# Bridging the Digital Skills Gap for Museums:
# A Pedagogical Framework for Training Students in VR-Based Heritage Presentation

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## Abstract

Developing VR-based cultural heritage experiences for interpretation and presentation is highly technical, and many digital teams lack the necessary expertise. In the industry, workers skilled in the interactive 3D (i3D) or VR process are recruited aggressively by the high paying entertainment sector, leaving the GLAM (Galleries, Libraries, Archives, and Museums) sector struggling to fill these specialized roles. Museums therefore, face significant challenges in hiring specialists capable of creating 3D scanning, i3D, and VR applications for heritage engagement. The rapid evolution of digital tools requires a workforce proficient in both technical execution and creative ideation—yet traditional education often fails to provide training in this interdisciplinary domain. This research explores ways to equip non-heritage students with transferable skills that meet the needs of the GLAM sector. We present an innovative approach to curriculum design, focusing on teaching and learning (T&L) activities that integrate technical competencies, ideation process, storytelling techniques, and hands-on experience with digital heritage tools, supporting students in developing VR-based systems tailored for heritage interpretation and presentation. By aligning academic training with industry demands of VR-based heritage interpretation, we aim to cultivate a new generation of professionals equipped to bridge the gap between cultural heritage and digital innovation.

## 1. Introduction

The past decades have seen the proliferation of Virtual Reality (VR) exhibits within museums internationally (Ch'ng et al., 2019; Carvalho, 2020; Barekyan, Peter, 2023). The technology has become a powerful medium for heritage presentation and interpretation (Carrozzino and Bergamasco, 2010; Shehade and Stylianou-Lambert, 2020). Furthermore, integrating digital tools for heritage has also become the trend in the Galleries, Libraries, Archives, and Museums (GLAM) sector (Gradin and Matti La Mela, 2022; Finnis and Kennedy, 2020), and within the academic circle, VR for heritage has become an important part of the academic enquiry (Ch'ng et al., 2018, 2020; Lee et al., 2020; Paladini et al., 2019; Quintero et al., 2017). Within the museum sector, there is a growing demand for a workforce that can not only handle the intricacies of the technologies for digitising heritage, but also has an in-depth knowledge of cultural heritage with the ability to creatively communicate heritage information to newer generations. This demand implicates a critical gap, i.e., the gap between the need for digitally adept professionals who can bridge heritage knowledge, technical skills and creative communication, and the lack of specialised training that cultivates young talents in interdisciplinary domains within the traditional educational frameworks (Ch'ng et al., 2018). Museum digital teams are greatly lacking in acquiring skilled workers capable of developing immersive digital experiences using technologies such as i3D and VR for heritage interpretation and presentation. For instance, many museums and galleries embraced interactive 3D installations through "sub-contract digital works to third-party digital media companies" as they lacked in-house teams with the necessary expertise for conservation (White and Ch'ng, 2019). We feel that there is an urgent need for interdisciplinary education for training specialists for the GLAM sector, and particularly for museums.

The tenet of the paper is to explore an effective pedagogical approach for training non-heritage students to fill this missing gap. We intend to cultivate skilled students who have an adequate understanding of heritage, accompanied by technical abilities for developing VR, 3D scanning, interactive 3D (i3D), 3D laser scanning, close-range photogrammetry, gaussian splatting, etc. that is geared towards the presentations of information, preparing them for specialist roles within museum digital teams for heritage presentation.

In our study, we tested our approach on our very first cohort of targeted student (n=14) by streamlining the courses Virtual Reality Art and Digitising Heritage between two semesters (See Figure 1 for details), both designed and developed as a result of a decade of observations and working with the GLAM sector. As this is a completely new elective, the number of students that have signed up were 14 students. This is a small sample, but we expect the number would grow as the quality of the i3D and VR product would attract future cohorts. The small sample of students will allow us to focus on tailored contents, that we can adjust for performance in the future. In the study, we probe the questions–'What combinations of teaching activities can effectively equip art and design students in developing VR for cultural heritage presentation?', and 'How does our course syllabus design influence students' ability to produce effective VR-based storytelling for heritage interpretation and presentation?' We believe the challenge lies in the delivery of effective learning outcomes toward non-heritage students, and the secondary difficulty would be the interdisciplinary skills

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needed to produce storytelling contents in i3D and VR.

