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Application and evaluation of interactive virtual technologies in nursing students' learning and clinical skills assessment. A mixed methods study

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Abstract

Background: During the 2020 iteration of a Bachelor of Nursing Clinical Health Assessment skills course delivered in Singapore, the sudden cancellation of all face-to-face classes due to the pandemic resulted in innovative strategies being quickly created to enable students to successfully complete Objective Structured Clinical Examinations online. However, the realism of the experience was rudimentary. After exploration of a range of technologies, a mixed reality (interactive virtual patient) application was developed within the Microsoft Power Apps platform, implemented and evaluated for the 2022 iteration of the Clinical Health Assessment course.

Methods: A mixed methods exploratory design was used with quantitative and qualitative data collected regarding student performance and user experiences.

Results: The data suggested positive user experiences, with 60% feeling the application involved them and 80% reporting consistency with real-world experiences. Students' assessment item results from the 2022 iteration were also compared to previous iterations of the course and showed comparative alignment across the ranges of marks.

Conclusion: The mixed reality (interactive virtual patient) application provided a realistic and interactive user experience as well as an effective means of online clinical skills assessment.

Introduction and background

Over recent years, the global COVID-19 pandemic and resultant biosecurity measures have brought many challenges for universities and colleges, including those providing nursing education programs. While many courses can be taught and assessed effectively online, delivery and assessment for courses that focus on clinical skills have been somewhat more challenging (Crawford et al., 2020; Dewart et al., 2020; Grafton et al., 2021). As the COVID-19 pandemic began to impact Singapore in early 2020, a Clinical Health Assessment (CHA) skills course in a Bachelor of Nursing (BN) program provided by an Australian university for nurses in Singapore was rapidly moved online. While tutorials and lectures were able to be delivered online with relative ease, more imaginative and innovative strategies were quickly developed to provide the clinical skills laboratories and the Objective Structured Clinical Examinations (OSCEs). The strategies developed and used at that time, although somewhat rudimentary, were effective in teaching and assessment, provided a supportive learning environment, and enabled course learning outcomes to be met, and thus maintained academic continuity for students (Grafton et al., 2021).

Education for healthcare practitioners is ever-evolving as new and emerging technologies impact on the way education is provided (Co & Chu, 2020; Mtshali & Harerimana, 2019). Research recommends that nursing programs continue to adapt and transform (Ion et al., 2021) and report on the successful use of virtual learning platforms not only to conduct effective teaching but also to facilitate students' clinical learning experience (Co & Chu, 2020; Choi et al., 2022; Manakatt et al., 2021; Schmitz et al., 2021). As the COVID-19 pandemic unfolded from early 2020, and face-to-face teaching and assessment were no longer practicable, many institutions moved to online alternatives (Crawford et al., 2020). The World Health Organization (WHO) warned, in mid-2020, that the global pandemic would be persisting for the foreseeable future (WHO, 2020). At the end of the 2020 teaching semester, and with the possibility that the next iteration of the course would also need to be online, it was decided to explore opportunities for crafting a mixed-reality experience combining simulated patients and a virtual learning environment to further enhance the students' sense of reality and interactivity for the 2022 iteration of the CHA course and particularly for the OSCEs.

The interdisciplinary research team

The project was initiated in 2021 with the aim of developing and testing the use of virtual or mixed-reality applications for online simulated learning and clinical skills assessment. The research team was led by the BN Program Director (Singapore) and initially included the principal academic convenor for the CHA course and the BN Health Technical Services team leader. Experience with applications and virtual and augmented technologies was brought to the team via the addition of a senior academic from the School of Pharmacy and Medical Sciences and two academic staff from the College of Art and Immersive Design.

It is reported by Leigh and Brown (2021) that interdisciplinary research teams may face challenges not usually found within one's own discipline, such as different epistemological beliefs and research practices, as well as discipline-specific language. In this project, the different disciplines and members of the research team brought different perspectives and skills and gave rise to creativity that would not ordinarily be found in a team from within the same discipline (Grant et al., 2023; Zhang & Wang, 2021). From a graphic and design perspective, it was an opportunity to experiment with different technologies to provide a sense of realism and believable spatial construct (Grant et al., 2023). From a nursing perspective, any new virtual solution would need to facilitate the OSCEs to be able to be performed and assessed in real-time, to maintain the rigour and integrity of the assessment (Grafton et al., 2021). Having a diverse interdisciplinary research team provided a valuable opportunity to experiment with different technologies at the development and testing stages and helped reshape the project as a whole in the search for a solution that delivered the 'best fit for purpose.'

