Reflecting on Research: a Virtual GLAM Proposal

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***Abstract*—Galleries, Libraries, Archives, and Museums (GLAM) are known to embrace new technologies so they can offer a more informative visitor experience, merging physical artifacts with supporting information offered in a digital format. It is proposed that university and corporate research laboratories can take the form of a GLAM if appropriated as a virtual entity. A virtual GLAM can subsequently support a holistic overview of research projects undertaken by associated researchers to ensure academic affinity with the overall research theme and facilitate the planning of future research. The paper describes the development of a virtual GLAM as a Case Study and adopts reflective practice as a lens through which to evaluate 12 years of research projects.**

Index terms—GLAM, reflection, virtual reality

I. INTRODUCTION

University and company laboratories fall into one of three categories: research laboratories, development laboratories, and test laboratories [1]. Each has a specialized focus with a specific thesis to be researched, developed or tested. Within the laboratories a number of related themes may be researched. The Virtual Human Interaction Lab (VHIL) at Stanford University, USA provides a good example (https://stanfordvr.com). The Lab has an explicit Mission: "… to better understand the psychological and behavioral effects of Virtual Reality (VR) and, more recently, Augmented Reality (AR)" (https://stanfordvr.com/mission/), and Founding Director, Jeremy Bailenson, aims to determine how virtual experiences lead to changes in perceptions of self and others to support effective VR in training and education. The students' projects within the VHIL are varied but all fall within the Mission purview: for example, Psychology of Augmented Reality; Empathy and Perspective Taking; Medical Virtual Reality; and Integrating VR into Classrooms and Curricula (https://stanfordvr.com/projects/). Over a number of projects, a Principal Investigator or research supervisor collates the experiences and outcomes into a general narrative or framework, and publish as informed text for corporate investors, news media or as academic publications. The productive outcome of innovative progress is shared for others to implement and further develop. Experience on Demand by Jeremy Bailenson, for example, is a book with examples taken from the Virtual Human Interaction Lab [2] with the result that the text becomes an historical artifact of the VHIL's combined knowledge.

Museums are known to embrace new technologies to offer a more informative visitor experience, merging physical artifacts with supporting information offered in a digital format. Two especially personal examples are volumetric 360 degree photography used in the display of the Apollo LM (https://dbiela.com/vrgallery/) and Augmented Reality using iPads to portray previously unseen inner chambers of Egyptian tombs at Amsterdam's Allard Pierson museum (https://allardpierson.nl/en/). It is therefore not surprising that research laboratories also exist outside the university and corporate sectors. In 2019 researchers from the British Library and the Danish Royal Library proposed the inclusion of research-focused Innovation Labs within galleries, libraries, archives, and museums [3]. The premise was that futures innovation within historical structures offer opportunities for GLAMs to be "… dynamic, adaptive, tolerant and active to the emerging social, political, natural and digital environments" [3]. A number of benefits point to increased access, past and present information embedded in multi-modal artifacts, new perspectives of future relevance, and the offering of a broader range of knowledge to subsequently enhance the visitor experience.

An alternate, switched, proposal is the immersion of GLAMs within an Innovation Lab. An imagined scenario was portrayed in the 1994 film Disclosure where the main protagonist (i.e., a detective played by Michael Douglas) enters a Virtual Reality library seeking incriminating information among virtual card stacks (https://www.youtube.com/watch?v=qk3PK3W_wvo). More recently the concept of a gallery within VR has been adopted by Shu Yamamoto to display paintings using the ENGAGE VR application. In addition, the Louvre's 'Mona Lisa: Beyond the Glass' VR exhibit enables viewers to virtually meet the real Mona Lisa, Lisa Gherardini, and learn more about the famous painting (https://www.louvre.fr/en). The paintings come alive as the characters interact with the viewer in Virtual Reality for puerile entertainment or constructive learning, respectively. Museums are also adopting Virtual Reality to augment the visitor experience either physically or virtually (https://www.museumnext.com) EUseum (https://thevirtualdutchmen.com), for instance, aims to enable an experience of all the European museums in one virtual location.

It is posited that the virtual GLAM can therefore be adopted by researchers to display past and present projects, thereby facilitating an opportunity to reflect upon research and gain a holistic oversight of the research laboratory. The paper continues

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with a review of GLAMs and virtual environments, followed by a Case Study detailing the development of a virtual GLAM to facilitate a holistic reflection of 12 years of research. Finally, the Case Study is evaluated through the lens of reflective practice.

