinking processes in elementary learners. Building on this pedagogical context, this article adopts Bloom's revised taxonomy (Anderson et al. 2001) as an analytical framework for critical thinking, and applies Falk and Dierking's Contextual Model (2000, 2016) to interpret how these processes unfold across both virtual and conventional conditions.<sup>3</sup>

### ***Art Museum Education as a Catalyst for Critical Thinking***

The field of art museum education is currently undergoing significant expansion and transformation. Art museums have developed numerous school programs incorporating visual literacy components to enhance self-expression, foster connections with art, improve communication skills, encourage engagement in classroom discussions, and inspire future artmaking (Al-Radaideh 2012). These initiatives are increasingly designed to cultivate students' critical thinking skills by offering interactive experiences with artworks in both physical and virtual settings (Bowen et al. 2014; Broome et al. 2018; Burchenal and Grohe 2007; Luke et al. 2007).

A growing body of research suggests that the most direct educational impact of the arts lies in close perception and comprehension of aesthetic features (Bowen et al. 2014). The ill-structured nature of visual arts experiences, as described by Arthur Efland (2002), encourages students to develop their own cognitive frameworks, activating long-term memory and language (Alter 2007), developing critical thinking and literacy skills (Randi Korn and Associates 2007) and engaging habits of mind associated with critical thinking, including hypothesizing and testing, inference-making, and forming reasoned judgments (Bowen et al. 2014; Luke et al. 2007). Evidence from the Isabella Stewart Gardner Museum's Thinking through Art partnership with Boston City schools for example, reports measurable improvements in students' observation, interpretation, evaluation, and related competences through inquiry-based discussion (Burchenal and Grohe 2007; Luke et al. 2007; Bowen et al. 2014; Poce 2021).

Critical thinking is understood as 'purposeful, self-regulatory judgment that results in interpretation, analysis, evaluation, and inference, as well as explanations of the considerations

on which that judgment is based' (Facione 1990: 2). Practice-based formulations in museum education align with this emphasis: the Columbus Museum of Art describes critical thinking as the purposeful and reflective process of synthesizing, analyzing, and evaluating (Coldiron 2015: 41), while the Isabella Stewart Gardner Museum characterizes it as a set of skills encompassing 'learning to look', observation, inference, speculation, and the ability to provide evidence for those inferences (Burchenal and Grohe 2007: 112). These practitioner descriptions inform the educational context, while Peter A. Facione (1990) provides the formal definition adopted for analysis, subsequently operationalized through Bloom's revised taxonomy (Anderson et al. 2001).

To structure the construct analytically, this study adopts Bloom's revised taxonomy (Anderson et al. 2001) and foregrounds six skills for art-looking tasks, mapped to Bloom's levels:

- observation: attentive noticing of visual elements (supports remember/understand)
- interpretation: making coherent sense of what is seen (understand)
- evaluation: stating and justifying a position with visual evidence (evaluate)
- analysis: differentiating and relating compositional components (analyze)
- association: connecting the artwork to prior knowledge, contexts, and emotions (apply/analyze)
  - creation: producing original visual responses or recombination (create)

This mapping distinguishes lower-order processes (observation, interpretation, evaluation) from higher-order processes (analysis, association, creation) in children's engagement with artwork and provides a coherent theoretical basis for examining how different engagement modalities may differentially support these processes (Luke et al. 2007; Al-Radaideh 2012; Bowen et al. 2014).

### ***Virtual Museum Modalities: An Integrative Lens***

This paper uses the term 'virtual museum experience' to describe digitally mediated engagement with artworks, for example, gigapixel (high-resolution, zoomable) images with annotations, navigable 3D models, and 360°/VR environments and uses 'immersive' specifically for formats that emphasize a sense of presence (e.g. narrative 360°/VR). Such tools extend opportunities for close looking, contemplation, and access. Gigapixel imaging (e.g. Google Arts & Culture's Art Camera), for instance, reveals micro-details such as texture and brushwork that are often invisible during gallery viewing (Cabezos-Bernal et al. 2021).

To analyse how virtual formats may support critical thinking, this study focuses on four categories (Mateos-Rusillo and Gifreu-Castells 2016):

1. navigation / user control (free vs automatic)
2. interaction style (active manipulation vs predominantly passive viewing)
3. content presentation (descriptive text/annotations vs narrative video/voice-over);
4. visual rendering (realistic texture/zoom vs animated synthesis)

These categories tend to align with Bloom-level processes (see above). For example, fine-grained zoom with free navigation can support analysis; annotations can support interpretation and evidence-based evaluation by directing attention to visual evidence; narrative 360°/VR can prompt association by providing contextual cues linked to prior knowledge; and design elements that invite making align with creation (Cabezos-Bernal et al. 2021).

Virtual museum experiences are also associated with engagement and autonomy, enabling students to interact with exhibits in ways that align with their individual learning preferences and pacing (Yow 2022). Furthermore, they increase learning motivation and foster a sense of independence and self-management (Ofianto et al. 2023). Higher levels of immersion can deepen focus (Wu et al. 2023), but effectiveness depends on alignment with clear learning objectives (İşlek and Asiksoy 2024). Another significant advantage of virtual museums is advancing accessibility and inclusion, as they provide equal opportunities for individuals with disabilities, thereby promoting greater inclusion in museum experiences (Ilhan et al. 2022).

Interpreting how these cognitive processes unfold draws on Falk and Dierking's (2000, 2016) Contextual Model of Learning, which conceives museum learning as the interaction of

personal (prior knowledge, interests, emotions), sociocultural (peer and facilitator discourse), and physical/digital contexts over time. Virtual modalities reconfigure these contexts, shifting the physical to a digital interface, altering opportunities for talk, and changing personal agencies through navigation and cues. This framework helps explain why some features may privilege observation, interpretation, and evaluation, while analysis, association, and creation may require more scaffolded engagement. This dual framework - Bloom's revised taxonomy and Falk and Dierking's Contextual Model - underpins the analyses that follow.

## Methodology

### *Design Rationale*

This study investigates the impact of virtual museum experiences on the development of critical thinking skills among school students in formal education. It aims to assess the potential of digital technologies in fostering critical thinking through art education. The experimental design involves two levels of comparison:

- **Conventional vs. Virtual Museum Experience:** The conventional experience serves as a baseline to evaluate how digital technologies influence students' critical thinking.
- **Comparison of Virtual Museum Experiences:** Three distinct virtual museum experiences are assessed to determine which virtual features most effectively promote critical thinking skills.

### *Setting and Participants*

The experiment was conducted in collaboration with the American School of Creative Science in Sharjah, UAE. The school was selected based on its English-language curriculum and students' familiarity with digital tools. The participants were third grade students (N=55, ages 8–9) from mixed-gender classes. All took part during their scheduled art periods. According to the art teacher, most students had limited prior museum visit experience; this context is considered in the discussion and limitations.

### *Designing the Experiment*

#### *Artwork and Virtual Museums Selection*

Two paintings by Vincent van Gogh were chosen for their vivid colors and expressive style, commonly used in primary school programs to engage young learners (Korn-Bursztyn, 2002). *The Harvest* was selected for the conventional museum visit, while *The Starry Night* was used in the virtual experiences, as shown in Figure 1. Both artworks were chosen for their strong visual impact and cultural accessibility.