Methods

Considerations and development of the interactive virtual patient application

With the course convenor in Australia and students in Singapore and the Objective Structured Clinical Examinations (OSCEs) needing to be completely online, several considerations were prioritised for development. The application would need to be of low or no cost, require no specialised equipment, be accessible on any electronic device, be able to be applied in "virtual private rooms/channels" for OSCE assessment purposes and include culturally appropriate aspects for Singapore. The app would also need to function seamlessly within existing platforms used on the university's course sites.

Through experimentation with different educational technologies as well as technologies from outside the educational paradigm, an interactive virtual patient application (abbreviated by the research team and referred to in this paper as the VR App) was built using the 'Microsoft Power Platform' with life-like and stylised virtual patients designed using 'Unreal Engine' and 'Meta-Human Creator' (Epic Games Inc., 2004-2023). Three virtual ethnically appropriate patients were created, with two scenarios for each virtual patient, providing different body systems assessment options. The research team experimented with the appearance and functionality of the application on a range of devices, including laptop computers, tablets, and mobile phones, and with different browsers, to mimic the different ways students may access their course content and online assessment. Further detail of the development and operationalisation of the VR App can be found in another publication by the authors (Grafton et al., 2023).

One month prior to the OSCEs, students were given access to one virtual patient in the initial version of the VR App via an open OSCE practice channel on the course Teams site. Students were asked for feedback on appearance,

functionality and user experience. A small number of students who had completed the OSCEs online in the previous iteration of the course participated in a live demonstration of the interactive virtual patient application (VR App), allowing those students to compare the process for OSCE using the VR App to the previous online OSCE process. Feedback from both groups of students facilitated the final refinements of the VR App. The virtual patient in the OSCE practice channel was then updated to the final version of the VR App. The VR App with the remaining two patients and their scenarios was embedded in the private examiner's channels on the course Teams site for the formal OSCEs. Private channels were selected for examiners, with students given access, one at a time, to an examiner's channel to facilitate uninterrupted privacy and confidentiality during each individual student's exam.

Recruitment, sample and data collection

All students in the course (n=104) were made aware from the start of the semester that an application was being developed for use for online OSCES as a pilot research project. As such, they would have the opportunity to provide anonymous and confidential feedback, should they consent to do so, and that feedback and statistics would also be garnered from the university's standard student evaluation of the course (SEC) questionnaires. All students were reassured that they would be provided with clear instructions on the use of the application and ample opportunity to practice before their formal OSCEs. An online survey was developed for the students' experiences survey, comprising 16 questions in two sections. Ten of the questions were statements with responses provided on a 5-point Likert scale, and the remainder were a mix of open questions related to their experience, learning, and questions related to the technology they used. Section one questions were based on the Student Experience Questionnaire (SEQ) from the Quality Indicators for Learning and Teaching (QILT; Australia), which focuses on aspects of the higher education experience that are measurable, linked to learning and development outcomes, and potentially able to be influenced by institutions (QILT, 2022). Section two questions were developed from Witmer and Singer (1998) and Busselle and Bilandzic (2008). The student survey can be seen in Appendix A.

After completion of the OSCEs, students were sent an email seeking their voluntary participation. The information included a participant information sheet and consent details outlining that completion of the survey would be anonymous, would not influence or impact their grade, the right to withdraw at any time, and the link to the online survey. Descriptive statistics were used to analyse the data. The examiners were also sent a similar online survey amended slightly to reflect their role in the OSCE process, using the VR App. The qualitative data were not subjected to any formal analysis such as content or thematic analysis but were used to provide insights and highlight aspects that students experienced through the process.

Ethical approval

To evaluate user experience, ethical approval was sought and given via the University Ethics Committee REF 2022/260. This included the sanctioning of participant information and informed consent procedures. Ethical approval was also granted to include statistics of OSCE results to compare the 2018, 2020, and 2022 iterations of the course.