countries, there is also a widespread problem of technical job vacancies, and the Observatory for Digital Innovation in Cultural
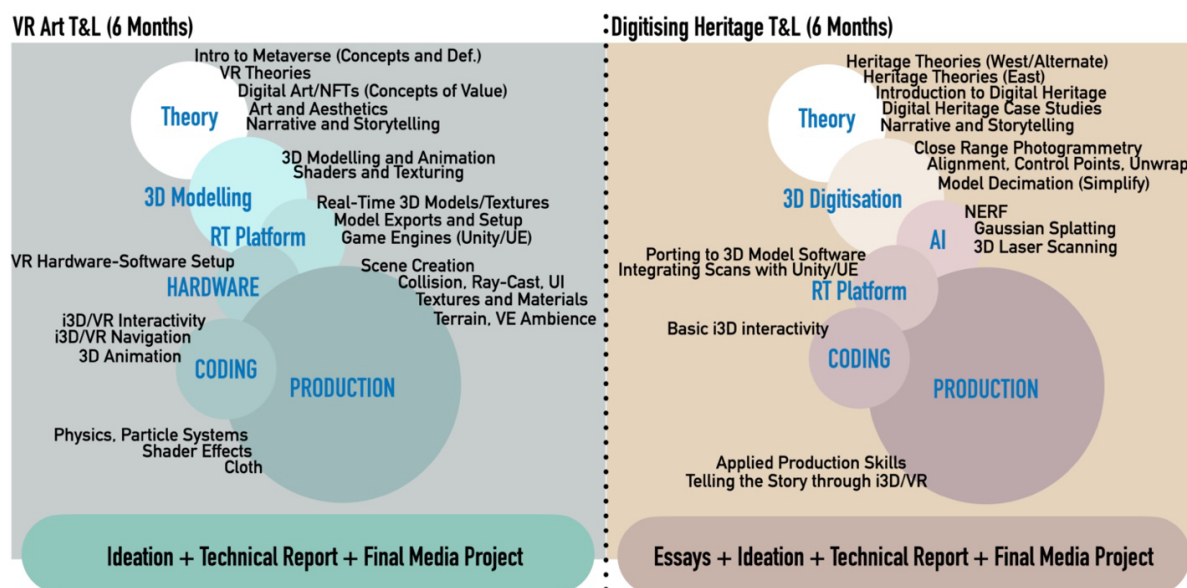


Figure 1. A framework outlining the streamlining of the two elective courses Virtual Reality Art and Digitising Heritage which non-heritage students can take in preparation for the digital workforce. Larger circles depict the amount of effort/time that students were taught or exposed to, for the particular content category.

## 2. Digital Skills Demand and Workforce Challenge

Many museums require professionals to have not only a strong foundation in art but also technology (Giannini and Bowen, 2019), and emphasize technical competencies of the workers (Shehade and Stylianou-Lambert, 2020), leading to the emergence of new job roles as well as establishing new departments (Carvalho, 2020). In Europe, many opportunities are available, oriented towards learning, education, and training for new professionals in these interdisciplinary roles/domains. Many projects are currently putting specialised personnel training on the agenda, allowing museum professionals to improve their digital skills (Charter-Alliance, 2022; NEMO, 2020). For example, the emergence of positions (such as Digital Interactive Experience Developer) requires a university degree in art, humanities, information technology, etc., and the ability to design, develop, and implement innovative interactive experiences according to audience needs (Carvalho, 2020). In a report on digital projects developed in European museums by Network of European Museum Organisations, it also emphasizes the importance of using sustainable digital mediation in museums as well as the ability of heritage storytelling in digital projects as indicated by museum professionals (Barekyan and Peter, 2023).

However, the GLAM sector faces significant challenges in recruiting skilled workers for their digital teams capable of developing such technologies for cultural heritage presentation. For instance, the research by Luna Leoni and Mateo Cristofaro shows that the lack of technically skilled personnel in small Italian museums is one of the most cited challenges (Nikolaou, 2024). In many museums in Greece, Italy, Portugal, and other

Heritage and Activities reported that 64% of museums believe that they lack internal professionals with appropriate digital skills (Carvalho, 2020). Moreover, many museums in China also lack in-house digital teams, outsourcing high-resolution photography to "external companies" and "prominent digitisation works result from collaboration with western institutions" (White and Ch'ng, 2019). Nevertheless, there is a mismatch between existing education and employment requirements (Nespeca et al., 2023). Studies have shown that due to the lack of courses in digital technology education, challenges remain for students to acquire the necessary digital skills and knowledge required for digital roles in museums, and, the work tasks in museums are often disconnected from the knowledge they have learned (Giannini and Bowen, 2019 n.d.).