II. LITERATURE REVIEW

To maximize the impact of teaching and research, whilst simultaneously reaching new audiences, university museums and galleries can be influential resource centers bridging the dissemination of knowledge and the understanding of science, as well as being repositories of collected artifacts. Consequently, university-affiliated GLAMs have evolved significantly: "No longer simply repositories of knowledge and stewards of objects, academic libraries and museums play critical roles in the intellectual engagement, cultural enrichment, and personal as well as professional development of the many constituents they serve" [4]. In addition, libraries have survived due to their "… culture of cooperation and innovation... becoming centres of digital practice... navigating changes in digital content and scholarly communications" [6]. It has been acknowledged that as universities progress from delivery of content to a more engaged student-centred experience, so too must the supporting institutions that act as repositories of that content [4].

GLAMs can offer faculty and student support in specialized, interdisciplinary, and international contexts leading to a richer and broader learning experience. Also, collections and exhibitions can bridge the academic divide between Humanities and the Sciences. As faculty pedagogy reacts to changes in the digital landscape (pre and during pandemic) and course syllabi evolves, so too are the galleries, libraries, archives, and museums. Lynch termed the juncture as the network turn: " increasingly, we can represent collections in digital form and do things with them that we could not do before ... There's also though ... the network turn ... which takes a turn to the digital as a prerequisite, but goes far beyond that and I think changes a lot of the rules about everything from inter-institutional collaboration to public engagement and I think in some ways, may have more lasting impacts on our strategies going forward than simply the ability to represent and capture material in digital form" [5]. In other words, it is not enough to simply digitize content for passive viewing, but a more collaborative, immersive, interactive, and engaging experience is required.

Hoang et al propose a tapestry of Alternating Reality: a "… narrative that supports the communication of cultural heritage as an interweaving experience that alternates between real and virtual environments" [7]. The storytelling as narrative is established practice in museum settings [8]. Also, interactive artifacts have been established using projection screens, near-field technologies, wearables, portable devices, and motion capture [9]-[11] to promote a connection between the visitor and the information on display at the museum. In addition, "… a VR system can offer users the opportunity to record their performance, reflect on it and experiment again supporting in that way the enhancement of teaching performance" [12], and this premise can also apply to researchers.

Merging the institutions into a proposed laboratory format for the purpose of sharing research, a GLAM Lab can be considered a place for experimenting with digital collections and data [3]. The meeting of experts at the Innovation Labs at Qatar National Library event, for instance, recommend that "… (t)he lab should be grounded in user-centred and participatory design processes" [3]. The inclusion of a Lab within a library, for example, allows the reuse of cultural heritage collections and data in innovative and creative manners, even involving makerspace activities where visitors can print 3D replicas. Similarly, Labs in galleries enable stories to be told and re-told in multiple ways using technology. Additionally, archival Labs are large scale repositories of data that are organized by computational methods.

Gaining traction within an understanding of the benefits of viewing research in VR is the concept of presence. Prescence is defined as the psychological sensation of being in a virtual place [13]. Within a virtual environment, for instance, as the participant views past projects, there is a sense of engagement as presence increases. This has been shown to enhance the learner experience [14] and thus similarly facilitate the reflection of the compendium of research projects within a research laboratory.

III. METHOD

As a Case Study contextualizing the proposal, the International Virtual Environment Research Group (iVERG) Lab was set up in 2008 with initial funding from the UK Prime Ministers Initiative (PMI2) and the Japan Society for the Promotion of Science (JSPS). The overarching theme of the iVERG Lab is to research extrasomatic communication: communication outside the body. Crowley and Heyer's Communication in History states that communication has progressed through non-verbal gestures and an evolving system of spoken language [15]. As the world became more complex the shared memory of a group was limiting, so a memory outside of the body was required (termed extrasomatic memory); from wall paintings to stone tablets to iPhones, these are the arbiters of extrasomatic memory. Communication is becoming even more complex though as we enter other worlds such as Virtual Reality. For instance, a person partakes in extrasomatic communication as they interact with others in VR, with others outside VR, and with artificial entities in and out of VR. Extrasomatic communication is complex but can be defined as relating to, or being something that exists external to, or distinct from, the individual human body or being. Subsequently, the interlocutor is mentally removed from reality and, when fully immersed in a state of flow, may also be considered physically removed.

