Virtual Museum Tours for Schools: Teachers' Experiences and Expectations

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Abstract—**Students have always been main targets for museums with clear learning strategies between schools and museums that contribute to a reinforced student learning experience. Although several museums offer virtual experiences (also available for schools), these cannot be easily manipulated or combined with other resources to form curriculum-focused learning activities. This study aims to explore the views and expectations of teachers on the use of Virtual Museum Tours (VMT) in their classrooms. Main findings from an online survey with 101 teachers (with or without VMT experience) shed light on their motivations and challenges when engaging their classrooms in such activities. Statistical analysis and visualisations were used to present teachers' experiences and expectations, and a binary logistic regression analysis was employed to indicate the factors that associate with teachers' decision to join VMTs in their classrooms. This study's observations have implications for the design of customisable VMTs for schools, for how museums develop VMTs that facilitate school participation, and how game designers develop virtual gaming apps used in formal education settings.**

Keywords—museum learning, virtual museums, virtual reality, technology-enhanced learning, game-based learning

I. INTRODUCTION

Museums engage people in a variety of displays to help them understand and appreciate cultural heritage [1]. However, with the ongoing Covid-19 pandemic, audiences, including schools, have had limited access to the museums. Although several museums offer virtual experiences (also available for schools), these cannot be easily manipulated or combined with other resources to form curriculum-focused learning activities. This work is part of a multinational project that aims to develop a gaming app that facilitates virtual museum tours (VMTs) for schools. The paper focuses on teachers' experiences and expectations with VMTs, knowledge that will contribute to the successful development of the project's gaming app and other school-based virtual world learning technologies.

Students have always been main targets for museums [2], with clear learning strategies between schools and museums that contribute to a reinforced student learning experience [3]. For example, Natural History Museums, as prominent informal science learning institutions [4], support science teaching and learning. Overall, research has shown that learning in museums extends beyond cognitive gains, focusing on the development of attitudinal, affective and social outcomes (e.g., [5]). Further to their traditional exhibitions, museums have recently developed citizen science programmes and activities to engage adults and young people more actively. For instance, a study by Lorke et al. [6] describes how young people, aged 5-19, participated in museum events and generated biological records that can be used for research purposes. Citizen science programmes aim to escalate museum learning, by developing a sense of agency and responsibility within adult and young citizens.

Hence, based on their motivation, interests, and prior knowledge, casual museum visitors select what, why, and how to learn from their experiences in these spaces [7]. Like casual visitors, teachers and school children may choose how to engage with exhibitions and what they wish to learn, even when taking part in guided tours. A recent review on learning and engagement through Natural History Museums found that teachers often plan museum visits in advance for a number of reasons, including not perceiving visits as educational experiences that may affect a lack of learning goals for the experience [8]. Nevertheless, Jahraie et al. [9] and [10] highlight the importance of students' preparation prior to a museum visit and the influence of post-visit activities. They explain that students need to be cognitively and psychologically prepared and equipped with the proper knowledge and skills for the visit. Further, they emphasise the importance

of post-visit activities for the assimilation of the new-learnt concepts.

Advice to maximise the learning potential of museum visits includes becoming familiar with learning materials for compulsory education curricula and professional development training that museums may offer [8]. Museums may work with schools or vice versa to create partnerships that recognise discrete aspects of communication such as mutually beneficial learning goals and the purpose of visits [11], [12]. Meanwhile, a number of technology-enhanced tools have been developed to support teachers and students during museum visits as facilitators of the exploration, communication and documentation activities. For example, Myartspace [10] was developed to support inquiry learning, processes such as goal setting, and collection and annotation of artefacts. However, the changing museum landscape during the Covid-19 pandemic has made school-museum partnerships more difficult.

As a response to museum closures amid the pandemic outbreak, the International Council of Museums [13] prepared a list of best practices in digital outreach to inspire museums to reach their audiences in different ways. These include putting museum collections online, organising virtual tours, and engaging the audience via social media contests. Nevertheless, the online presence of museum exhibitions has been around for some decades, providing greater access provision to remote visitors. These virtual museum experiences deliver information to remote visitors, focus on user-exhibit interactions, and teach specific content around pedagogical tasks [14]. Therefore, opportunities and benefits exist for online museum-based learning and teaching, such as major opportunities to use and manipulate visual resources for engagement and learning and document experiences with museum content [15].