In view of the demands of the industry, we took on the challenge of designing a pedagogical approach to course curriculum design in supporting students in the development of i3D and VR experiences tailored for the GLAM sector. The transferable skills that we are able to impart to students, will fill the gap in the workforce, and perhaps countering the competitive packes provided by the entertainment industries over those in the museums (Archivists, Curators, and Museum Workers Work Environment, n.d.; Association of Art Museum Directors 2023 Salary Survey, n.d.).

## 3. 'Digitising Heritage'

The elective courses *Virtual Reality Art (VRArt)* and *Digitising Heritage (DH)* provide a year-long pedagogical framework from which students from fields other than cultural heritage could have

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an entry into the workforce with 3D and VR-based technologies. Figure 1 depicts a framework that we designed for cultivating skilled workers for museum digital roles. The Larger circles depict the amount of effort/time that students were taught or exposed to, for the particular content category. Each category is attached topics that are necessary for achieving production quality i3D and VR systems for cultural heritage. While *VRArt* is the pre-requisite course of *DH*. The students who enrol in this course are drawn from art and design disciplines, within the animation and interactive media programme. *VRArt* teaches students real-time 3D model integration into virtual environments, and VR concepts and production process, including interactivity, navigation and coding, all focused on aesthetics, creating beautiful contents. The course *DH* covers important heritage concepts from both the Western and Eastern discourses, looking at the value and impact of the use of digital technology within cultural heritage domain with case studies. It provides a practical basis for documenting, recording, and preserving cultural heritage using a suite of digital technologies such as close-range photogrammetry, 3D laser scanning, through NeRF (Neural Radiance Fields) and Gaussian Splatting, empowering students in creating real-time visualisation with processed 3D models for i3D and VR. The course provides a necessary introduction to cultural heritage as a background, but primarily focuses on T&L activities that integrate technical competencies, ideation process, storytelling techniques, and hands-on experience with digital heritage tools. The course assessment methods include ideation, project planning&analysis, digitisation technologies, and a group-based final media project.

### 3.1 Motivation and Performance Measures

The design of the course is due to the awareness of the gap in the skilled workforce which we are attempting to fill. However, the distance between the cultivation of the students, and of them being adopted by the GLAM sector is far, and therefore, we are unable to test performance in the museums for now. However, there are pedagogical approaches for measuring the quality of their works, and that is through a set of Rubrics that measures:

- The quality of their 3D digitisation in terms of quality and completeness, and the processing of the models into real-time, VR-ready models.
- The quality of the 3D modelling (manually built models that complement the scans) and VR environment.
- The technical ability to integrate VR hardware and software, through interactivity, navigation, and avoiding interface errors.
- The understanding of the values of heritage, and the ability to communicate heritage information in a way that tells a story, through narrative structures.
- The ability to create an interactive storytelling system that is both aesthetically pleasing, but also as an experience.

We also measured student motivation in heritage works after taking the courses, and through surveys. Self-reported questionnaires is subjective, but it allows us to gain a direct access to how students have rated various measures. The student

self-report of motivations are of course, complemented and balanced by the production rubrics mentioned above. The survey covers the motivation for doing heritage works before and after taking the course, the effectiveness of pedagogical strategy of our course design, skill acquisition, project challenges, reflections, and future intentions for master's programmes and the industry.