A number of projects in the iVERG Lab by undergraduate and Masters students vary in thesis topics but the underlying theme has always been to learn more about communication when using three-dimensional virtual spaces. Since 2008 the Principal Investigator, international collaborators, and student researchers have collated data in the form of diaries, videos, photographs, computer screen captures, flowcharts, and drawings. In-house and international conference presentations have reported developments, in addition to publications within peer-reviewed journals detailing the research. All these artefacts have had to be stored for academic evaluation (e.g. external moderation) and ethical compliance. An overview of the projects is displayed in the flowchart (see Fig. 1).

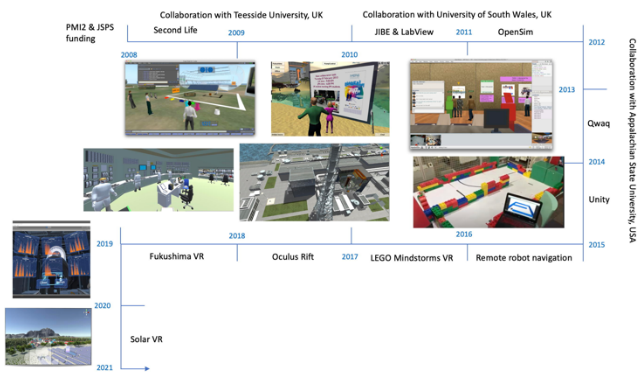

Fig. 1. Flowchart of iVERG Lab research projects from 2008 to 2021.

As the COVID-19 pandemic took hold in early 2020, and with government restrictions preventing students from physically entering institutes of education, a virtual representation of the iVERG Lab was proposed. To prepare the virtual GLAM, a post-graduate student was employed. The development of the virtual GLAM progressed through five instructional design phases: Analysis, Design, Development, Implementation and Evaluation (ADDIE). The five stages constitute a set of activities that target specific outcomes. More specifically, the five stages were:

- Phase 1: Analysis of research projects along a timeline, and their connection to the main iVERG Lab theme of extrasomatic communication.
- Phase 2: Design the virtual GLAM to reflect the longitudinal process and significant epoch moments displayed in multiple media formats.
- Phase 3: Develop the virtual GLAM using Unity, and also prepare the photogrammetry tools.
- Phase 4: Implementation of the virtual GLAM using Oculus Rift HMD.
- Phase 5: Evaluation through user experiences, and refine the virtual GLAM with recommended improvements.

To save time, a pre-designed structure was purchased from the Unity Asset store (see Fig. 2). The advantage was that the structure could be used as a template upon which to include the iVERG Lab artifacts in multiple media formats (such as video, photographs, presentation slides, and virtual animations). Thereafter, research images, information slides, pedagogical frameworks, short videos, sound files, and 3D objects as virtual artifacts were added (see Figs. 3–5).

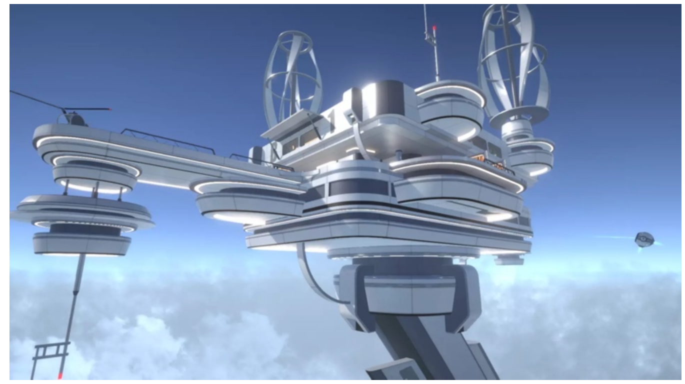

Fig. 2. Showroom template in VR.

Fig. 3. Showroom entrance in VR.

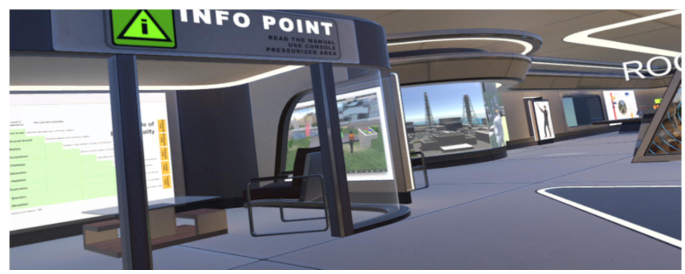

Fig. 4. Showroom information point in VR.