**The Harvest, 1888**

Artwork for the Conventional Experience



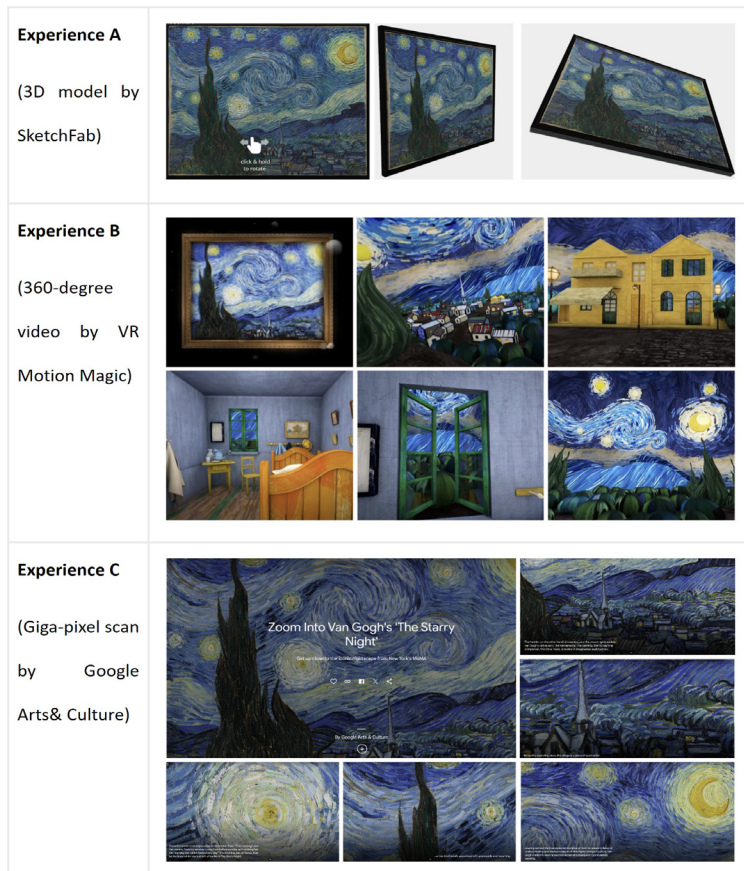
**Starry Night, 1889**

Artwork for the Virtual Experience

*Figure 1: The selected artworks for the experiment. Sources: The Harvest, Van Gogh Museum, Amsterdam (Vincent van Gogh Foundation); and The Starry Night, Van Gogh Gallery*

Three virtual museum experiences centered on *The Starry Night* were selected for their accessibility and interactive features (see Figure 2):

- Experience A (3D model by SketchFab): A detailed 3D model allowing for close examination of texture and brushstrokes from various angles.<sup>4</sup>
- Experience B (360-degree video by VR Motion Magic): An immersive video integrating elements from Van Gogh's works, providing an immersive exploration of the artist's world, including a look inside his house.<sup>5</sup>
- Experience C (Giga-pixel scan by Google Arts & Culture): A high-resolution scan enabling detailed exploration through zooming with access to corresponding information.<sup>6</sup>



*Figure 2: Selection of print screens for the three virtual museum experiences centered on The Starry Night selected for the experiment.*

The three selected experiences were not created by the authors but were rather selected from publicly available online resources. These experiences varied in their presentation of the artwork, enabling diverse engagement and interaction methods and matching the research objectives. Table 1 summarizes the key characteristics of each experience across four categories— navigation/user control, interaction style, content presentation, and visual rendering— based on Santos Mateos-Rusillo and Arnau Gifreu-Castells' (2016) model.

Category	Sub-category	Experience (A) 3D model by SketchFab	Experience (B) 360-degree video by VR Motion Magic	Experience (C) Giga-pixel scan by Google Arts& Culture	
Design of the Interaction	Navigation	Free	Accompanied (Free & Automatic)	Automatic	
	Interaction	Active	Active and Passive	Passive and Active	
Content	Formats	Navigable 3D-Model	Navigable Video with audio	Photo and Text	
Degree of correspondence	Contents	Artwork with a description	Artwork in a narrative context, merging it with another artwork	Artwork with explanatory annotations	
	Visual	Association with offline exhibition	Mirror metaphor	Immersive interface	Mirror metaphor
		Graphics	Realistic graphics, illustrating texture and brushstrokes	High-quality animated graphics with vivid colors	Realistic graphics with concentrated zoom

Table 1: Analyzing the characteristics of the selected virtual museum experiences

*Experimental Framework*

The experiment spanned two consecutive weeks, as illustrated in the experimental setup (Figure 3). In the conventional setting, all students experienced the same museum visit. In the virtual setting, students were divided into three groups (A, B, C) which were assigned with one of the virtual museum experiences. Each group was led by a facilitator, ensuring structured engagement and uniform implementation. Students were assigned coded name tags (e.g. A7, B2, C3) to maintain anonymity during data collection.

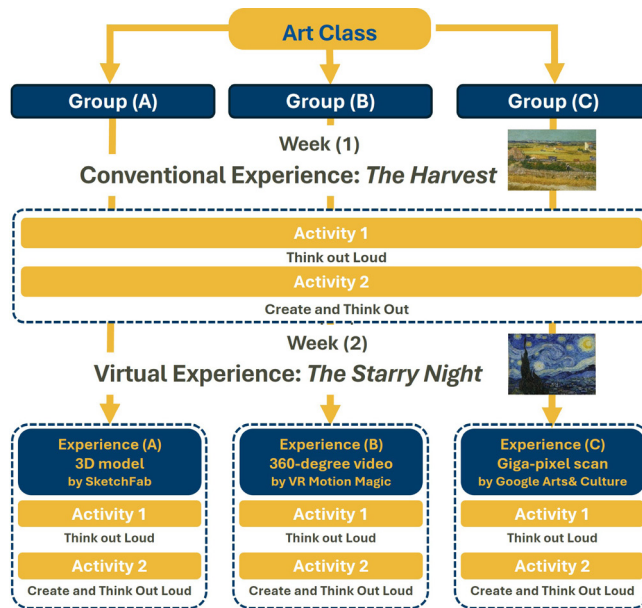


Figure 3: The design of the experimental setup

Two structured activities were conducted following the museum experiences to foster critical thinking skills, drawing on John Dewey's art criticism framework (Broome et al., 2018):

#### **Activity 1: Think Out Loud**

This written task guided students through a systematic process of observation, interpretation, and evaluation based on Bloom's revised taxonomy (Anderson et al. 2001), as explained in Figure 4. It was structured around three critical thinking skills:

- observation: encouraging students to identify details in the artwork, enhancing engagement (Burchenal and Grohe 2007)
- interpretation: helping students synthesize observations into a coherent narrative (Broome et al. 2018)
- evaluation: developing logical reasoning to make informed judgments (Alter 2007)

Students responded to four main guiding questions, supplemented by facilitator-led discussions to deepen reflection (Figure 5a).

#### **Activity 2: Create and Think Out Loud**

This drawing task engaged students in critical thinking through creative expression, following Bloom's higher-order thinking model (Figure 4):

- analysis: breaking down visual elements to understand composition (Center for Gifted Education 2003)
- association: connecting artwork to prior knowledge and emotions (Burchenal and Grohe 2007)
- creation: producing original work based on learned insights (Anderson et al. 2001)

Facilitators guided discussions with semi-structured questions to ensure consistency across groups (Figure 5b). This method, aligned with the open-ended guided inquiry approach (Lampert 2011), encouraged self-reflection and intellectual independence (Pujana et al. 2024).

These activities ensured a structured yet flexible engagement, allowing students to transition between different levels of critical thinking in a natural, iterative manner (Center for Gifted Education 2003).

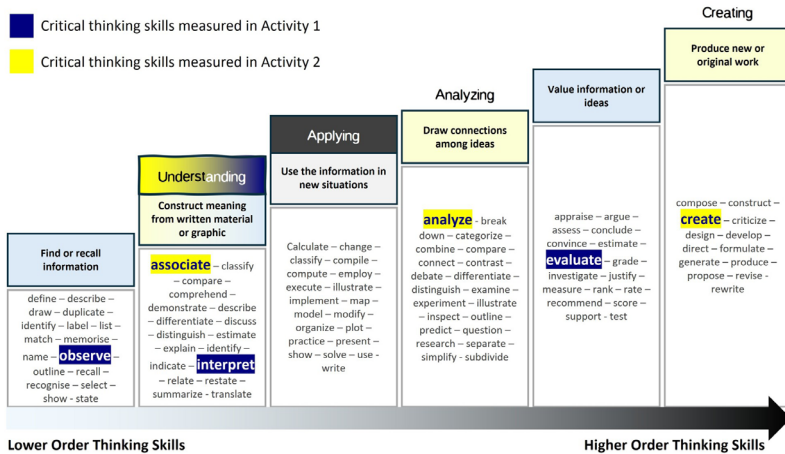


Figure 4: The selected critical thinking skills in both Activity 1 and Activity 2, building on Bloom's revised taxonomy by Anderson et al. 2001 Source: Arizona State University, modified by the author

**(a)**

Activity 1: Observe and Think Out Loud

Project Title: Assessing the Impact of Virtual Museum Experiences on Developing Children's Critical Thinking Skills