### 3.2 Shifts in Motivation Pre- and Post-Course

During the course, we sought a preliminary understanding of student interests and the frequency of museum visits. Fig. 2 shows a graph illustrating the frequency of visits to museums prior to taking our course. 43% of respondents visit museums once every three months, which is the highest percentage among all the options. Fig. 3 shows the students' motivation for doing heritage works before and after attending our course. The results reveal that the average score increased from 3.6 to 5.7 (out of 7) after taking the course. This is a significant increase of motivation. For the question of "Rate your motivation for doing heritage works before attending this course," 43% of participants rated 3 (moderate level). Comparatively, the question "Rate your motivation for doing heritage works after attending this course" saw a heightened increase in motivation. 85.7% of our participants rated the score of 5-7, with 57% clustering around 6. The low ratings of motivation (1-3) had entirely disappeared. All participants had high motivations for doing heritage works. The student with the lowest initial motivation (score of 1) rose to 6 after completing our course, highlighting a strong positive impact on the students.
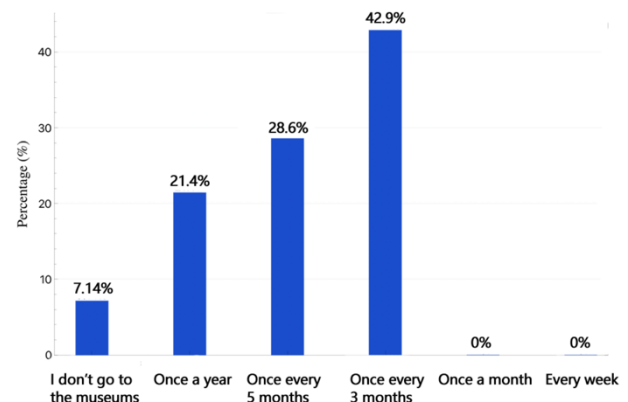


Figure 2. Student response to the question "how often do you visit museums in the past?"
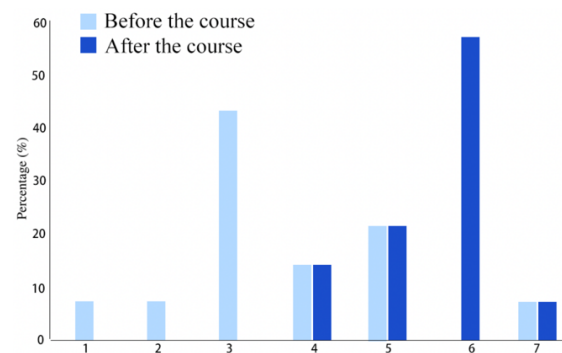


Figure 3. Comparison between the motivation for doing heritage works before and after taking the course.

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Furthermore, synthesizing the questions of frequency of visiting museum and the motivation before and after taking the course based on the data we collected, we conducted a cross-tabulation analysis, and observed that the students who visit museums once every three months had significant increase in motivation after taking our course; 50% of the students selected visiting museums "once every three months," and the scores for the question "Rate your motivation for doing heritage works after attending this course" all increased to 6. It implies that the course content can effectively stimulate a deeper interest in heritage works among the individuals who visit museums more frequently (Fig. 4).
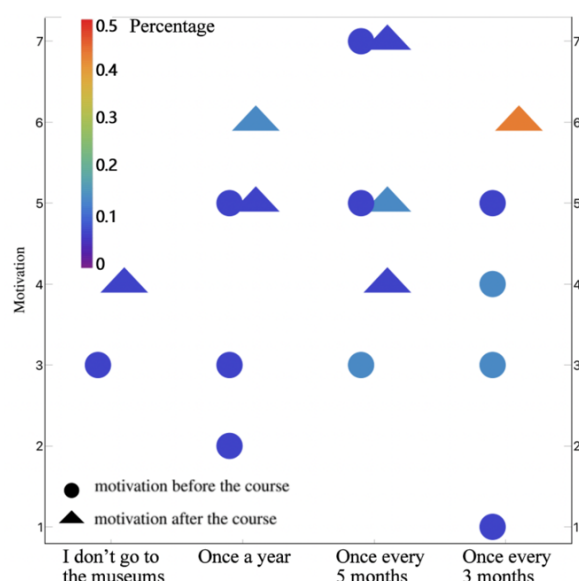


Figure 4. Cross-tabulation analysis between the frequency of visiting museum, and the motivation for digital heritage works before and after taking the course.

Regarding confidence levels in independently creating digital heritage project, Fig. 5 indicates that the majority of students reported a high level of confidence (≥5, out of 7) in their ability to do so, after taking the courses we offered (*VRArt* and *DH*), year-long learning which is part of the strategy for creating a digital workforce for museums.
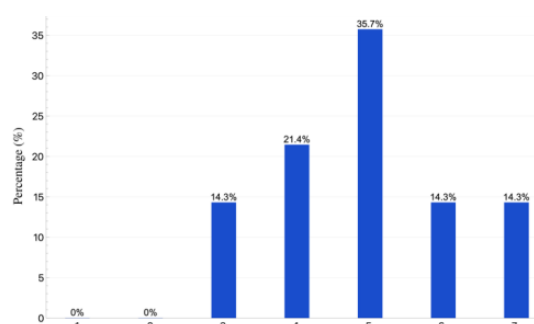


Figure 5. Student response on "How confident are you that you are able to create digital heritage projects by yourself after the two courses (*VRArt* and *DH*), year-long learning?"