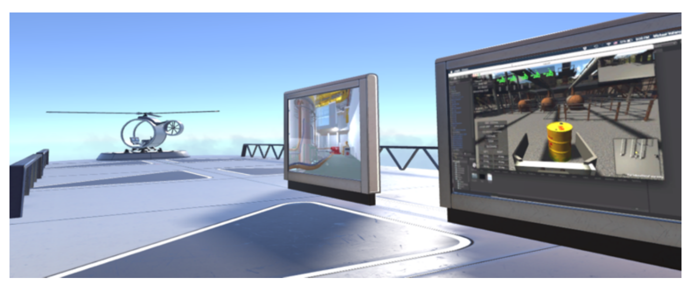

Fig. 5. Showroom images and movies in VR.

Due to the restrictive access imposed by COVID-19 regulations, the development was undertaken remotely using Unity, PlasticSCM and Teamviewer. The researcher was allowed to be physically located within the university while the student developer remotely accessed the main PC for developing the virtual GLAM. Iterative updates were synchronized using the distributed version control tool PlasticSCM (https://www.plasticscm.com), and then viewed using the connected Oculus Rift HMD. Plastic SCM allows a remote developer to iteratively update content within the GLAM. The update is subsequently viewed by another developer or researcher who, in turn, can accept, merge or edit the update. The PlasticSCM interface is shown in Fig.6 where each node represents an update.

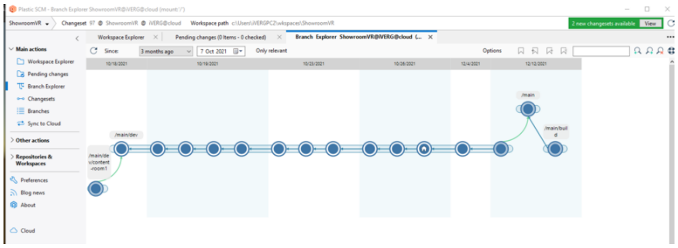

Fig. 6. PlasticSCM interface.

To display the hardware used throughout the research projects, such as LEGO EV3 and Arduino robots, required the programming of a dedicated photogrammetry application. Photogrammetry is the process of taking multiple overlapping photographs and then stitching them together with the aim of creating exact 3D representations. The student developer decided to use Apple's XCode to program a bespoke photogrammetry application, but it was left to the researcher to physically capture images of each robot. This required a turntable, an iPhone 12 camera, a tripod, lighting, and a light box (see Fig. 7).

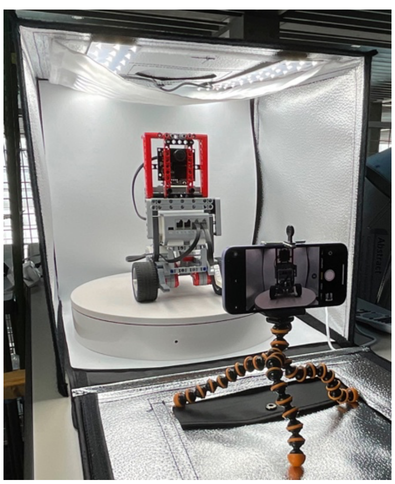

Fig. 7. Photography hardware set up.

Each object required 96 photographs which were then transferred to a required M1-chip Apple computer. The application, named phog, then blended the photographs into a 3D model saved in usdz format. This was then converted to required dae format for the Unity Project and uploaded to, and positioned in, the virtual GLAM. Within the virtual GLAM the 3D model can then be rotated 360 degrees, thus providing detailed, multi-perspective, and omnidirectional views. Fig. 8 displays a 3D representation of a student-designed VR haptic glove in the photogrammetry application.