**Read the questions carefully and answer the following:**

**Q1:** What can you see in the painting?  
*(Define key elements: colors – people – buildings)*

**Q2:** Describe the scene you see.  
*(Where? What? What?)*

**Q3:** What do you see that makes you say that?

**Q4:** Do you like the painting? Why? *(what do you like or dislike about it?)*

Observation

Interpretation

Self-regulation

Evaluation

**(b)**

Activity 2: Create and Think Out Loud

Project Title: Assessing the Impact of Virtual Museum Experiences on Developing Children's Critical Thinking Skills

Instructions for Educators	Questions
<ul style="list-style-type: none"> <li>Assess you have talking about the exhibit.</li> <li>Give them time to explore discussion in their language.</li> </ul>	<p><b>What did you do?</b></p>
<ul style="list-style-type: none"> <li>Let the conversation flow and encourage them to elaborate on the exhibit, engaging them to have a deeper look.</li> </ul>	<p><b>Exhibit that you have chosen "we didn't have 'artworks' and "it's not" tell me more about it"</b></p>
<ul style="list-style-type: none"> <li>Encourage them to describe with their personal experience.</li> <li>Be open to recognizing the student's connections with their personal experiences.</li> </ul>	<p><b>What inspired you to share us? How your drawing related you of anything?</b></p>

Creation

Analysis

Association

Figure 5: Guided questions of the two activities analyzed with the alliance to the critical-thinking skills: (a) Questions of Activity 1, and (b) Questions of Activity 2

**Evaluation Framework**

*Critical Thinking Skills Development*

The evaluation focused on assessing the development of critical thinking skills through both conventional and virtual museum experiences. Students' responses to the activities were analyzed to measure critical thinking progression. Each response was evaluated based on a predeveloped rubric using a Likert scale for quantitative comparison (Tables 2 and 3). While numerical values were used for analysis, qualitative insights and pattern identification remained integral. The rubric was designed to align with the experiment's scope and data volume.

In Activity 1, skills were assessed as follows (Table 2):

- observation: measured by the number and detail of elements and colors listed (maximum nine blank spaces provided)
- interpretation: evaluated through the coherence of narratives including 'what, when, and where'
- evaluation: assessed based on students' opinions (like/dislike) and their justification

Observation			
Elements		Colors	
Number	Details	Number	Details
5: Very high (9-7 elements)	5: (1-2) exotic details	5: Very high (9-6 colors)	5: (1-2) exotic colors
4: High (6-5 elements)	4: Normal elements - high accuracy	4: High (5-4 colors)	4: Normal colors - high accuracy
3: Neutral (4 elements)	3: Normal elements - less accuracy	3: Neutral (3 colors)	3: Normal colors - less accuracy
2: Low (3-2 elements)	2: Limited details	2: Low (2 colors)	2: Limited details
1: Very low (1-0 elements)	1: No details	1: Very low (1-0 colors)	1: No details
Interpretation			
Narrative		Emotions	
5: Narrating a full story with extensive details		5: Expressing direct and forward emotions towards the place	
4: Narrating a story - high accuracy		4: Expressing a feeling - high accuracy	
3: Narrating a story - less accuracy		3: Having a neutral feeling	
2: Limited narrative		2: Didn't have any feelings	
1: No narrative		1: Didn't mention	
Evaluation			
Yes/No		Detailed Opinion	
5: Yes - No		5: Expressing direct and forward opinion towards the painting	
3: Don't know		4: Expressing an opinion - high details	
1: Didn't mention		3: Expressing an opinion - low details	
		2: Didn't know	
		1: Didn't mention	

Table 2: The designed rubric for analyzing Activity 1

In Activity 2 assessments included (Table 3):

- analysis: comparing student drawings to the original artwork to evaluate shape and color accuracy
- association: examining symbolic interpretation, alternative visual perception, and inspiration from the experience
- creation: evaluating originality in merging ideas or producing new artwork, in line with Bloom's revised taxonomy

Analysis			
Elements		Elements	
Number	Number	Number	Number
5: Very high (9-7 elements)	5: Very high (9-7 elements)	5: Very high (9-7 elements)	5: Very high (9-7 elements)
4: High (6-5 elements)	4: High (6-5 elements)	4: High (6-5 elements)	4: High (6-5 elements)
3: Neutral (4 elements)	3: Neutral (4 elements)	3: Neutral (4 elements)	3: Neutral (4 elements)
2: Low (3-2 elements)	2: Low (3-2 elements)	2: Low (3-2 elements)	2: Low (3-2 elements)
1: Very low (1-0 elements)	1: Very low (1-0 elements)	1: Very low (1-0 elements)	1: Very low (1-0 elements)
Association			
Recalling information from previous or current experience			
5: Associating the drawing with more than 3 detailed associations			
4: Associating the drawing with 3 associations			
3: Associating the drawing with 2 associations			
2: Associating the drawing with at least 1 association			
1: No association			
Creation			
The ability to communicate his ideas and understanding through visual art			
5: High communication skills			
3: Moderate communication			
1: Limited communication			

Table 3: The designed rubric for analyzing Activity 2

Assessing creative work posed a challenge, as artistic evaluation is inherently subjective. To ensure fairness and minimize subjectivity and bias, fixed evaluation criteria were established, and a triangulation approach was used, with three authors reviewing scores for consistency.

**User Engagement and Satisfaction**

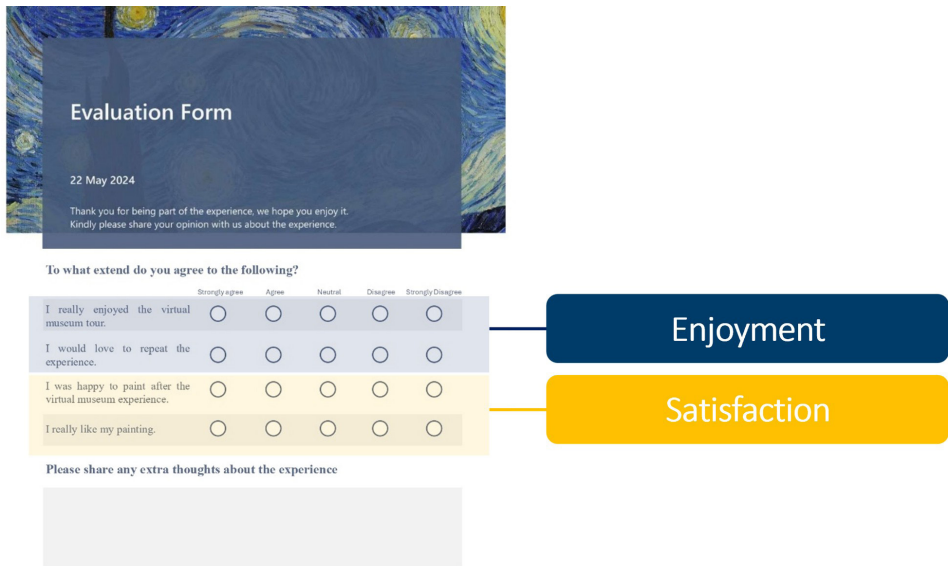
*Observation*

Engagement and satisfaction were further assessed through video recordings, capturing

student interactions. Three video cameras were strategically placed around the experiment space, ensuring comprehensive documentation. Guardian/parent consent forms were secured in advance.

### Questionnaire

A post-experiment questionnaire (Figure 6) was used to gauge student engagement and satisfaction. Responses were collected using a Likert scale (1 = strongly disagree; 5 = strongly agree), providing insights into subjective experiences and user engagement levels.



**Evaluation Form**

22 May 2024

Thank you for being part of the experience, we hope you enjoy it.  
Kindly please share your opinion with us about the experience.

To what extent do you agree to the following?

	Strongly agree	Agree	Neutral	Disagree	Strongly Disagree
I really enjoyed the virtual museum tour.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I would love to repeat the experience.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I was happy to paint after the virtual museum experience.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I really like my painting.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Please share any extra thoughts about the experience

**Enjoyment**

**Satisfaction**

Figure 6: Students questionnaire, analyzed in alignment with the measured criteria

### Experimentation

#### Pilot Study

A pilot study was conducted one week before the main experiment to validate the design, schedule, and activity execution. Three randomly selected students participated, and the results indicated a smooth workflow. The sketching activity, in particular, showed promising potential, as each student expressed their ideas in unique ways, suggesting a diverse range of outcomes for the full study (Figure 7). The pilot study led to minor time adjustments to optimize facilitator-student interactions.