## 4. The Effectiveness of Pedagogical Strategies

Our course curriculum design (Fig.1) integrates technical competencies, ideation process, storytelling techniques, and hands-on experience with digital heritage tools, through various T&L activities. As the goal of the course is to cultivate skilled workers in i3D and VR production, we found that a 30% theory (heritage, etc.), and 70% production composition were very effective. For example, we incorporated reading, lectures, and writing essays to help students understand the underlying meaning of heritage and support their ideation process. From the survey, the majority of our samples believed that reading, lectures, and writing essays were helpful in understanding heritage (Fig. 6). In the evaluation of the usefulness of lecture, 64% of our samples selected the highest two levels (score of 6 and 7), with 21% giving a full score of 7. Also, there were no responses in the low score range (score of 1-3), indicating the high effectiveness of knowledge transmission in understanding heritage. We further measured in detail the effectiveness of specific lectures.
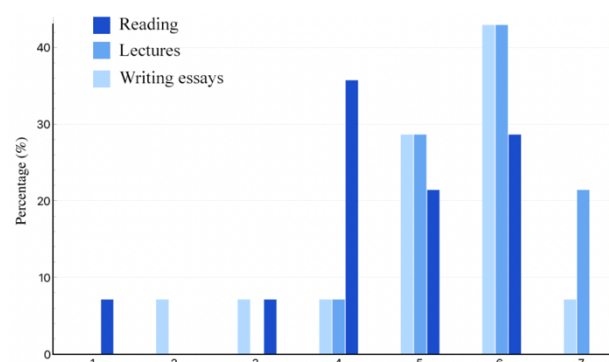


Figure 6. Non-heritage student response on the usefulness of reading, lectures, and writing essays in helping them understand heritage.

We covered four major topics in the lectures in heritage. The lecture *Introduction to Heritage* gave students a foundation in both tangible and intangible heritage, and explored global heritage organizations such as UNESCO and ICOMOS, introducing heritage as a dynamic social resource shaped by time, memory, cultural context. *Authorized Heritage Discourse* articulated the concept of Authorised Heritage Discourse (AHD), which refers to dominant institutional narratives that define cultural heritage primarily by its material, monumental, and historical value. *Chinese Heritage* specifically focused on the heritage in China by presenting case studies, and elaborated in detail on the application of digital technology in the protection of cultural heritage. *Digital Heritage Case Studies* introduced the application of digital technologies in the field of cultural heritage, and elaborated on the application and value of technologies such as 3D digitization, VR, and AR from different aspects, including research, protection, reconstruction, and experience enhancement of cultural heritage through project cases such as the landscape of the ancient Beihai landmass and Stonehenge. In the question "Which lectures on heritage were most useful" (Fig. 7) the data shows that 42.8% of the sample ranked the lecture *Introduction to Heritage* as their top choice, and the lecture on

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Chinese Heritage was ranked highest overall (four students ranked it first, four ranked it second, and six ranked it third), suggesting that the case studies may enhance learning effectiveness by strengthening the connection to the cultural identity that resonates more closely with the students. It is important to note that our students are all from the Chinese Mainland.
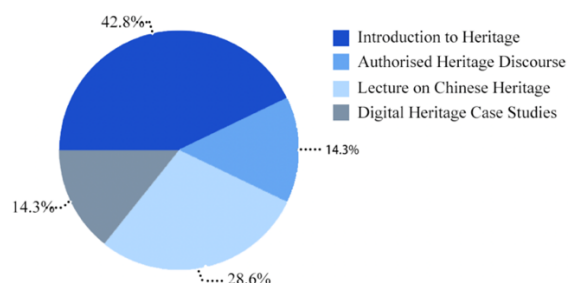


Figure 7. Distribution of top student-rated lectures in response to the most useful lectures on heritage