Results

Quantitative data

Responses were received from 25 of 104 students (24%) and two of the three examiners. Anecdotal feedback throughout the semester was encouraging and positive, and the results of the final survey were positive. In general, students reported that they received clear instruction and that the opportunity to practice, as well as using the VR App for OSCES, was engaging and allowed them to effectively demonstrate the appropriate skills. In terms of the visual effects, and realism, 60% of students reported they felt involved or very involved with the visual aspects of the VR App, and 80% reported that the virtual scene and patient were consistent with real-world experiences. This was particularly heartening, given that the students were already practicing nurses, so had real-world experiences for comparison. A summary of quantitative results is provided in Figure 1.

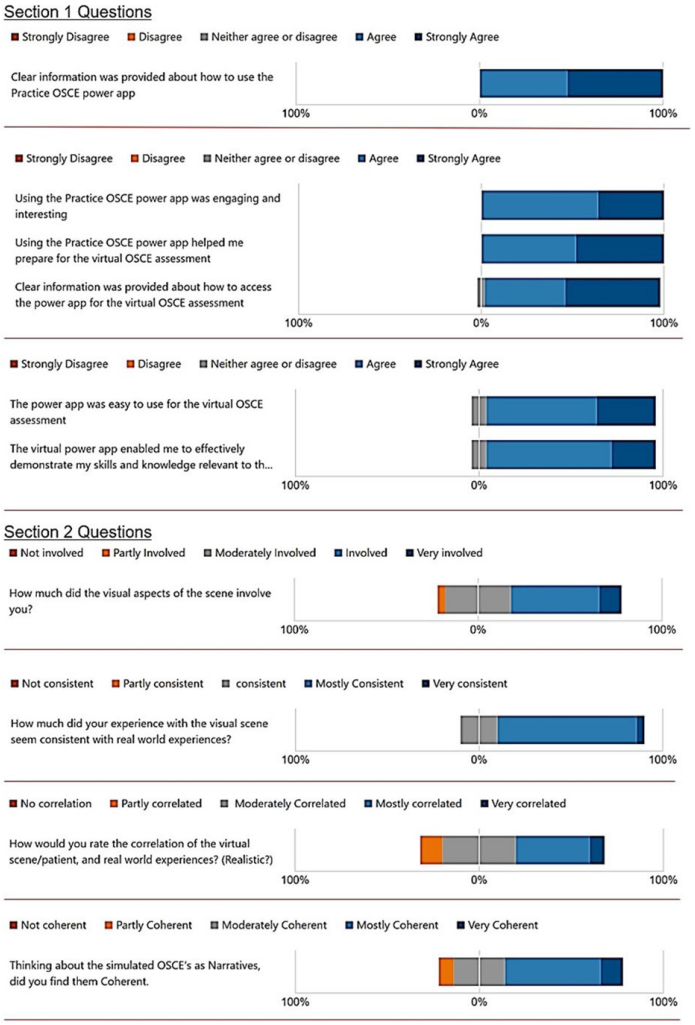

Figure 1: Student experience of the VR App - quantitative responses.

Of the three examiners involved, two completed the examiner version of the survey. These yielded favourable agree/strongly agree responses in relation to the questions posed. The examiner version of the survey can be seen in Appendix B.

A comparison of statistics for student results for the OSCEs was made for the 2018 iteration, when these had been completed face-to-face, the 2020 iteration (the first online OSCEs), and the 2022 iteration, where the OSCEs had been completed using the VR App. Despite variation in number of students in each cohort and the different processes for the OSCEs, it is interesting to note that the number of students (calculated as a percentage of the respective cohorts) is similar across most of the different grades for all iterations, although slightly higher for the 2022 iteration. Details of statistics of the number of students and percentage of the cohort for each grade band and median mark are provided in Table 1.

Table 1. Comparison of OSCE results across iterations.

Results / Year	2018 (n=296)	2020 (n=375)	2022 (n=104)
Grade	**No. of students (%)**	**No. of students (%)**	**No. of students (%)**
Fails (<50%)	11 (3.72)	7 (1.86)	3 (2.88)
Pass (50% - 64.5%)	64 (21.62)	82 (21.87)	11 (10.57)
Credit (65% - 74.5%)	59 (19.93)	82 (21.87)	28 (26.93)
Distinction (75% - 84.5%)	92 (31.09)	116 (30.93)	34 (32.69)
High Distinction (85 - 100%)	67 (22.64)	88 (23.47)	28 (26.93)
Median	**53.5 / 70 (76.42%)**	**52 / 70 (74.28%)**	**54 / 70 (77.14%)**

Qualitative data

The qualitative feedback produced some interesting insights, although no formal qualitative analysis, such as content or thematic analysis, was used. This qualitative feedback was also positive, with one student summing up the experience.