Figure 7: Sketching outcomes of the students in the pilot study

### Conventional Experience

The conventional experience followed the predefined experimental setup (Figure 8). Students were grouped around tables, each assigned a facilitator, including the art teacher, ensuring fair distribution based on artistic interests. Video cameras and static photography documented the session.

Students first received an introduction to the museum setting, artist, and artwork. The painting (*The Harvest*), printed in A2 size with a museum label, was displayed on a board, simulating a conventional museum experience while A3 copies were distributed for individual interaction.



Figure 8: Conventional experimentation. Left: the experiment setting with students gathered around three tables, and one of the facilitators giving a brief introduction. Right: the art teacher guiding a group through the experience

- **Activity 1:** Students answered a guided question sheet, supported by facilitator-led discussions that encouraged independent thought without direct answers. Responses were recorded for later analysis (Figure 9a).

- **Activity 2:** Students visualized their interpretations using provided art materials. Facilitators assisted without interference, later initiating open-ended discussions to deepen engagement (Figure 9b).



Figure 9: A collection of photos for the students during (a) Activity 1, and (b) Activity 2.

### Virtual Experience

The virtual experience mirrored the conventional setup, with each group engaging in a different virtual museum experience (as explained above). Facilitators guided students through the digital exploration using their tablets (Figure 10).

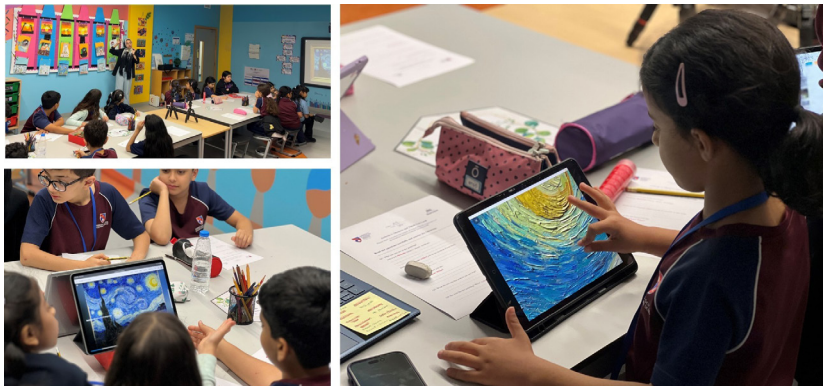


Figure 10: Experimentation with virtual experience. Upper left: Students listening to the instructions from the facilitator. Right: One of the students experiencing the Virtual Museum experience via her tablet.

## Results

Two third grade classes, involving 55 students, participated in the experiment. The results are structured according to the evaluation framework. The first section examines students' critical thinking skill development through Activities 1 and 2, while the second section assesses their engagement and satisfaction.

### Critical Thinking Skills Development

#### Activity 1: Think Out Loud

Incomplete responses were excluded, resulting in 27 students completing the activity in the conventional experience and 37 in the virtual experience. Most students found the observation and evaluation questions straightforward, while interpretation posed challenges due to its reliance on oral communication and the experiment's limited timeframe.

The following graph (Figure 11) illustrates the average percentage change in students' critical thinking skills between the conventional and virtual experiences. The results indicate a significant improvement in critical thinking skills through virtual museum experiences compared to the conventional setting.

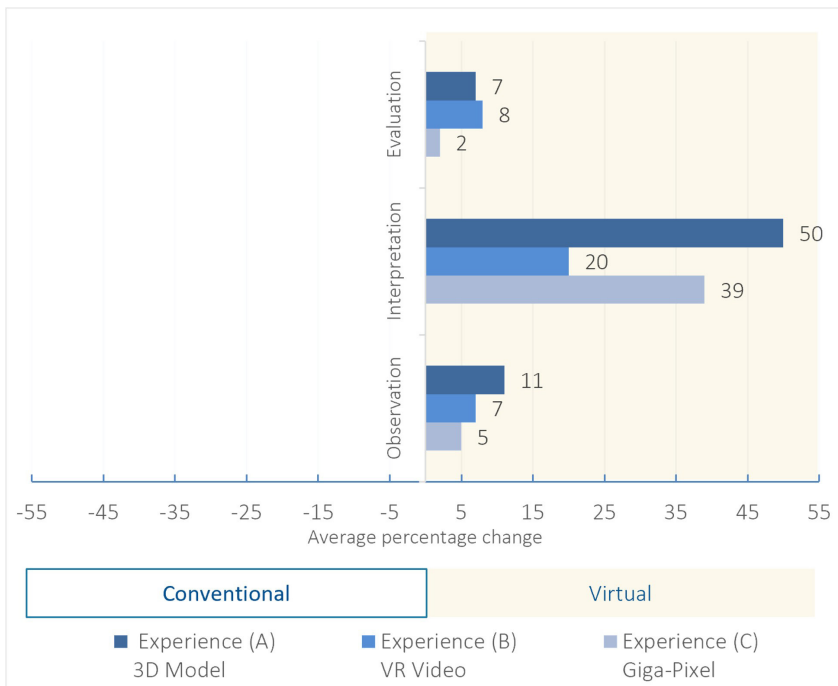


Figure 11: Average percentage change in students' critical thinking skills between the two experiences (Activity 1)

Interpretation skills exhibited the most improvement, with an average increase of approximately 36 per cent across the three virtual museum experiences (e.g., Figure 12). Notably, Experience A (3D model) had the greatest impact on students' interpretation (50 per cent), allowing them to provide comprehensive narratives linked to prior knowledge; for instance, one participant (A10) commented: 'it looks like a city at night, with the tall element resembling Burj Khalifa, and the overall mood giving off a ghost town'.



Figure 12: Sample student answers to the interpretation question from Activity 1. Above: Two students from groups (A) and (C) in the conventional experience. Below: The answers of the same students in the virtual experience

Observation skill scores were similar across experiences, though variations emerged in students' independent recognition of elements and colors (Figure 13). Experiences A and B enhanced color perception, while Experience C emphasized element identification.

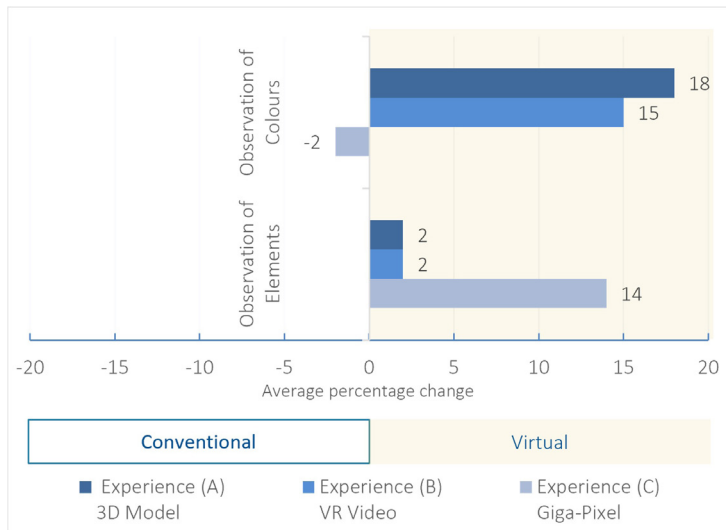


Figure 13: Average percentage change in students' observation of elements and colors (Activity 1)

The students' expression and engagement were further reflected in their activity outcomes. Figure 14 presents samples of student responses, demonstrating a strong use of color in Experiences A and B, and a detailed focus on shapes and elements in Experience C.

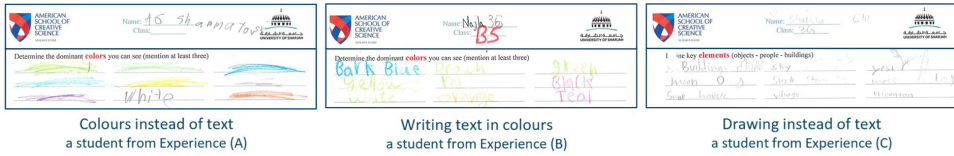


Figure 14: Activity 1 outcomes for three students from Experiences A, B, and C (virtual experience)

Activity 2: Create and Think Out Loud

Students approached the activity with enthusiasm, although some hesitated due to perceiving the drawing task as complex. Ultimately, 31 drawings were evaluated in the conventional experience and 36 in the virtual experience.

Figure 15 illustrates the average percentage change in students' critical thinking skills between the two experiences. Unlike Activity 1, Activity 2 revealed a decline in critical thinking skills within the virtual museum setting.