We also generated a graph showing the distribution of perceived importance of various skills taught in class in relation to the students' digital heritage projects, including 3D texturing, Coding/Programming, Unity/Unreal Engine, Blueprint, Storyboarding, Story Scripts, Close-range Photogrammetry, 3D Laser Scanning, Gaussian Splatting, Processing 3D Models into Real-time Models, etc. (Fig. 8). According to the data, the students rated technical tool-related skills such as Unity/Unreal Engine, Close-range Photogrammetry, all above 6 out of 7. This suggests that the technical skills taught in our classes was useful and were effectively applied in their actual digital heritage projects, demonstrating the successful integration of technical competencies with digital heritage tools in the course.
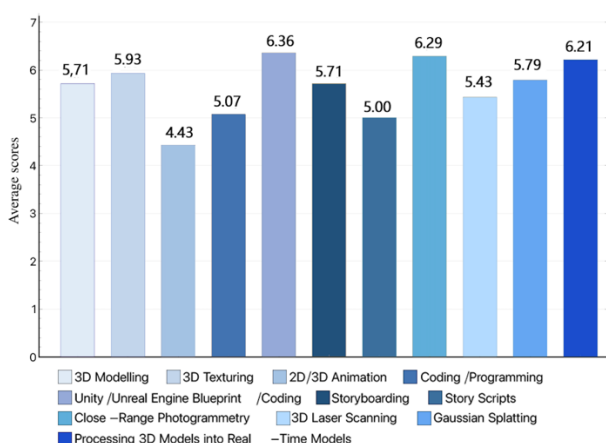


Figure 8. Distribution of the average scores per skill related to the response of the most important skill in their digital heritage project.

Moreover, we provided hands-on activities throughout the course, and conducted a structured presentation and feedback session in Week 13 to support the development of their final digital heritage projects, as a part of our pedagogical strategies. Fig. 9 illustrates the students' responses on the usefulness of Week 13's

presentation and feedback in helping them prepare for Week 14's assessment of their digital heritage project, and Fig. 10 shows the comparison of students' confidence levels before and during Week 14. According to the data, the average score of the presentation and feedback session in Week 13 was 5.6 (out of 7), and 73% of the respondents gave high scores ($\geq 5$, out of 7), indicating that most students recognized the effectiveness of presentation and feedback. The average self-confidence before Week 13 was 4.2 and it rose to 5.3 in Week 14, with an increase of 26.2%. Among them, the proportion of high score levels ($\geq 5$, out of 7) increased from 28% in the question "Confidence before Week 13" to 78% in "Confidence in Week 14" (Fig. 10), indicating that the overall level of students' confidence has improved and the distribution structure has also been optimized. It is worth noting that the presentation and feedback sessions had significantly improved the students' confidence, and this is especially true on the low and medium confidence groups.
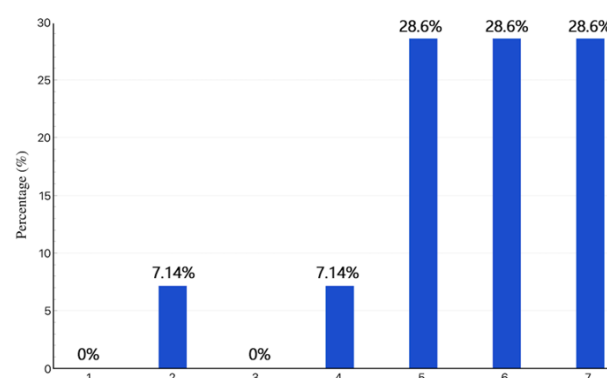


Figure 9. The usefulness of Week 13's presentation and feedback in helping them prepare for Week 14's assessment of their digital heritage project.

Furthermore, from the cross-tabulation data analysis based on Fig. 9 and Fig. 10, we observe that among the group with low original self-confidence (confidence level of 3-4 points before Week 13), the feedback effectiveness was particularly significant. First, among the students whose confidence score was 3 (score of 3/7), 33% thought that the feedback was "very useful" (score of 7/7). Everyone in this particular group rated an improved score that is >4 points after Week 14. Among the students whose confidence score was 4 points, 43% gave the highest evaluation (score of 7/7) to the presentation and feedback, and 71% of them scored higher (5 points) in Week 14, indicating that feedback has a direct improvement effect on the low and medium confidence groups.