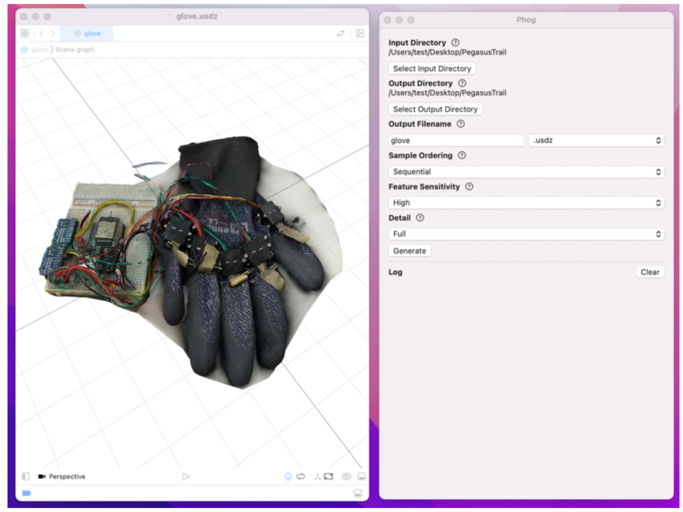

Fig. 8. Photogrammetry application and subsequent 3D model capture.

Photographs, videos, screen captures, flowcharts, images, presentation slides and past papers were all collated for consideration as representations of 12 years of research within the iVERG Lab. Once all the screens and panels within the virtual GLAM were utilized, the Unity Project was then exported for use as a stand-alone artefact viewable within the portable Oculus Quest by any user.

IV. DISCUSSION

Reflection is "… a learning mechanism that includes the process of stepping back from an experience and through extensive consideration get a better and deeper understanding of a phenomenon" [12]. Reflection on learning is a student-centered activity most often associated with course content or disciplinary practices. The aim is to develop learners' cognitive strategies to enhance self-regulation skills in order to prepare students for continuous learning beyond specific subject content. Similarly, reflection within a research environment aims to promote informed deliberation in the discovery of new or additional knowledge to the topic under investigation, and often incorporates the use of researcher diaries in the form of text, audio, video, drawings, flowcharts or a combination of multiple media artifacts. Progress reports and secure reliable data collection are essential to meet the requirements of valid research practice and ethical expectations.

A reflective structure of three components specific to research is proposed: research projects have to be context specific, meaningful, and trustworthy. The context of research is the circumstance or situation in which its process or outcomes are implemented. It is the weaving together of thoughts, ideas, information, data, and knowledge in order to position results into existing paradigms. "The circumstances that form the setting for an event, statement, or idea, and in terms of which it can be fully understood" [16]. Research has to be meaningful; i.e., practically useful and stimulating [18]. Meaningful, high-quality research is characterized as a multidimensional concept: "… researchers' conceptions of research quality [include] a multitude of notions [which] span from correctness, rigor, clarity, productivity, recognition, novelty, beauty, significance, autonomy, difficulty, and relevance to ethical/sustainable research" [17]. Research must also be trustworthy; i.e., abide by trust and personal responsibility. Helmer et al., "… advocate more personal responsibility for researchers, creating space for them to apply their own intellectual judgment …" [18] though not at the expense of research validity and reliability. In addition, trustworthiness may be apportioned externally through international peer-reviewed publications.

The culmination of 12 years of research was able to be viewed within the virtual GLAM in order for the researchers to reflect upon their implementations and progression. This had the added advantage of identifying strengths and opportunities, thus becoming more focused when planning future research proposals and recruiting students. Table 1 summarizes reflective commentaries after touring the virtual GLAM, observing video clips, reading short summaries, looking at photographs, screen captures and posters, listening to snippets of captured data, viewing graphs and frameworks, and watching short clips of conference presentations given physically and virtually. To reiterate, the iVERG Lab's primary research theme is extrasomatic communication (i.e., communication in and out of virtual environments between people as well as insentient objects). It can be seen that all 10 major research projects in the iVERG Lab adhere to the aim of determining recognition and metrics of extrasomatic communication.