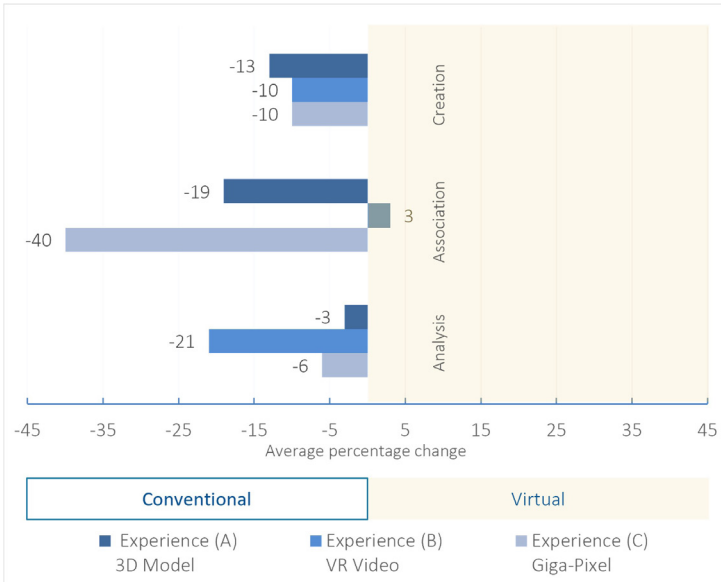


Figure 15: Average percentage change in students' critical thinking skills between the conventional and virtual experiences (Activity 2)

The only improvement was seen in association skills within Experience B (VR video), which increased by 3 per cent. This result suggests that the narrative-driven VR environment facilitated better contextualization and association. However, the same experience showed the lowest score (-21 per cent) for analysis, indicating that the immersive narrative distracted students from analyzing the artwork's details (Figure 16).



*Figure 16: Sample student outcomes from Experience B (Activity 2), illustrating the students' association skills in carrying out the activity*

Experience C (Gigapixel scan) showed the least improvement in association skills (-40 per cent), followed by Experience A (-19 per cent). The zoom-in effect in both cases likely heightened attention to details but hindered broader associations, as evidenced by students' more fragmented drawings (Figure 17).



*Figure 17: Student C5's Activity 2 outcomes in the conventional and virtual experiences. Left: the conventional drawing, where he drew a part of the painting with children playing football, and added complementary elements like the clouds, and the street. Right: the virtual drawing with only the main components*

The creation skill remained relatively consistent across virtual experiences, with a slight decline in Experience A. Activity outcomes varied: some students closely replicated the original artwork, while others extracted elements and integrated them into imaginative compositions. A notable example was a student who depicted a cup of blueberries framed with sun motifs, drawing color inspiration from *The Harvest* (Figure 18).

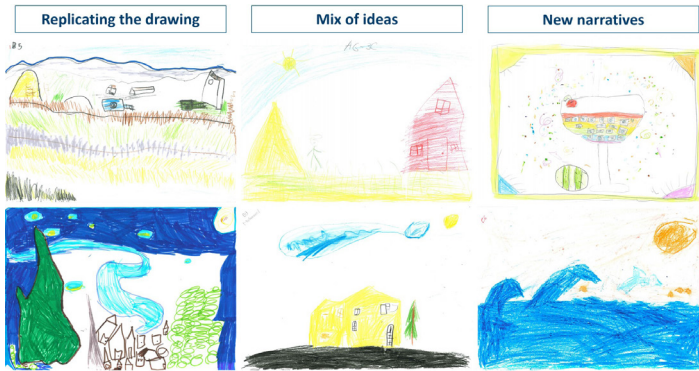


Figure 18: A Comparison of different creative approaches in Activity 2: Conventional (above) vs. Virtual experience (below)

**User Engagement and Satisfaction**

*Observation*

This section examines students' behaviors and interactions throughout both the conventional and virtual experiences, drawing from body language, engagement levels, and facilitators' observations.

Students were noticeably more engaged in the virtual experience. In Activity 1, several students expressed excitement by adding hearts and love notes to their worksheets (Figure 19). Additionally, facilitators observed heightened enthusiasm in Activity 2, where students appeared more comfortable and interested in drawing. For instance, the facilitator in Experience A noted that a typically shy student became more relaxed and communicative in the virtual experience, a trend further confirmed by recorded audio interactions.

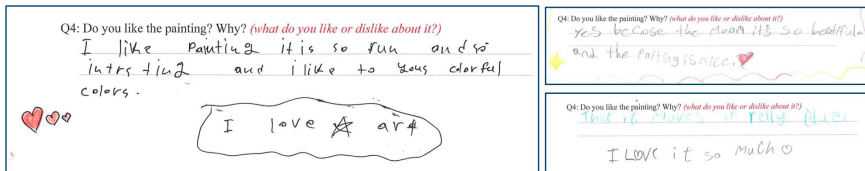


Figure 19: Sample of students' engagement with Activity 1

Video footage analysis also revealed increased enjoyment in the virtual experience. Students displayed more smiles, less fidgeting, and higher sustained attention. They also exhibited a greater level of comfort, engaging in more collaborative and social interactions.

*Questionnaire*

A questionnaire was distributed at the end of the experiment's second week. Due to time constraints, some students were unable to complete it in full. However, facilitators reinforced key engagement aspects during discussions, ensuring consistency with the questionnaire results.

The questionnaire's results indicated an 86 per cent enjoyment rate and 84 per cent satisfaction with the virtual experience. These findings aligned with student responses during the experiment, where approximately 80 per cent stated they preferred the virtual experience due to its engaging, clear, and informative nature.

Overall, observations and questionnaire findings strongly suggest that the virtual

museum experience successfully engaged students and introduced them to the artwork in an impactful manner. According to the art teacher, who is well-acquainted with the students, they thoroughly enjoyed and actively participated in the virtual experience.

## **Discussion**

The discussion section interprets the findings in relation to the study's objectives and existing literature. It highlights how virtual museum experiences contribute to critical thinking development, identifies key characteristics of effective virtual museums, and examines user satisfaction levels. Additionally, it acknowledges study limitations and suggests avenues for future research.

### ***The Impact of Virtual Museum Experiences on Critical Thinking Skills***

Virtual museum experiences have a varying impact on different critical thinking skills in school students. The study's findings revealed significant improvements in observation, interpretation, and evaluation, which are essential for analyzing artwork. However, skills related to synthesizing artwork, specifically analysis, association, and creation, showed a notable decline. These results align with previous research, which suggest that interactive and immersive experiences deepen students' understanding and interpretation of art (Burchenal and Grohe 2007) but may not effectively support higher-order synthesis skills.

Virtual museums provide a multi-sensory environment that actively engages students, in contrast to traditional museum settings where they tend to be passive observers. Features such as zooming into artwork and viewing it from multiple perspectives helped students focus on details, thereby enhancing their observation and interpretation abilities. Additionally, contextual videos supported students in evaluating artistic choices and forming reasoned judgments. However, challenges related to tablet navigation divided students' attention, potentially detracting from their ability to synthesize information. The narrative style and animations within virtual experiences, while beneficial for observation and interpretation, may have distracted students during the drawing process in Activity 2.

These findings highlight the need for a balanced approach integrating both conventional and virtual museum settings to optimize educational outcomes. Alternatively, careful selection between these environments is necessary to effectively target specific critical thinking skills. Future studies should explore how to refine virtual museum experiences to support synthesis-based skills while maintaining engagement with observation and interpretation processes.

### ***Optimizing Characteristics of Effective Virtual Museums***

Virtual museum characteristics play a crucial role in enhancing specific critical thinking skills. The study's results indicate a strong link between certain virtual museum features and the improvement of targeted cognitive skills, as shown in Figure 20. To maximize the educational benefits of virtual experiences, selecting the appropriate characteristics based on the desired critical thinking outcomes is essential.

#### ***Visual Graphics and Observation***

The quality and presentation of visual graphics in virtual museums significantly influence students' observation skills. The study found that Experience A (realistic, textured presentation) and Experience B (animated, vibrant colors) were the most effective in enhancing students' ability to accurately identify colors in the artwork, with percentage changes of 18 per cent and 15 per cent, respectively. In contrast, Experience C (realistic representation) improved students' focus on elements rather than colors, achieving a 14 per cent change. This suggests that the free zoom feature in Experience A allowed for flexible navigation, enabling students to explore brushstrokes and textures in greater depth, thereby reinforcing their observational skills.