Although the online presence of museums has facilitated engagement with the audience, this shift from physical to virtual visits is not without its challenges. Alawad et al. [16] indicate copyright issues that prevent virtual visitors from accessing certain artworks, and Sylaiou et al. [17] describe the difficulties of technologically illiterate visitors in using special software the equipment to view virtual museum exhibitions. Poor image quality and feelings of being lost, alone, or not being able to proceed were also issues mentioned in a qualitative study on visitors' perspectives of virtual museum tours (Aytekin & Aktas, 2021)

Concerning the school-based educational purposes of such virtual visits, Harron et al. [20] explain that teachers controlling the tour, which usually lasts much less than a physical tour, have a high risk of students' low or passive engagement. Further, unlike physical museum tours, teachers and students can only experience the exhibits that have been included by the developers of the content [21]. In addition to that, teachers and students may rely on desktops and laptops provided by the school, as students may not own mobile or other devices to take part in the activities [16]. Further to the ownership of activity and selection of exhibits, Cosovic and Ramic Brkic [22] alert to the hidden risks of a decrease in attention span, as students may engage more with the interface and navigation features and fail to focus on the context of a particular artefact or

activity. Finally, teachers who want to include such online extra-curricular activities in their classrooms express their need for these to be well connected to the curriculum outcomes and linked to learning models and theories [23].

Beyond the use of VMTs by the educational process as a virtual learning environment, many digital tools have become necessary for teaching with technology. These tools enable them to design and provide dynamic digital environments where students are meaningfully engaged in learning activities through interaction with others [18], [24]. These kinds of simulations can be used as substitutes for "real" situations when these situations are difficult to be created in real life, while they provide role-playing by which students can get engaged with the role of a scientist or technician and get encouraged to identify with science and technology [25]

Therefore, the development of low or free cost digital applications their incorporation into the educational process has been increasingly popular. Virtual spaces such as labs, classes, rooms that provide training free from location and time can be a virtual escape milieu from the classroom walls for students [24]. Indeed, the use of Multi-User Virtual Environments (MUVEs) such as virtual laboratories or virtual reality (VR) experience games using almost any smartphone running Cardboard-enabled apps (e.g., Google Cardboard), seem to strengthen the learning process [18], [26]. These results stem from the fact that abstract concepts become more concrete, daily life experiences supplement lessons, and students can go ahead according to their learning pace.

Other famous digital apps, such as the Google Street View App (an application which provides the ability to create photospheres as a full view of a location from the centre of a sphere) and the iMovie (for digital storytelling), enable users to record video clips via their mobile phones, tablets, and digital cameras. Such virtual tools can be used in school-based settings to approach knowledge through a process of critical information seeking, synthesis and knowledge production [24], [27].

Recent research results have verified the usefulness of VLEs as educational tools in the learning process. According to the results of a recent large-scale study on primary and secondary schoolteachers' perceptions and tendencies, the use of VLE can improve the innovative way of teaching that can increase students' triggering in constructing knowledge [28]. Similarly, in Limniou and Smith [29], teachers found that VLE strengthened students' background knowledge. In turn, students reported that the use of VLE can lead to a more student-centred approach. Finally, considering the evidence, Guan, Wang, Chen, Jin & Hwang [30] claimed that the VR-based learning approaches foster children's creativity and cognitive engagement.

However, while most teachers would agree that technology is essential for teaching and learning, many teachers fail to integrate it across their curriculum [31]. Teachers' use of technology in the classroom can be influenced by several factors, such as the lack of ability, the lack of knowledge, the limited time and tools, a poor internet connection and a lack of confidence [32]–[34]. More specifically, Eguz's study [35] on schoolteachers' views about VMTs highlights a negative association among

adequacy of technological support and productivity, stressing the importance of detailed lesson planning in order to achieve the goals of all instructional activities in the classroom effectively and efficiently. Consequently, Eguz [35] argues that for increased efficiency, preparations should be conducted before, during, and after the virtual museum visits – as with physical museum visits. Another study on the views of teachers, who used virtual trips in their classrooms, indicates challenges for their implementations, such as lack of interaction, language affordance and hardware/network problems [36].

The lack of virtual museum experiences that can easily be manipulated or combined with other resources to form curriculum-focused activities alongside teachers' challenges with VMTs and other TEL activities motivated this project and inspired this particular study on teachers experiences and expectations in VMTs.