> The Practice OSCE Power App was very interesting to use and was very engaging. It can be used at any time for practice, which I had done several times before the OSCE assessment. I feel like I'm communicating with a real patient when I practise. I feel confident in the virtual OSCE assessment. During the class, I got a clear explanation of how to access the… App for the virtual OSCE assessment (S14).

Of particular interest to the research team was the student feedback on the ease of use, level of realism and interactivity. Students commented that they found the interactive virtual patient application (VR App) easy to navigate and use for their OSCE:

> The app is very engaging, interesting and user-friendly. it helped me effectively prepare for the assessment and, overall, was very useful and effective for the students (S25).

> It is smooth throughout the whole process despite accessing at a different time zone. I took my OCSE while I was in London and the examiner in Singapore (S12).

Students also felt it was realistic and liked the visuals and level of interactivity:

> It was interesting and exciting having the visuals (S23).

> I am able to draw on the avatar (the patient). I feel like talking to real patients (S14).

> I'm impressed that I could actually see the abdominal, chest area, face etc., clearly. It really helps me to visualise the actual sites properly for physical assessment (S19)

> The scene is like a ward setting, and the patient is quite realistic for a virtual model (S3).

There were some suggestions for development to add to the realism, such as the addition of vocal patient responses, sound effects (e.g., heart sounds or bowel sounds), or visual effects.

> The patient looks realistic. However, if the scenario patient has bruises, they should be included on the patient (S8).

Of the students who completed the survey, most reported that they used laptop computers, and used the recommended browser (Google Chrome) to access their exam, although the convenor noted throughout the week of OSCEs that many students successfully used tablets and mobile phones, and some used other browsers. While some students needed support with technical issues such as camera and microphone settings and controls for sharing their screen, these were able to be successfully resolved with the convenor in the 'OSCE waiting room', validating the usefulness of the waiting room concept. There were no reported technical difficulties with the VR App for the OSCEs, and all 104 students were able to complete all sections of the OSCE via the application. One student reported that the application loaded slowly on their device, but they were able to complete all sections of the exam within the allocated time.

Feedback from the examiners was also very positive and encouraging:

> The app was easy to use, and the content page was easy to follow (Examiner 1).

> I thought the face of the patient for the neurology assessment could be improved: The instruction guide was easy to follow. I think this is a very good app at the University level internationally (Examiner 2).

A summary of the project and results was reported on a poster presented at the 2022 NETNEP 8th International Nurse Education Conference (Grafton et al., 2022).

Data from the Student Evaluation of Course (SEC) survey

In higher education, student evaluation surveys have become commonplace. Despite inconsistencies in how the data are used, the aim of such surveys is one of quality assurance, to improve teaching and the student learning experience (Borch et al., 2020). The student evaluation of the course (SEC) for the 2022 iteration of the CHA course yielded responses from 35 of 104 students (33.7%). Students rated the course highly overall, with scores of 4.5 – 4.6 on a 5-point Likert scale. A question on the use of online technologies was included in the SEC survey and yielded a mean score of 4.5 on a 5-point Likert scale, with 75% of students agreeing or strongly agreeing that the online technologies provide access and resources for effective learning.

In qualitative comments in the SEC, some students commented specifically about the interactive virtual patient application (VR App):

> The team… is showing their effort, innovation and creativity to support the course throughout the pandemic period. The creation of the app for CHA is proof.
>
> I found that they catered well for the OSCEs with the help of the app developed.