In addition, the feedback effectiveness is positively correlated with the students' confidence improvement. Among the students whose confidence score is >6 Week 14, there were 67% (score of 6/7) and 50% (score of 7/7) rate the feedback 6 points or above, indicating that those students with high confidence improvement recognise more the value of our feedback. Meanwhile, 67% of our students whose confidence score was 5 points before Week 13, had increased to 6 by Week 14, and all the students of this group gave feedback scores of 5 points or above, further confirming the effectiveness of our feedback and advice. These

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findings reflect the value and effectiveness of our pedagogical approach. Out of 14 students within the cohort, there were 4 students (30%) who have applied for culture and heritage related programmes at the Master level.
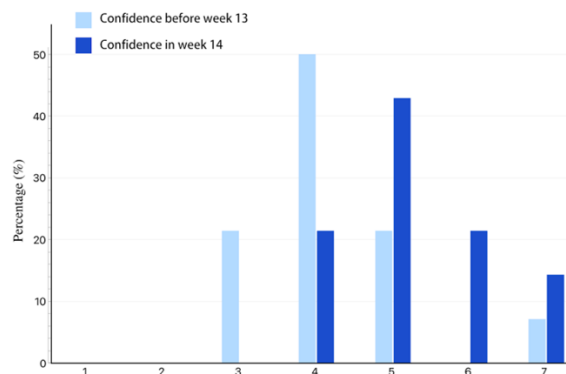


Figure 10. Student confidence levels before and on Week 14.

### 4.1 Student i3D and VR-based Digital Heritage Projects

This section focuses on storytelling through i3D and VR. Digitising heritage requires the effective translation of heritage values into interactive media through compelling storytelling. In this context, digital storytelling has become a crucial strategy for cultural heritage institutions, such as museums and historical sites, to communicate heritage and engage audiences. We think that effective storytelling in digital heritage necessitates the seamless integration of three key components: a precise understanding of heritage values, proficiency in storytelling techniques, and adeptness in utilising media tools.

In the storytelling lecture and tutorial, we taught students the principles of effective narrative design for heritage projects, including character development, plot structure, spatial design, and interaction design. Through hands-on storytelling practices in their projects, students discovered that the most challenging aspect of the process lies in integrating and aligning these elements cohesively. Only through this integration can a project achieve visual and emotional impact, provide an immersive experience for the audience, and successfully convey its educational and intellectual value.

Here, we present selected projects to exemplify the outcomes of our course. Each group selected a specific tangible or intangible cultural heritage and incorporated various of i3D and VR-based technologies to digitise the heritage, including 3D Laser Scanning, Gaussian Splatting, 3D Modeling, 3D Texturing, 2D/3D Animation, Close-range Photogrammetry, Processing 3D Models into Real-time Model, interactive 3D, Coding/Programming, etc.

**4.1.1** *Beyond Fish Lantern***:** The student group project *Beyond Fish Lantern* digitally reproduced the craftsmanship and dynamic aesthetics of the intangible cultural heritage 'Daliang Fish Lantern' in the Guangdong province in China, and promoted the living protection and rejuvenation of folk culture with innovative technological means through high-precision 3D scanning

technology, i3D, and immersive interactive mechanisms (Fig. 11 and Fig. 12).



Figure 11. A display of light effects in the *Beyond Fish Lantern* project in Unreal Engine.



Figure 12. A digital gallery of the *Beyond Fish Lantern* project within Unreal Engine.

**4.1.2** *Common Paradise***:** The project *Common Paradise* leverages 3D scanning technology and interactive digital mapping to achieve high-fidelity visualisation of the tangible heritage 'Common Paradise' in Zhuhai, Guangdong, China (Fig. 13 and Fig. 14). By reconstructing its historical landmarks and ecological landscapes through point cloud modelling and Gaussian Splatting, simultaneously preserves cultural heritage and enhances environmental interpretation.



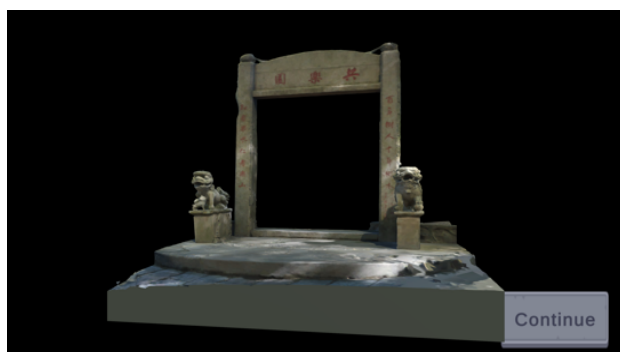Figure 13. A close-range photogrammetry 3D model from the *Common Paradise* project.

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Figure 14. A close-range photogrammetry 3D model from the *Common Paradise* project.