II. AIM AND RESEARCH QUESTIONS

The aim of this study is to explore the views of teachers on the use of Virtual Museum Tours (VMT) in their classrooms, as an alternative to physical visits to museums. Further, we examined the experiences of teachers who have already engaged in VMT with their students, and the preferences of those who have not.

The research questions (RQs) of this study are:

1)   What is teachers' previous experience with technology-enhanced learning (TEL) and VMTs?
2)   What are teachers' motivations, settings and challenges when joining VMTs with their classrooms?
3)   What are teachers' expectations from a classroom-based VMT gaming app?
4)   What are the main predictors of accepting an invitation to a semi-structured classroom-based VMT, and their relative influence?

This study is part of the project VISITOR (virtual museums in the covid era). VISITOR is a European research collaboration among universities and small organisations, funded by Erasmus+, that aims to develop VMTs for schools. The final product of this collaboration will be a VMT gaming app. The app will enable teachers to create their own themed museums, by selecting digital museum artefacts stored in the game's library and creating or re-using learning material to engage their students with the artefacts. While there are studies exploring the experiences of VMT visitors (e.g., [19]), the current work is a first step towards understanding the views and experiences of teachers, potential users of a customisable app for classroom use. To that end, teachers' expectations and previous experiences with VMT will guide the first design versions of the VISITOR gaming app (RQs 2, 3). Moreover, acknowledgement and exploration of the factors that usually influence teachers' engagement in such activities [32]–[34] will contribute to a better design and recruitment plan (RQs 1, 4).

This study's findings have implications for the design of customisable VMTs for schools, how museums develop VMTs that facilitate participation by schools, and how game designers develop virtual gaming apps used in formal education settings. The aim of this work is to broaden current knowledge on virtual museum visits by building on teachers' previous knowledge on the topic and extending the use of VLEs to support school visits. The result will be an innovative solution for teachers who want to engage students in visiting more than one museum at a time, and develop creative activities that span across location, discipline, and point in history.

III. APPROACH

A. Participants and settings

For the current study, we recruited in-service primary and secondary schoolteachers to take part in an online survey. The invited teachers were of any age, teaching experience and experience with virtual tours. Participants were recruited via project partners' existing channels and previous collaborations. Ethical approval was obtained from Author A's university ethics committee, and participation in the survey was voluntary. Prior to completing the survey, the respondents were provided with an online information sheet and a consent form. The survey was initially piloted with two teachers, and minor changes took place. The survey ran between 15 July – 15 September 2021 and received 101 responses, mainly from teachers in the UK and Greece. The dataset was anonymised on the 16th of September 2021, prior to initiating the process of data analysis.

B. Data Collection

Collected data included teachers' demographics, such as their gender, age and country, and other information such as school-level they teach, years of teaching experience, and experience with learning technologies and online virtual tours. Closed-ended questions, with an 'other' option, retrieved information on teachers' views and existing or expected experiences with VMTs, such as their motivations for joining, the activity settings (museum types, school subject, tools), and their challenges and preferences. The survey questions built on findings from previous research on the motivations and challenges of schoolteachers when engaging their classrooms in TEL activities and on desk research around the VMT specifications in several museums.

C. Data Analysis

Teachers' responses were aggregated, statistically analysed and visualised. In this work, we are interested in the overall picture of teachers in relation to VMTs and their experiences and preferences of VMTs. However, several participants in this study already have experience of VMT activities in their classrooms and their perceptions differ from those of teachers who are not familiar with these activities. Hence, on some occasions, the findings are presented separately for each group and compared. This approach helps us understand more about the support that teachers need to both initiate and sustain or improve VMT activities.

Further to examining teachers' overall views, a binary logistic regression analysis was performed to investigate the effect of teachers' motivations and challenges on their decision to join semi-structured VMTs. Our unit of analysis was teachers ($n = 89$), of which we had information about their motivations and challenges while controlling for their age, teaching experience and VMT experience. Factors like gender and experience with TEL were excluded from the model due to their very disproportional groups (i.e., 97% were experienced with TEL). The dichotomous

dependent variable was either a positive answer (teachers responding 'yes') or a non-positive answer ('no' or 'not sure').