Learnings from the research team

An unexpected outcome of the interdisciplinary team approach was the learning that occurred for individual team members. Literature on interdisciplinary research teams identifies that where team members clarify communications, are open to different perspectives, and provide opportunities for individual reflection, real learning can occur, and the potential of the project is likely to be maximised (Leigh & Brown, 2021). From a nursing perspective, the experience brought greater knowledge and skills with technologies, and greater confidence in using such technologies to create interactive, engaging online experiences for students. Non-nursing team members reported an increased understanding of nurse education needs and that this led to more innovative creativity and experimentation with how technologies and graphic design programs may be used and adapted for purposes outside their own discipline. A hallmark of this project was the cohesiveness of the research team, characterised by an unwavering commitment to the project, clear and regular communications, and mutual respect and openness to learn something new. Democratic leadership, openness to embracing new knowledge and skills from different disciplines, and respectful equity within the interdisciplinary team are identified as key elements for collaborative co-learning and creativity and make the most of individual members' strengths for the benefit of the project (Lorenzetti et al., 2022).

Discussion

Although the student response rate for the interactive virtual patient application (VR App) user experience survey was relatively low, with only 24% of students returning the survey, the feedback demonstrates that the application did provide the desired effective, realistic and interactive online user experience as well as direction for possible future development. The results presented in this paper also demonstrate that the application developed for this course did provide an effective means of completing OSCEs for the students, thus enabling all students to complete all assessment requirements and meet the learning outcomes of the course. Several aspects of assessment quality were of interest to the convenor and Program Director (Singapore), including the validity of the online version as an assessment item and the comparison of student OSCE results across this iteration and previous iterations. Literature reports that an OSCE provides an accurate, reliable form of assessment of nurses' clinical skills competence (Chen et al., 2021). In the 2020 iteration of the CHA course, the OSCE had been completed online for the first time for this course. At that time, the process, rigour and validity of the online OSCE format were reviewed and approved by the School of Nursing of the Australian university and the Singapore Nursing Board accrediting the course in Singapore and reported by Grafton et al. (2021). It was determined that the online format did provide a valid and effective alternative to face-to-face OSCEs and did effectively assess the relevant course learning outcomes. For the 2022 iteration of the course, the learning outcomes, scenarios, marking criteria and online process remained essentially the same; thus, the validity was considered established. The essential difference was the development and use of the interactive virtual patient application (VR App) for OSCE assessment with the aim of providing a more realistic interactive user experience in the online environment. From the results reported, this aim was achieved.

In terms of student marks and grades for the OSCEs, it is noted that there is a higher percentage of students in the credit grade and a slightly higher percentage of students in the distinction and high distinction grades for the 2022 iteration compared to the previous iterations. This may be due to the smaller student cohort in the 2022 cohort than in previous iterations, allowing for more contact with the convenor and promoting greater engagement (Karas, 2019). It may also be a testament to the quality of the VR App and the support provided for students, in terms of detailed instruction for use and opportunity to practice, which are reported to develop familiarity with the technology and reduce anxiety (Choi et al., 2022; Lee & Xiong, 2022).

As the pandemic continues its impact, and bio-security restrictions continue to ebb and flow in response to risk, it could be argued that the pandemic has provided a catalyst for the rapid development, expansion and innovative use of education technologies (Khamis et al., 2021; Manakatt et al., 2021; Miller & Guest, 2021). For the Clinical Health Assessment course, the ongoing suspension of all face-to-face teaching and assessment provided an ideal opportunity to explore and evaluate virtual reality technologies and integrate knowledge and skills from different disciplines in order to provide a more realistic online user experience than the previous experience. In an uncertain world, educators need to be prepared to deliver courses online (Matthias et al., 2019) and be prepared to adopt immersive and interactive technologies to enhance learner experience (Cho et al.,

2022). The creative and innovative use of technologies such as the VR App reported in this paper can facilitate realistic and interactive learning and assessment when face-to-face classes are not possible.

Limitations

The main limitations of this project were the relatively small number of students who responded to the user experience survey, having only one site and one method of data collection. It is recognised, however, that participation was voluntary, and as full-time working registered nurses (RNs), time and focus were likely prioritised to completion of their studies amid work and family commitments in the midst of the ongoing COVID-19 pandemic.