TABLE I. REFLECTION ON A SAMPLE OF IVERG LAB RESEARCH BETWEEN 2008 AND 2020

Research	**Reflection**		
	Context	***Meaningful***	***Trustworthy***
Title: Processes, outcomes and metrics for assessing synchronous and asynchronous collaboration in Virtual Worlds. (Prime Minister's Initiative 2 (PMI2) Science Connect Research) May 2008 – April 2010.	To determine successful metrics for assessing tasks in emerging Virtual Worlds.	International collaboration discovering the affordances of 3D virtual environments, resulting in a valid and reliable framework tested in subsequent projects.	60 hours of communication recorded, transcribed and categorized. Subsequent quantitative data analyzed. Results confirmed by inter-rater reliability of 3 experienced researchers. 6 peer-reviewed publications.
Title: Beyond iStorm: Mindstorms in Virtual Spaces. April 2008 – March 2009.	Immersing students in activities and communication in a virtual space will lead to specific, measurable learning outcomes and concurrent metrics for assessing related tasks.	Testing of hypothesis framework for educational robot applications communicated via a 3D virtual environments.	Quantitative data of task implementations collated and results tested for significance. 2 peer-reviewed publications.
Title: The Virtual Institute April 2009 – March 2010.	Criteria for building an institute in a virtual world where activities can be undertaken by students.	Informed use of Successive Approximation Model for design of 3D virtual environments.	An antidisciplinary approach was surmised; supporting the thesis of Joi Ito, Director of the MIT Media Lab. 3 peer-reviewed publications.
Title: Augmented worlds April 2010 – March 2011.	Challenging science-based tasks in an OpenSim virtual world, which use innovative tools that would be difficult to replicate in real life, be implemented.	International student-centered collaboration designing wicked tasks for others to solve collaboratively.	Quantitative and qualitative data confirmed by inter-rater reliability of 3 experienced researchers. 1 peer-reviewed publication.
Title: Augmented reality for science literacy (JAIST Challenging Exploratory Research) April 2010 – March 2012.	Framework of metrics to measure real learning in virtual worlds.	Framework informed by Bloom's Taxonomy, hence applicable to school curricula for integrating 3D environments.	Implementation in authentic education settings, with quantitative and qualitative self-report data supporting video captured evidence. 7 peer-reviewed publications.
Title: Collaborative Learning, Cognitive Processes and Telerobotic Communication in Virtual Spaces April 2012 – March 2013	Cognitive processes best supported by virtual world tasks.	International solutions for Fukushima nuclear disaster replicated as a 3D virtual environment.	The design of the virtual Fukushima nuclear power plant and ongoing accident problems were identical to the videos being released by TEPCO. 3 peer-reviewed publications.
Title: Robot Mediated Interaction April 2013 – March 2014	Cognitive processes captured as quantitative data and represented in a 3D virtual world supported by robot mediated virtual world tasks.	Representations of learning processes within a 3D virtual environment for user to view while engaged in communication within and out of the environment	Implementation in authentic disaster training settings, with quantitative and qualitative self-report data supporting video captured evidence. 4 peer-reviewed publications.
Title: New ERA for virtual collaboration April 2014 – March 2015	Quantifiable measured tasks for effective virtual collaboration.	Merging of task framework with cognitive processes and learning outcomes when collaborating and communicating in VR.	A return to quantitative and qualitative data confirmed by inter-rater reliability of 3 experienced researchers. 4 peer-reviewed publications.

Title: Engineering active learning in a 3D virtual world (JAIST Challenging Exploratory Research) April 2015 – March 2018	International collaboration in robot-mediated active learning interactions significantly increases participants' declarative, procedural and meta-cognitive knowledge.	User communicating with a responsive technology in real-world (i.e., a physical robot), when fully immersed in VR (i.e., a state of flow) becomes mentally removed from reality.	International and inter-disciplinary collaboration and communication during the research process. Qualitative data collated and analyzed. 8 peer-reviewed publications.
Title: Engineering virtual reality for real learning (JAIST Challenging Exploratory Research) April 2018 – March 2021	Solar power tasks for remote maintenance and training where robots and sensors in a virtual reality (VR) space will be synchronized to real-world robot and sensor outcomes.	Extasomatic communication is the subsequently measured intra-cognitive and inter-cognitive communication which occurs during a VR immersive experience.	International and inter-disciplinary collaboration and communication during the research process. Quantitative data collated and supporting qualitative data subsequently analyzed. 8 peer-reviewed publications.

V. CONCLUSION

It has been posited that research laboratories can take the form of a Gallery, Library, Archive and Museum (GLAM) if appropriated as a virtual entity. The subsequent virtual GLAM can then support a holistic overview of research projects undertaken by associated researchers (i.e., Principal Investigator, collaborators, and students) to ensure academic affinity with the overall research theme and facilitate the planning of future research. A limitation of this proposal is its narrow focus on one Case Study though. However, it is posited that the emergence of VR as an accessible and reliable technology will enable researchers to reflect on their projects and consider sharing their efforts to a broader audience in the form of virtual GLAMs.

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