Correlation analysis was performed before entering the variables into the regression to examine for multicollinearity. No variables were found to correlate highly or significantly. Nagelkerke R^2 was used to characterise the relationship between prediction and grouping. Associations between positive responses and the independent variables in our dependency model were estimated using odds ratios (ORs) produced by the logistic regression procedure in SPSS (Version 25). The ORs were used to explain the strength of the presence or absence of significant positive impact. Wald tests were used to assess the significance of each predictor. Findings could help identify which factors we have to address in order to engage teachers in VMTs successfully and inform the VISITOR gaming app design and recruitment strategies.

IV. OUTCOMES

Survey respondents in this study were teachers mainly located in Greece (57%) and the UK (43%). The majority of the participants teach in upper secondary schools (62%), with one-third teaching in more than one school level (i.e., lower and upper secondary). Participants' average age was 45 ($SD = 10.5$), with the vast majority to report they are women (80%); these characteristics match with statistics on teachers' gender and age, provided by Eurostat (2021). The average teaching experience of this study's respondents is 16.5 years ($SD = 8.5$).

A. Experience with TEL and VMTs (RQ1)

This section answers RQ1: *What is teachers' previous experience with technology-enhanced learning (TEL) and VMTs?*

Nearly all of the teachers (97%) are somewhat or very much familiar with online and digital tools (or TEL) for teaching, but slightly less than one-third (32%) with VMTs. Finally, 29% reported that they have already been to VMTs with their classrooms.
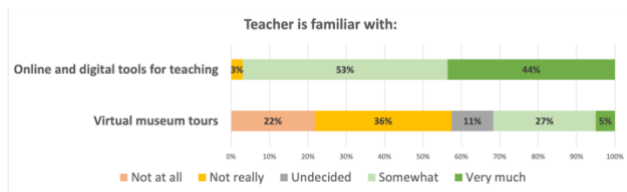

Fig. 1. Teachers' experience with TEL and VMTs

B. Motivations, Settings and Challenges (RQ2)

This section answers RQ2: *What are teachers' motivations, settings and challenges when joining VMTs with their classrooms?*

1) Motivations

Main motivations for joining VMTs, by both VMT experienced and inexperienced respondents, were to increase students' interest in museums, selected by 20% of the experienced and 18% of the inexperienced teachers, and novelty in teaching, selected by 17% experienced and 18% of the inexperienced teachers (Fig. 2). Beyond the commonly chosen motivations, experienced teachers further cited the Covid-19 pandemic and museum closures

(18%), as well as more permanent reasons for not being able to visit museums, such as the school being located in geographically disadvantaged areas (5%). Motivations chosen or reported by both groups, but slightly more by inexperienced teachers, involve a liking to the exhibit or museum topic by teachers or students, and curriculum-related incentives. Teachers' professional development was a less popular motivation, more cited by inexperienced teachers.
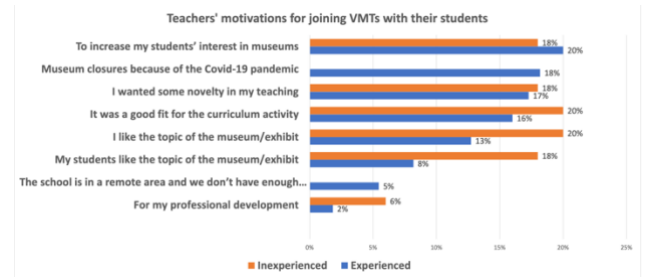

Fig. 2. Teachers' motivations for joining VMTs with their students

While there are some differences among the two groups, findings in this study suggest that both groups would be attracted by VMT-extracurricular activities that aim to add novelty to their teaching and increase students' interests in museums. For inexperienced teachers, reasons such as fun, and students' and their own interests are major reasons to attract them to VMT activities, while experienced teachers seem to cite more practical reasons, such as the use of VMTs as a replacement to existing practices that are not available.