#### ***Content and Interpretation***

The type and presentation of content in virtual museum experiences affect students'

interpretation skills. Experience A, which provided a realistic 3D model with a brief description, offered the closest simulation to a physical artwork and was the most effective in supporting interpretation. Experience C, with its annotated zoom-in scenes, also facilitated interpretation by providing structured insights into the artwork. However, Experience B, despite its narrative and contextual style, failed to enhance interpretation skills effectively. Instead of deepening students' understanding of the artwork's narrative, the additional context distracted them from forming their own interpretations.

### **Navigation, Analysis, and Association**

The navigation style in a virtual museum significantly influences students' analysis and association skills. The study found that Experience A was the most effective in fostering analysis, followed by Experience C and then Experience B. Conversely, Experience B excelled in developing association skills, followed by Experience A, with Experience C performing the weakest in this area.

- Experience A offered complete freedom of navigation, allowing students to zoom in and out and view the artwork from multiple angles. This flexibility helped students break down the artwork into fundamental components, strengthening their analysis skills.
- Experience B combined zooming with a narrative video that immersed students in a contextual environment. While this approach strengthened association skills, as students related elements to their drawings, it hindered analysis by introducing additional visual information that shifted focus away from the original artwork.
- Experience C used an automatic zoom feature, which facilitated structured analysis but limited students' personal exploration. While students could still analyze details, their lack of control over navigation resulted in weaker association skills.

These findings suggest that virtual museum design should align with specific educational objectives. If fostering observation and interpretation is the priority, realistic 3D models and structured annotations are beneficial. For developing analysis skills, flexible zooming and free navigation enhance engagement. In contrast, immersive narratives may be more effective in promoting association skills but should be carefully integrated to avoid overshadowing analytical engagement. Future virtual museum designs should consider these findings to optimize learning outcomes based on targeted cognitive skill development.

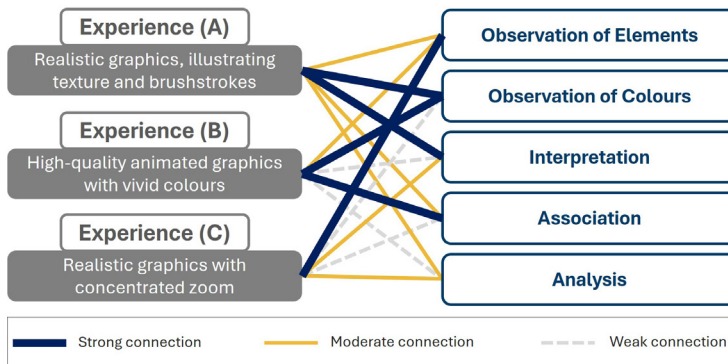


Figure 20: The relationship between the three virtual museum experiences, their characteristics, and the associated critical thinking skills

### **Virtual Museum Experiences and User Satisfaction**

Virtual museum experiences create highly engaging environments that foster students' satisfaction and motivation in educational settings. With an approximate 84 per cent satisfaction and engagement rate, the study demonstrates that virtual experiences effectively immerse students in an interactive art museum while enhancing overall satisfaction. These findings

align with prior research showing that interactive virtual museum experiences significantly boost student engagement, motivation, and enjoyment (Ofianto et al. 2023; Wu et al. 2023; Yow 2022).

Virtual museums can provide stimulating and accessible learning spaces, especially for students who may find traditional museum formats challenging. Given these benefits, integrating virtual museums into educational contexts is highly recommended. However, careful consideration of learning objectives is essential when designing these experiences to ensure alignment with educational goals.

### **Limitations**

The primary limitation of this experiment was time constraints. The 45-minute duration of the art class restricted the study, as students needed time for introductions, task explanations, and activity completion. This limitation reduced opportunities for deeper discussions and affected the volume of data collected for evaluation.

Additionally, students' unfamiliarity with museum visits influenced their engagement. Since many were experiencing a virtual museum visit for the first time within an art education context, their lack of prior exposure may have impacted their responses. Future studies should consider conducting multiple visits to assess long-term engagement and learning outcomes.

Another challenge was the involvement of three different facilitators, each with their own approach to engaging and guiding students. Although general guidelines were established to standardize the experience across groups, slight variations in facilitation styles may have influenced the collected data.

Lastly, the classroom setting facilitated group discussions, leading to peer influence in students' responses. While this setting encouraged collaborative learning, it also meant that some answers were shaped collectively rather than being purely individual reflections. Future research could explore individual-based assessments to further validate these findings.

### **Conclusion**

This study highlights the transformative potential of virtual art museum experiences in developing elementary students' critical thinking skills, using Bloom's revised taxonomy as the analytical framework. For third grade students in one UAE school, virtual formats enhanced lower-order skills: observation, interpretation, and evaluation, while higher-order skills: analysis association and creation, showed a relative decline.

Two implications follow. First: align features with targeted skills. Free navigation and high-resolution zoom can support analysis; concise annotations can cue interpretation and evaluation; narrative/immersive sequences may prompt association but can also distract from close analysis if not paced. Second: balance structure with open-ended making. Pair virtual looking with short, VTS-style prompts and then move quickly into a guided creation task to exercise higher-order processes.

Interpreted through Falk and Dierking's contextual model, outcomes reflect how personal (prior knowledge and interest), sociocultural (peer/facilitator talk), and digital contexts interact. Effective designs make space for talk, provide control over viewing, and minimize interface load during drawing.

Limitations include a single school and age group, short class periods, varied facilitation styles, and limited prior museum exposure for many students. Future work should test repeated exposures across weeks, compare pacing of narrative vs free-navigation modes, and trial built-in 'pause-and-look' prompts before creating artwork. Replication with other grades and schools, and hybrid visits that combine on-site and virtual elements, would show how effects scale.

The study contributes evidence from an Arab context and offers practical design guidance: choose virtual features deliberately for the targeted cognitive skills and integrate structured looking with opportunities for creative production.

## Acknowledgements

We extend our sincere gratitude to the American School of Creative Science in Meliha, Sharjah (UAE) for their invaluable collaboration. Special thanks to Mrs Passant Sadek, Head of the Department of Art, and Ms Radwa Abdelwahab, Art Teacher, for their continued support. We also express our heartfelt appreciation to the volunteers who assisted with the experiment: Ms Reem Ahmed, Ms Mariam Bernieh, and Mr Osama Hassan. Finally, we appreciate all the students who participated and contributed to the success of this study.

## Notes

- <sup>1</sup> Guggenheim Museum, 'Pedagogical Approaches to Museum Teaching', Guggenheim Museum [n.d.]. <https://www.guggenheim.org/accessibility/guggenheim-for-all/guggenheim-for-all-toolkit/teaching-strategies-for-museum-educators/pedagogical-approaches-to-museum-teaching>, accessed 15 February 2025.
- <sup>2</sup> The British Museum, 'Virtual Visit: Myth-busting Ancient Egypt', The British Museum [n.d.]. <https://www.britishmuseum.org/learn/schools/ages-7-11/ancient-egypt/virtual-visit-myth-busting-ancient-egypt>, accessed 19 February 2025.
- <sup>3</sup> The British Museum, 'Virtual Visit: Myth-busting Ancient Egypt'.
- <sup>4</sup> The Museum of Modern Art, 'The Starry Night', SketchFab 2020. <https://sketchfab.com/3d-models/the-starry-night-756b03a918544497b7a4ba644e37550b>, accessed 1 April 2024.
- <sup>5</sup> VR Motion Magic (2016) The Starry Night Stereo VR Experience. <https://www.youtube.com/watch?v=G7Dt9ziemYA>, accessed 1 April 2024.
- <sup>6</sup> Google Arts & Culture, 'Zoom Into Van Gogh's "The Starry Night"', Google Arts & Culture [n.d.]. <https://artsandculture.google.com/story/egVRmbCQ5tyrVA>, accessed 1 April 2024.