Conclusion and recommendations

From the results of this study, it is concluded that the interactive virtual patient application (VR App) developed and implemented via Microsoft Teams in the Clinical Health Assessment course provided an effective, realistic and interactive user experience for online Objective Structured Clinical Examinations (OSCEs). While shown to be valuable when face-to-face classes and clinical assessments are not possible, there is potential for the use of such applications to provide a valuable platform for learning and practice of clinical skills, not only in nursing but also in fields such as medicine. This is consistent with other studies that report the use of virtual, augmented and mixed-reality applications as an effective means for supporting learning and clinical skills practice (Schmitz et al., 2021; Zhao et al., 2020). Thus, this paper adds to the growing body of research on the effectiveness and practical use of virtual, augmented and mixed-reality technologies in health education. Drawing on student feedback in this study, further development to incorporate more advanced interactivity, such as vocal responses and movement of the virtual patients, is currently being explored.

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Appendices

Appendix A: 2201NRS CHA: Power apps and OSCES – student experience online survey.

Section 1: The following questions relate to your experience using the power app to facilitate practice and completion of your A2 OSCE assessment.

Question	Strongly disagree	Agree	Partly	Disagree	Strongly Disagree
1.Clear information was provided about how to use the Practice OSCE power app					
Comment:					
2.Using the Practice OSCE power app was engaging and interesting					
3.Using the Practice OSCE power app helped me prepare for the virtual OSCE assessment					
4.Clear information was provided about how to access and use the power app for the virtual OSCE assessment					
Comment:					
5.The power app was easy to use for the virtual OSCE assessment					
6.The virtual power app enabled me to effectively demonstrate my skills and knowledge relevant to the scenario					
7.On what electronic device did you access and complete your OSCE? (e.g., smart phone, table, laptop).					
8.Please identify the browser you used to access the power app:					
9.Please comment on your experience of navigating and using the app on your device:					

Section 2: The following questions relate to the experience of Power app virtual reality compared to real life experience:

10.How much did the visual aspects of the scene involve you?	Not involved	Partly Involved	Moderately Involved	Involved	Very involved
11.Can you comment on aspects of the scene or patient that you may have been visually attracted to or found visually deterring?					
12.How much did your experience with the visual scene seem consistent with real world experiences?	Not consistent	Partly Consistent	Moderately Consistent	Consistent	Very consistent
13.How would you rate the correlation of the virtual scene/patient, and real world experiences? (Realistic?)	No correlation	Partly correlated	Correlated	Mostly correlated	Very correlated
14.Thinking about the simulated OSCE's as Narratives, did you find them Coherent.	Not coherent	Partly Coherent	Moderately Coherent	Mostly Coherent	Very Coherent
15.Please comment on the overall narrative (involving both text and images) in regard to your level of engagement and comprehension?					
16.Please comment on any perceived inconsistencies in the narrative and what aspects you may have found more or less engaging?					

Appendix B: 2201NRS CHA: Power apps and OSCES – examiner experience online survey.

Section 1: The following questions relate to your experience using the power app to facilitate assessment of students.

Question	Strongly disagree	Agree	Partly	Disagree	Strongly Disagree
1. Clear information was provided about how to access and use the power app for the virtual OSCE assessment					
Comment:					
2. The power app was easy to use for the virtual OSCE assessment					
3. The virtual power app enabled me to effectively assess student my skills and knowledge relevant to the scenario					
4. On what electronic device did you access and complete the OSCE assessments? (e.g., smart phone, table, laptop).					
5. Please identify the browser you used to access the power app:					
6. Please comment on your experience of navigating and using the app on your device:					

The following questions relate to the experience of Power app virtual reality compared to real life experience:

7. How much did the visual aspects of the scene involve you?	Not involved	Partly Involved	Moderately Involved	Involved	Very involved
8. Can you comment on aspects of the scene or patient that you may have been visually attracted to or found visually deterring?					
9. How much did your experience with the visual scene seem consistent with real world experiences?	Not consistent	Partly Consistent	Moderately Consistent	Consistent	Very consistent
10. How would you rate the correlation of the virtual scene/patient, and real world experiences? (Realistic?)	No correlation	Partly correlated	Correlated	Mostly correlated	Very correlated
11. Thinking about the simulated OSCE's as Narratives, did you find them Coherent.	Not coherent	Partly Coherent	Moderately Coherent	Mostly Coherent	Very Coherent
12. Please comment on the overall narrative (involving both text and images) in regard to your level of engagement and comprehension?					
13. Please comment on any perceived inconsistencies in the narrative and what aspects you may have found more or less engaging?					