2) Settings

The majority of experienced teachers organised the VMT themselves (86%), and only 14% organised it together with their colleagues (Fig 3). Inexperienced teachers expected that such an initiative would be organised collaboratively (32%) or by someone else, such as their school (13%) or research project (13%), with only two in five teachers (39%) agreeing that they would organise it by themselves. This noteworthy difference between the reality of experienced teachers and expectations of inexperienced ones indicates the gap that a top-down approach to such extracurricular activities is invited to close. Therefore, teachers who are reluctant to engage in setting up a VMT by themselves could benefit from pre-organised activities that could be customised in collaboration with colleagues or independently.
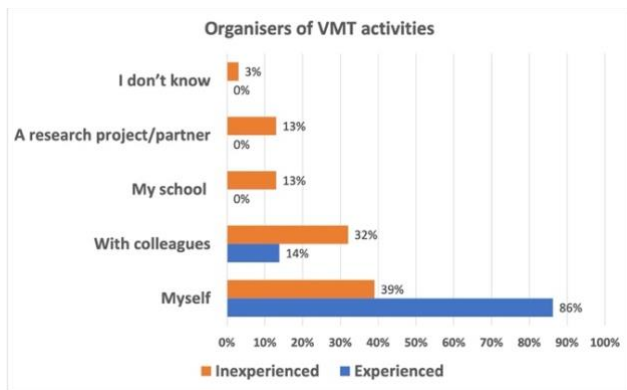
Fig. 3.   Organisers of VMT activities

Experienced teachers (*n* = 32) provided us with a record of the tools and devices used to access the VMT activities in the classroom. The most frequently used device was 'laptops' selected by 41% of the survey respondents, followed by desktop computers, chosen by 24%. Tablets and smartphones were used by a smaller proportion of teachers, 16% and 12%, respectively. Interactive whiteboards (6%) and interactive screens/webcams (2%) were employed by only a few teachers, while virtual reality headsets were not used at all. More than half of the survey respondents (58%) reported that the tools and devices used in the VMTs were provided by the school and 23% by a museum. Further, several teachers selected that they (18%) or their students (3%) own the devices used for the VMTs.

With regards to the type of museums that experienced teachers visited and inexperienced desire to visit for their VMTs, there were many disagreements among the two groups (Fig 4). While a nearly equal proportion of teachers (50% experienced and 41% inexperienced) indicated a preference towards archaeology museums, there were larger differences among other types of museums. Experienced teachers reported that they have mainly been to VMTs to archaeology (50%), art (28%) and history museums (22%); the top preferences for inexperienced teachers were science (78%) followed by technology (54%). This difference among the two groups may have several explanations. Teachers engaging in subjects relevant to classic studies, such as archaeology, art and history, may be more familiar with VMTs, due to their importance in enriching the subject content. Another explanation may be the type of VMTs provided by the relevant museums, which may be more usable, classroom-friendly or popular. However, this finding urges us to develop VMT learning and supporting material that will allow teachers who teach or are interested in more practical subjects (such as science and technology) to use them in their classroom activities.
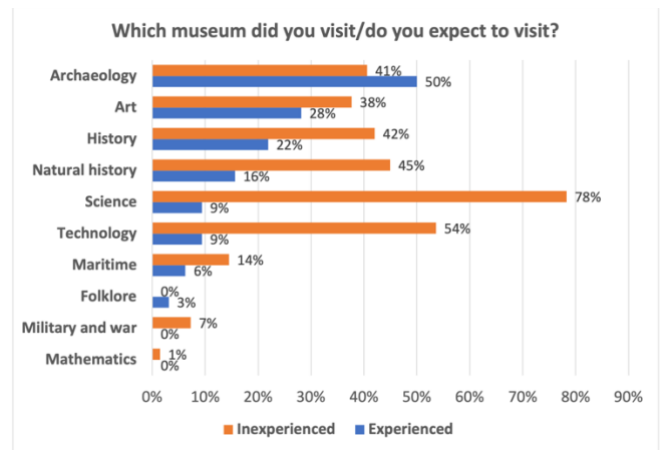