## References

- Al-Radaideh, B. (2012) 'The Contribution of Art Museums to Art Education', *Journal of Social Sciences*, 8 (4) 505-511 <https://doi.org/10.3844/jssp.2012.505.511>.
- Alter, F. A. (2007) 'Artful Thinking: Critical and Creative Thinking in Primary and Secondary Visual Arts Education', PhD thesis submitted to the University of New England.
- Anderson, L. W. and Krathwohl D. R. (eds) (2001) *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*, New York: Longman.
- Andre, L., Durksen, T. and Volman, M. L. (2017) 'Museums as Avenues of Learning for Children: A Decade of Research', *Learning Environments Research*, 20 (1) 47-76 <https://doi.org/10.1007/s10984-016-9222-9>.
- Bowen, D. H., Greene, J. P. and Kisida, B. (2014) 'Learning to Think Critically: A Visual Art Experiment', *Educational Researcher*, 43 (1) 37-44 <https://doi.org/10.3102/0013189X13512675>.
- Center for Gifted Education (2003) *TCT Examiner's Manual 1. Williamsburg: Center for Gifted Education*. [https://education.wm.edu/centers/cfge/documents/resources/tctfinalmanual.pdf?\\_gl=1\\*1919qo\\*up\\*MQ.\\*\\_ga\\*MTg1OTU1MDc0LjE3NzU1NjkzNDk\\*\\_ga\\_B7LSBY109V\\*czE3NzU1NjkzNDkkbzEkZzAkdDE3NzU1Njk0NjkkajYwJGwwJGgw](https://education.wm.edu/centers/cfge/documents/resources/tctfinalmanual.pdf?_gl=1*1919qo*up*MQ.*_ga*MTg1OTU1MDc0LjE3NzU1NjkzNDk*_ga_B7LSBY109V*czE3NzU1NjkzNDkkbzEkZzAkdDE3NzU1Njk0NjkkajYwJGwwJGgw).

- Broome, J., Pereira, A. and Anderson, T. (2018) 'Critical Thinking: Art Criticism as a Tool for Analysing and Evaluating Art, Instructional Practice and Social Justice Issues', *International Journal of Art and Design Education*, 37 (2) 265–276 <https://doi.org/10.1111/jade.12111>.
- Burchenal, M. and Grohe, M. (2007) 'Thinking Through Art: Transforming Museum Curriculum', *Journal of Museum Education*, 32 (2) 111–122 <https://doi.org/10.1179/jme.2007.32.2.111>.
- Cabazos-Bernal, P. M., Rodriguez-Navarro, P. and Gil-Piqueras, T. (2021) 'Documenting Paintings with Gigapixel Photography', *Journal of Imaging*, 7 (8) 156 <https://doi.org/10.3390/jimaging7080156>.
- Coldiron, M. (2015) 'Cultivating Creativity: The Columbus Museum of Art and the Influence of Education on Museum Operation', MA thesis submitted to the Ohio State University.
- Corich, S., Hunt, K. and Hunt, L. (2006) 'Computerised Content Analysis for Measuring Critical Thinking within Discussion Forums', *Journal of E-Learning and Knowledge Society*, 2 (1) 47–60.
- Ebitz, D. (2008) 'Sufficient Foundation: Theory in the Practice of Art Museum Education', *Visual Arts Research*, 34 (2) 14–24 <https://doi.org/10.2307/20715471>.
- Efland, A. D. (2002) *Art and Cognition: Integrating the Visual Arts in the Curriculum*, New York: Teachers College Press.
- Ennes, M. (2021) 'Museum-Based Distance Learning Programs: Current Practices and Future Research Opportunities', *International Review of Research in Open and Distributed Learning*, 22 (2) 242–260 <https://doi.org/10.19173/irrodl.v22i2.5225>.
- Facione, P. A. (1990) Critical Thinking : A Statement of Expert Consensus for Purposes of Educational Assessment and Instruction, Executive Summary 'The Delphi Report'. Millbrae: The California Academic Press. <https://www.qcc.cuny.edu/socialSciences/ppecorino/CT-Expert-Report.pdf>.
- Falk, J. H. and Dierking, L. D. (2000) *Learning from Museums: Visitor Experiences and the Making of Meaning*, Walter Creek: AltaMira Press.
- Falk, J. H. and Dierking, L. D. (2016) *The Museum Experience Revisited*, 1st edn. New York: Routledge.
- Golding, V. (2009) *Learning at the Museum Frontiers: Identity, Race and Power*, Abingdon: Routledge.
- Gómez-Hurtado, I., Cuenca-López, J. M. and Borghi, B. (2020) 'Good Educational Practices for the Development of Inclusive Heritage Education at School through the Museum: A Multi-case Study in Bologna', *Sustainability*, 12 (20) 1–22 <https://doi.org/10.3390/su12208736>.
- Hawkey, R. (2004) Learning with Digital Technologies in Museums, Science Centres and Galleries. Report no. (9). London: NESTA Futurelab (National Endowment for Science Technology and the Arts). <https://www.nfer.ac.uk/media/eecph0ty/futi70.pdf>.
- Hein, G. E. (1998) *Learning in the Museum*, 1st edn., Abingdon: Routledge.
- Hooper-Greenhill, E. (1994) *The Educational Role of the Museum*, London: Routledge.

- Hooper-Greenhill, E. (2007) *Museums and Education: Purpose, Pedagogy, Performance*, Abingdon: Routledge.
- Ilhan, G. O., Erol, M. and Özdemir, F. (2022) 'Virtual Museum Experiences of Primary School Teacher Candidates During the COVID-19 Pandemic Process', *Malaysian Online Journal of Educational Technology*, 10 (4) 232-243 <https://doi.org/10.52380/mojet.2022.10.4.259>.
- İşlek, D. and Asiksoy, G. (2024), 'Evaluation of the Effectiveness of Museum Education in Virtual Environment with 360° Videos', *Revista Romaneasca Pentru Educatie Multidimensionala*, 16 (1) 113-137 <https://doi.org/10.18662/rrem/16.1/814>.
- Jeffery, K. R. (2000) 'Constructivism in Museums: How Museums Create Meaningful Learning Environments', in Joanne S Hirsch and Lois H Silverman (eds) *Transforming Practice: Selections from the Journal of Museum Education, 1992-1999*, 212-221, Abingdon: Routledge.
- Kelly, L. (2003) 'Understanding Museum Learning from the Visitor's Perspective', *Curator: The Museum Journal*, 46 (4) 362-366 <https://doi.org/10.1111/j.2151-6952.2003.tb00102.x>.
- Korn-Bursztyn, C. (2002) 'Scenes from a Studio: Working with the Arts in an Early Childhood Classroom', *Early Childhood Education Journal*, 30 (1) 39-46 <https://doi.org/10.1023/A:1016593915591>.
- Lampert, N. (2011) 'A Study of an After-school Art Programme and Critical Thinking', *International Journal of Education Through Art*, 7 (1) 55–67 [https://doi.org/10.1386/eta.7.1.55\\_1](https://doi.org/10.1386/eta.7.1.55_1).
- Luke, J. J., Stein, J., Foutz, S. and Adams, M. (2007) 'Research to Practice: Testing a Tool for Assessing Critical Thinking in Art Museum Programs', *Journal of Museum Education*, 32 (2) 123-135 <https://doi.org/10.1080/10598650.2007.11510564>.
- Marty, P. F. (2008) 'Museum Websites and Museum Visitors: Digital Museum Resources and Their Use', *Museum Management and Curatorship*, 23 (1) 81-99 <https://doi.org/10.1080/09647770701865410>.
- Mateos-Rusillo, S. M. and Gifreu-Castells, A. (2016) 'Museums and Online Exhibitions: A Model for Analysing and Charting Existing Types', *Museum Management and Curatorship*, 32 (1) 40–49 <https://doi.org/10.1080/09647775.2015.1118644>.
- Meirbekov, A., Maslova, I. and Gallyamova, Z. (2022) 'Digital Education Tools for Critical Thinking Development', *Thinking Skills and Creativity*, 44 101023 <https://doi.org/10.1016/j.tsc.2022.101023>.
- Moore, C. (2015) 'Embracing Change: Museum Educators in the Digital Age', *Journal of Museum Education*, 40 (2) 141-146 <https://doi.org/10.1179/1059865015Z.00000000090>.
- Moore, T. (2013) 'Critical Thinking: Seven Definitions in Search of a Concept', *Studies in Higher Education*, 38 (4) 506-522 <https://doi.org/10.1080/03075079.2011.586995>.
- Ofianto, Fatimah, S. and Ningsih, T. Z. (2023) 'Through Virtual Field Trip Technology Intervention, Can Museums Be a Source of Historical Learning?' in Recky Harold Elby Sendouw, Theodorus Pangalila, Sjamsi Pasandaran and Vivi P. Rantung *Proceedings of the Unima International Conference on Social Sciences and Humanities (UNICSSH 2022)*, Grand Kawanua International City, Indonesia 11-13 October 2022, Atlantis Press, Dordrecht, 1275-1283