**4.1.3 *Foguang Temple Pillar*:** This digital heritage project provided a virtual heritage experience through high-precision 3D scanning technology, interactive 3D (i3D), and immersive interactive mechanisms. The project was inspired by the *Black Myth: Wukong* game, where there is a stone pillar at the Foguang Temple. It compared the differences between Virtual Heritage Environments (VHE) and traditional game tours. (Fig. 15 and Fig. 16)



Figure 15. Foguang Temple Pillar, distant view of the pillar within the Unreal Engine.



Figure 16. Foguang Temple Pillar within the Unreal Engine. 3D model of the pillar was digitised using close-range photogrammetry.

**4.1.4 *Emperor of Kowloon*:** This project applies technologies such as 3D scanning, close-range photogrammetry, and Gaussian Splatting to digitally preserve the intangible aspects of the story, and present the calligraphic street graffiti heritage of Tsang Tsou-choi, known as the 'Emperor of Kowloon' in Hong Kong. Through 3D modelling and interactive animation, the morphological characteristics of his calligraphic handwriting are recorded, and the evolution process of the figure is visually presented in different periods. This project seeks to digitally present Tsang's life and works, reflecting the socio-cultural landscape of 20th-century Hong Kong. (Fig. 17 and Fig. 18)



Figure 17. Interactive 3D storytelling in the *Emperor of Kowloon* project in Unity.



Figure 18. A close-range photogrammetry 3D model in the *Emperor of Kowloon* project.

## 5. Conclusion

In our study, we have demonstrated a pedagogical framework which combines heritage studies and digital production ability, with the aim of filling the workforce gaps in the GLAM and heritage sector. Our goal is to cultivate students with the skills needed for i3D and VR-based experiences for heritage interpretation and presentation for the GLAM sector. The T&L activities that combines 30% theoretical grounding in cultural heritage studies, and 70% practical/production based works – creative ideation, technical training in VR tools, 3D scanning, interactive 3D, and hands-on project work, effectively supported the art and design students in developing immersive VR experiences tailored for communicating heritage using digital tools. Our approach increased student motivation for heritage works, and built confidence in creating digital heritage projects using real-time 3D and VR tools. We believe that the pedagogical strategies for digital heritage that we have explored will prepare students for the evolving landscape of cultural heritage presentation through i3D and VR tools in museums, cultivating a newer generation of the workforce equipped to bridge the gap between cultural heritage and digital innovation. Our plan targets the long-term sustainability of cultivating students for museum digital teams, with outcomes based T&L approach that explores state-of-the-art technologies that can enhance student abilities

while also provide a set of transferable skills in the broader cultural creative industry sectors, including GLAMs, and archaeological visualization. We believe that these areas will fill gaps in the digital heritage domain, particular for a digitally empowered workforce for museums.

## 6. Limitations and Future Plans

We noted that our analysis is based on an initial experiment involving a small group of 14 students for the course *Digitising Heritage, an elective opened to students*. The small sample was due to the course being created just last year. In the initial offering, students had no idea how useful the elective would become, and how it could add many transferable skills that would empower them to work across many sectors. Furthermore, the course had the prerequisite *VRArt*, which would have stopped many students from enrolling. Currently, we have made provisions to remove the *VRArt* course as a prerequisite this year, and we should expect a larger number of students in the Autumn Semester (2025 Fall). The distance between the cultivation of DH students, and their work in the GLAM sector is far, and it remains to be seen when their works could be seen in museums in the immediate future. However, the survey of motivational levels for the heritage sector have shown promising results. Many of these students have applied for heritage related studies.

As experts in VR and i3D, and also conducting research in the space, we will keep updating our curriculum yearly to keep abreast with current developments in the space. For example, we added Gaussian Splatting in this year's run of the course, on top of NeRF modelling. These topics would not have been included if academics are not aware of the development in the computer graphics space.

With regard to storytelling and narrative in the pedagogical method, digitising heritage involves effectively translating heritage values into interactive media through compelling storytelling. We noticed that digital storytelling has become a vital strategy for cultural heritage institutions (such as museums and historical sites to communicate meaning and engage audiences. The lack of established guidelines or frameworks for narrative design in this field makes teaching storytelling principles both essential and challenging. We will propose that effective storytelling in this domain requires the seamless integration of three key elements: a clear understanding of heritage values, mastery of storytelling techniques, and proficiency in media tools. As we continue to offer this course in the coming years, in the future, our research will focus on developing a preliminary framework for narrative design in digital heritage by analyzing and consulting on student projects.

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