Fig. 4.   Preferred types of museums

A closer look at the school subjects that teachers in both groups aim to connect or have connected the VMTs to, provides us with explanations for the preferred type of museums (Fig 5). Experienced teachers, who as we saw, engaged their students in mainly archaeology museum VMTs, connected their VMTs to mainly history studies (19%), and to a lesser extent, to language (8%) and citizenship studies (8%). However, it is observed that fewer teachers selected a wider range of subject to connect with the curriculum. Nevertheless, inexperienced teachers reported that they would like to connect VMTs to different types of school subjects, such as science (76%) and computing (60%). This finding links well to this group´s preferences on types of museums. Similar to the experienced teachers, this group also selected a range of school subjects. Our understanding from combining preferred museum types and selected school subjects is that this study's cohort teaches a wide range of school subjects, with those teaching classic studies to be more familiar with VMTs, and probably the rest to be more in need of support on how to integrate VMTs into their practice.
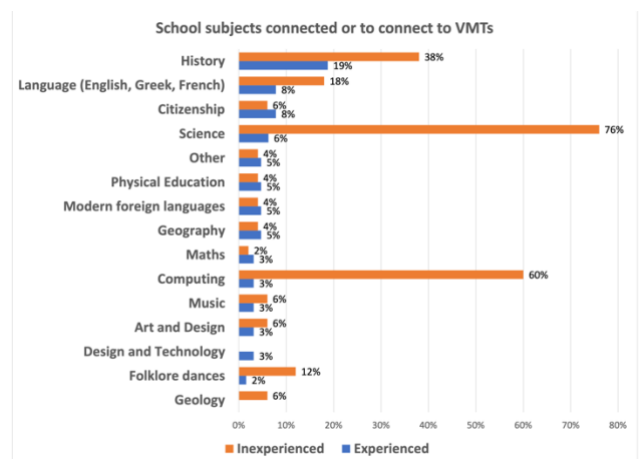

Fig. 5.   School subjects connected/to connect to VMTs

3)   Challenges

Both experienced and inexperienced teachers were asked about existing and potential challenges for when they engage in VMTs with their classrooms. The following figure (Fig. 6) presents an aggregated list of challenges

selected or suggested by both groups. The most frequently suggested by experienced teachers was 'securing a good internet connection' (47%) while for inexperienced teachers was 'designing learning activities around the visit' (64%). While the former was nearly as popular in both groups, experienced teachers stressed the importance of securing a good internet connection more than anything else. Meanwhile, inexperienced teachers' lack of exposure prompted them to highlight concerns around the design of learning activities that support VMTs.
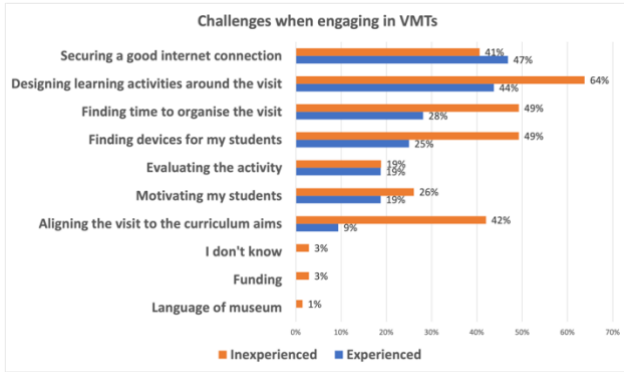

Fig. 6. Challenges when engaging in VMTs

While internet connection and learning design-related activities were the main concerns of experienced teachers, inexperienced teachers focused, equally or slightly less, on other challenges. These challenges are most relevant to the required resources for implementing the activity, with nearly half of this group's respondents (49%) emphasizing on difficulties in finding time to organise the activity and devices to implement the activity. Another challenge mentioned by two in five inexperienced teachers (42%) is the alignment of the VMT to the curriculum aims. Other common but less frequently mentioned concerns by both groups involve motivating students to take part and evaluating the activities.

C. Expectations for VMT Gaming Apps (RQ3)

This section answers RQ3: *What are teachers' expectations from a classroom-based VMT gaming app?*

Teachers' main expectation on the VMT app involved including exhibits and several options for their use (78%) (Fig. 7). Further, a relatively high proportion of the survey respondents (63%) suggested that an essential feature would be to structure the VMTs even more, by providing lesson plans that integrate the use of exhibits. About one in four survey participants proposed that the VMT permits some flexibility for the teachers by allowing them to create their own learning material for a provided exhibit (25%) or even further, to be able to choose and place their own exhibits and learning material in the gaming app (28%).
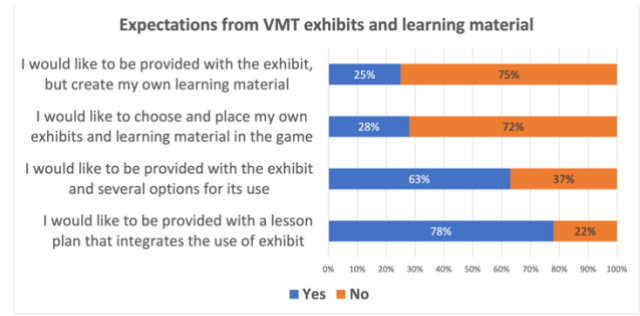