[494069-35-0\\_154.](#)

- Poce, A. (2021) 'Virtual Museum Experience for Critical Thinking Development: First Results from the National Gallery of Art (MOOC, US)', *Journal of Educational, Cultural and Psychological Studies*, 24 67-83 <https://doi.org/10.7358/ecps-2021-024-poce>.
- Pujjana, E., Rohaeti, E., Suyanta, S., Asmiati, L., Sari, D. R. and Syahana, S. (2024) 'The Role of Communication Skills in Guided Inquiry Process to Improve Critical Thinking Skills', *Jurnal Penelitian Pendidikan IPA*, 10 (3) 1458–1464 <https://doi.org/10.29303/jppipa.v10i3.6351>.
- Randi Korn and Associates, Inc. (2007) Solomon R. Guggenheim Museum Teaching Literacy Through Art, Final Report: Synthesis of 2004-05 and 2005-06 Studies. Alexandria: Randi Korn and Associates, Inc. <https://www.guggenheim.org/wp-content/uploads/2015/11/guggenheim-research-tlta-executive-summary-discussion.pdf>.
- Wu, X., Chen, X., Zhao, J., He, T., Xie, Y., Ma, C. and Wang, W. (2023) 'Research on Recognition and Intervention of Behavior Sequences in Virtual Museum Learning', *PLoS ONE*, 18 (9) <https://doi.org/10.1371/journal.pone.0285204>.
- Yenawine, P. (1999) 'Theory into Practice: The Visual Thinking Strategies', paper presented at the conference Aesthetic and Art Education: A Transdisciplinary Approach sponsored by the Caluste Gulbenkian Foundation, Lisbon, Portugal, 27-29 September 1999.
- Yow, H. Y. (2022) 'A Case Study of Virtual Anatomy Museum: Facilitating Student Engagement and Self-paced Learning through an Interactive Platform', *International Journal of Information and Education Technology*, 12 (12) 1345-1353 <https://doi.org/10.18178/ijiet.2022.12.12.1758>.
- Zakaria, N. N. (2024) 'Distance Learning through the Grand Egyptian Museum: Leveraging Modern Technology to Teach about Ancient Egypt among Schools and National Museums', *Education Sciences*, 14 (7) 714 <https://doi.org/10.3390/educsci14070714>.

**Eslam Nofal** is an Assistant Professor in the Department of Architectural Engineering and Coordinator of the Master Program in Conservation Management of Cultural Heritage at the University of Sharjah (UAE), and is also affiliated with Assiut University (Egypt). He has served as a consultant for the Museum Commission (KSA), specializing in e-learning programs in the museum sector. Previously, he was a Postdoctoral Researcher in Digital Heritage at Maastricht University (The Netherlands). His research focuses on digital heritage, human-computer interaction, and emerging technologies, including tangible interaction, augmented reality, and virtual reality, with an emphasis on enhancing heritage communication and visitor engagement. He holds a PhD in Architecture and Digital Heritage from KU Leuven (Belgium), where he developed the concept of "Phygital Heritage", integrating physical and digital approaches to communicate heritage information.

Email address: [enofal@sharjah.ac.ae](mailto:enofal@sharjah.ac.ae)

ORCID: <https://orcid.org/0000-0002-4687-266X>

**Doha H. Soliman** is an architect and cultural heritage researcher specializing in inclusive museum education and accessible cultural engagement. She holds a Bachelor's degree in Architecture and is currently pursuing a Master's in Conservation Management of Cultural Heritage at the University of Sharjah (UAE). Her work focuses on the intersection of architecture, accessibility, and education in museum contexts. She has contributed as a research assistant

to interdisciplinary heritage projects in the UAE and Saudi Arabia. Her current thesis explores strategies to enhance accessibility for neurodiverse audiences, particularly children with autism, through sensory-friendly design and participatory approaches.

Email address: [U23107034@sharjah.ac.ae](mailto:U23107034@sharjah.ac.ae)

ORCID: <https://orcid.org/0009-0007-9453-5119>

**Nevine Nizar Zakaria** is a senior museum professional and lecturer in Museum Studies. She holds an M.A. and Ph.D. in Egyptology and is currently undertaking her Habilitation at Julius-Maximilians-Universität Würzburg, Germany. She previously held an Alexander von Humboldt Postdoctoral Research Fellowship in Museology and Cultural Studies at the same institution (2021-2024). Her research focuses on accessibility, inclusion, and disability representation in museums, with particular attention to curatorial authority, community agency, and participatory practices. She has held senior roles within the Egyptian Ministry of Tourism and Antiquities, contributed to major national museum projects, and teaches museum studies across Egypt, Germany, and the UAE.

Email address: [nevine.zakaria@uni-wuerzburg.de](mailto:nevine.zakaria@uni-wuerzburg.de)

ORCID: <https://orcid.org/0000-0002-2224-3666>

**Priscilla Van Even** is a researcher and lecturer at KU Leuven and the University of Antwerp in Belgium, with an interdisciplinary background spanning philosophy, cultural anthropology, social sciences, media studies, and communication sciences. Her work explores how discursive, visual, artistic, and digital practices shape knowledge across scientific, societal, and cultural contexts. She has a particular interest in meaningful art-science-technology interactions, intercultural knowledge translation, cultural heritage, museum education, science storytelling, visual literacy, and participatory and arts-based research methodologies. Alongside her academic work, she is active as a museum educator at the Musical Instrument Museum and the Royal Museum of Art and History in Brussels, where she engages diverse audiences with archaeological, anthropological, and artistic collections. Across her research, teaching, writing, and public engagement, she acts as a bridge-builder between disciplines, institutions, and cultural contexts, connecting academic knowledge with broader societal conversations.

E-mail address: [priscillavaneven@hotmail.com](mailto:priscillavaneven@hotmail.com)

ORCID: <https://orcid.org/0000-0002-8272-1041>

Website: <https://sites.google.com/view/priscillavaneven?usp=sharing>

**Joëlle Martin** works a curator and scenographer at the intersection of art, architecture, and education. She holds a Bachelor's degree in Visual Arts and a Master's in Interior Architecture, with a specialization in exhibition design, from ZUYD University of Applied Sciences. Additionally, she earned a Master's in Arts and Heritage, focusing on curatorial practices, at Maastricht University. As a post-graduate fellow at the Museum of Modern Art (MoMA) in the Department of Architecture and Design, she co-curated the exhibitions *Body Constructs* (2023–), *Down to Earth* (2024–), and *The Many Lives of the Nakagin Capsule Tower* (2025–26). She was also shortlisted for the Luxembourg Pavilion at the Venice Biennale 2027. At ZUYD University of Applied Sciences, she developed and taught courses at the Academy of Architecture, with a focus on conscious and critical perception.

Email address: [joelle-martin@outlook.com](mailto:joelle-martin@outlook.com)

ORCID: <https://orcid.org/0009-0006-5014-539X>

**Seham M. Nofal** is an Assistant Professor at the Department of Architectural Engineering, Faculty of Engineering, Assiut University (Egypt). She also contributes to teaching in the Interior Architecture program at Assiut National University and is seconded to the Department of Interior Design and Furniture at the Faculty of Applied Arts, Badr University in Assiut. Her research focuses on interior space design and its impact on users, particularly human-space interaction. She specializes in developing interactive interior environments for children that enhance spatial understanding and engagement.

Email address: [sehamnofal@eng.aun.edu.eg](mailto:sehamnofal@eng.aun.edu.eg)

ORCID: <https://orcid.org/0009-0004-7150-2830>

**Monther Jamhawi** is an Associate Professor of Conservation and Management of Cultural Heritage in the Department of Architectural Engineering at the University of Sharjah, where he coordinates the heritage PhD Program. Dr. Jamhawi has extensive expertise in urban heritage conservation and management, cultural tourism, and heritage management strategies. He previously served as the Director General of the Department of Antiquities of Jordan. He contributed to UNESCO World Heritage nominations for As-Salt and the Baptism Site in Jordan. He has published widely in peer-reviewed journals and served as a consultant for EU-funded and Saudi heritage projects.

Email address: [mjamhawi@sharjah.ac.ae](mailto:mjamhawi@sharjah.ac.ae)

ORCID: <https://orcid.org/0000-0003-0062-5038>