Fig. 7. Expectations from VMT exhibits and learning material

Further to the use of exhibits and learning material, teachers shared their preferences on the technology-enhanced tools and activities of the VMT gaming app. The most popular request, selected by three out of four teachers (75%), was for integrated assessment that would allow them to engage students with ongoing evaluation during the VMT activity. Other important requirements, chosen by more than half of the survey participants, were the display of VMT activities in a chronological/linear order (59%), as opposed to random order (13%); and the use of a three-dimensional (3D) interface for the game (57%), as opposed to a two-dimensional (2D) interface (13%).

D. Predictors for Accepting Invitation to VMTs (RQ4)

This section answers RQ4: *What are the main predictors of accepting an invitation to a semi-structured classroom-based VMT, and their relative influence?*

1) Teachers' response

Three in four teachers (74%) from both groups agreed that they would join a semi-structured VMT with their classrooms, 22% stated they were not sure and 4% said they would decline such an invitation. Those with a non-positive response (not sure or would decline) cited lack of devices as the main reason (69%) and lack of time as a secondary reason (23%) (Fig. 8). Less selected or reported reasons include confidence with IT skills (8%) or lack of students' interest (4%).
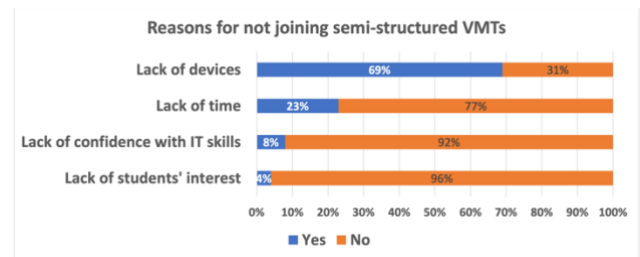

Fig. 8. Reasons for not joining VMTs

2) Logistic regression model

For predicting positive responses to an invitation to a semi-structured classroom-based VMT, a test of the full model against a constant only model was statistically significant, indicating that the predictors as a set reliably distinguished between teachers accepting or declining an invitation. Prediction success for joining semi-structured VMTs was 84.3% (95.5% for positive and 50% for non-positive response). Table I presents the logistic regression model results estimating the effect of independent variables

and control variables (such as teachers' background, experience with VMTs, motivations and challenges) on predicting positive responses.

TABLE I. LOGISTIC REGRESSION MODEL ESTIMATING EFFECTS OF INDEPENDENT VARIABLES ON TEACHERS' POSITIVE RESPONSES

Variable	B	S.E	Wald	P value	Odds ratio (OR)
Age	-0.13	0.06	4.78	**0.03***	0.88
Teaching experience	0.17	0.08	5.20	**0.23***	1.19
Experience with VMTs	-1.54	0.89	2.98	0.09	0.21
Motivations					
Novelty in teaching	-0.38	0.86	0.20	0.66	0.68
The topic of the museum/exhibit	-0.21	0.97	0.05	0.83	0.81
My students' interest in the topic of the museum/exhibit	1.09	0.86	1.63	0.20	2.98
Professional development	-0.50	0.93	0.29	0.59	0.61
To increase my students' interest in museums	-0.69	0.86	0.65	0.42	0.50
The visiting exhibit is a good fit for the curriculum activity	3.17	1.06	8.92	**<0.01***	23.83
Challenges					
Designing learning activities around the visit	0.39	0.97	0.16	0.69	1.48
Aligning the visit to the curriculum aims	-1.68	1.18	2.01	0.16	0.19
Finding devices (mobile phones, tablets, desktops) for my students	-0.71	1.09	0.43	0.52	0.49
Securing a good internet connection	-1.17	1.05	1.24	0.27	0.31
Motivating my students	-1.01	0.91	1.23	0.27	0.36
Evaluating the activity	1.22	0.95	1.62	0.20	3.37
Finding time to organise the visit	0.82	0.81	1.03	0.31	2.27
Constant	6.11	3.11	3.86	0.05	448.18

* = p < 0.05

The Wald criterion demonstrated that three variables – age, teaching experience and links to the curriculum – made significant contributions to predicting responses. Odds ratios (OR) indicated that the most significant factor that may affect teachers' decision is the link to the curriculum, with teachers who selected this motivation for joining VMTs to be 23 times more likely to accept an invitation to join a semi-structured VMT game ($p < 0.01$). Further, older teachers were slightly less likely to join (OR = 0.88), and those with more teaching experience were slightly more likely to join (OR = 1.19).

V. DISCUSSION AND CONCLUSIONS

This study aims to understand the experiences and expectations of teachers who have joined or plan to join VMTs in their classrooms.

Findings from this study indicate teachers' motivations and challenges when engaging in VMTs and their expected

or desirable support. Teachers' motivations in joining VMTs with their classrooms were associated with their desire to increase students' interests in museums and use novel teaching methods in their classrooms. Both types have been encountered in previous research studying teachers' motivations with VLE (e.g., [28]). However, teachers in the current study did not emphasise students' learning as an incentive, as for example in Limniou & Smith [29]. Rather, they focused on more contextual factors, such as students' increased engagement and interest in learning activities. An additional aspect to teachers' motivations was their choice of the VMT organiser, with experienced teachers reflecting the current reality – teachers having to organise the VMT by themselves – and inexperienced ones expecting to share this cargo with others. This project's initiative could attract to VMTs teachers with less confidence or time to spend on organising the activities by providing semi-ready solutions that they could modify for their learning purposes.

Moreover, in this study, we identified some of the teachers' main challenges when engaging with VMTs, such as securing a good internet connection, designing activities around the visit, finding time and devices to organise the visit and aligning it to the curriculum aims. These findings are in line with previous research looking into teachers' experiences with educational technology (e.g., [32]), VMTs (e.g., [35]), and online citizen science (e.g., [23]) that highlight the importance of preparation, extra effort, and support for the successful implementation of the activities. This project aspires to address VISITOR's participating teachers' challenges, and issues encountered in previous research, as a way to motivate and encourage experienced and newcomer teachers in using and benefiting from VMTs. For example, the VISITOR's gaming app design may focus on allowing access to offline versions of the VMT to tackle internet connection issues. Further, artefacts and exhibits in the VMT can be accompanied by use cases of different levels, from simple use suggestions to fully developed lesson plans, with the aim to equip teachers with pre and post-activities, as well as learning and evaluation activities, that will increase teachers' productivity. Higher levels of support within the VMT were also supported by at least three in five survey respondents. Finally, lack of devices, which was also encountered in other studies (e.g., [16]), could be tackled by introducing group activities with relevant learning material to maintain and activate all the team members.

Reflecting on the motivations and challenges of the participating teachers, we identify that although their main motivations for joining are engagement-related, they are still concerned with the design of VMT learning activities that target particular curriculum aims and learning outcomes. This is also evidenced in the logistic regression model, in which the leading factor for joining semi-structured VMTs is the presentation of exhibits that form a good fit for the curriculum activities.

Further, teachers' views can contribute to the selection of types of museums and school subjects that will be embedded in the gaming app. An interesting finding is a difference among experienced and inexperienced teachers on the type of museum they visited or would like to visit via the VMT (archaeology and art versus science and technology) and on the school subject that VMT was

connected. A possible explanation for this difference may be that archaeology and art artefacts are easier to integrate into the curriculum activities, while science and technology artefacts need more thoughtful learning activity design. Another explanation may be that the background of teachers who teach subjects such as history and languages enable them to search and use museum artefacts with ease. However, this question's strong message was that science and computing are subjects in which teachers are keen to integrate VMT activities. Therefore, artefacts and learning activities in this project's gaming app will be carefully selected to span over a wide range of topics.

Finally, future work should also capture the factors that associate age and teaching experience with teachers' willingness to join VMTs in their classrooms. Although these two factors were used to control findings in the logistic regression model, the outcomes show that more investigation is needed in relation to teachers' context. The findings from the logistic regression model have important design and recruitment implications for VISITOR as, similarly to other studies in teachers' use of technology [32]–[34], contribute towards an understanding of potential factors that can influence teachers' desire or ability to use VMTs or, in particular, the VISITOR gaming app.

This paper has highlighted the importance of understanding teachers' experiences and expectations from TEL activities and applications. Considerable insight has been gained with regard to why and how teachers decide to engage their classrooms in VMTs and how we could better support their experience and involvement. This study's findings aim to inform the design and development of VISITOR's VMT gaming app, but can also contribute to design decisions on other relevant TEL applications.

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