Development of A “PharmaComm” Serious Game for Teaching Pharmacist Communication and Drug Administration in a Virtual Hospital Setting

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***Abstract* — Practical experience is crucial in pharmacy education, but it can be difficult to provide pharmacy students with a sufficient level of experience during their education due to a number of challenges. Video games might provide a platform where students can gain positive learning experience in a virtual environment. Serious games have been used successfully across many industries, which suggest that a well-designed serious game can have positive learning outcomes. Increased engagement and motivation are mentioned by experts as some of the main benefits of serious games. Being able to practise skills before utilising them in real-world scenarios is another advantage identified. In this paper, we present a virtual patient simulator which is designed specifically teaching pharmacy students patient communication and administration of drugs. A pilot study and an expert review were carried out to evaluate the effectiveness of the application and its findings are presented.**

Keywords—virtual patient simulator for pharmacy communication, serious games for pharmacy education, educational games, game-based learning

I. INTRODUCTION

Practical experience is mandatory in pharmacist training. Traditionally, it is delivered through placement visits, but an ethical tension exists as the safety of patients must be ensured. Simulated exercises offer practical experience in an environment safe for patient and practitioner. However, challenges such as cost and specialist knowledge means it can be difficult to implement.

Video games might be able to provide a platform where pharmacy students can practise and enhance the skills they have been taught in the classroom, as well as prepare them for simulated and real-life experiences during their education. Also, video games might increase the engagement of students as games could improve motivation as well as allowing students to practise their skills in a low-pressure setting.

Practical experience is an essential component of pharmacist training, and it is a key area noted by the General Pharmaceutical Council [1]. Traditionally, practical experience has been taught through off-site placement visits, but an ethical tension exists between providing pharmacy students with real-life experiences while ensuring the safety of patients, as mistakes can have profound effects [2].

Simulated learning activities are used to offer students and healthcare professionals to experience risky or stressful scenarios in a safe environment free of risk for both patient and practitioner. The use of simulation mannequins has been utilised as an avenue for these simulated experiences [3], [4].

However, Seybert [5] describes how the use of mannequins can be limited by practicalities such as cost and the requirement for specialist support to operate the technology. Ziv et al. [2] note cost and *“resistance to change”* as challenges to simulated training exercises. Additionally, the reliance on students to physically attend can create organisational and timetabling pressure.

Cain and Piascik [6] mention several advantages in relation to serious games and pharmacy students, including students being able to practise their skills without the risk of endangering the patient, perform collaborative learning, receive immediate feedback and *“potential for behaviour and attitude change”*. They also argue that serious games can result in high motivation and that *“when well done, serious gaming provides a valuable additional tool for pharmacy education.”*

Serious games have been used successfully in a number of industries. Some of the examples include the American military, which has used games for training purposes [7], the serious game “Foldit” which allows users to fold protein to help solve real-life problems [8], the free online game “Darfur is Dying” which raises the user’s awareness of the crisis in Darfur and which has been spread virally [9] as well as “Supercharged!” which is a serious game designed to teach physics to middle school children [10].

It is argued that serious games can improve the engagement of learners. Prensky [11], Batson and Feinberg [12], Gee [13], Virvou et al. [14] and Rieber [15] all agree that motivation is crucial to learning and that games can help motivate learners.

The theory of *"flow"* introduced by Csikszentmihalyi [16] is described as the state when a person is deeply involved in an activity and loses track of time and place. Flow has been described as "*an optimal motivating experience"* [17] and Jones [18] suggests that provided a set of criteria is met, it is possible to achieve flow in educational games. Tang and Hanneghan [19] describe how real-world scenarios can be practised in a virtual environment via educational games. Problems can be presented via a number of tasks in the game which the learner has to solve. This allows the learner to practise the skills before using them in a real-world situation. Gee [13] also argues that there are many benefits to educational games with the most important being that learners are allowed to immerse themselves in the games and thus "*achieve recreation and deep learning at one and the same time."* Koster [20] argues that games can improve learning over books as games can provide the learner with an environment in which they can practise patterns by trying out different approaches and get feedback accordingly. Experts suggest games can be used as educational tools and that they can help increase the motivation and learning of students.

The ability for users to learn from their experiences and mistakes in a safe environment is also an advantage that is attributed to serious games [7], [21]. Previous research indicates that serious games can be used to teach pharmacy education if designed properly.

In this paper, we design and develop a novel serious game, called "PharmaComm", to suppliment the teaching of pharmacist communication and administration of drugs. The remainder of the paper is structured as follows. In Section II, we present the literature review of related work. Section III then describes the requirements for "PharmaComm" serious game. Section IV reports the development of "PharmaComm". Section V outlines an experiment conducted to evaluate the effectiveness of the serious game and the findings are presented in Section VI. A short discussion is presented in Section VII and finally, the conclusions and future work are presented in Section VIII.

II. RELATED PROJECTS

Ribaupierre et al., [22] list a number of healthcare topics where serious games have been used for training. The topics include *"neonatal care, cardiovascular drugs, abnormal blood clot formation, physiology, microbiology, cancer genetics, psychosocial aspects in paediatric or geriatric calls, clinical practice guidelines, how to maintain a medical practice, starting an insulin treatment for diabetic patients, treatment of stroke"*. The amount of healthcare topics which have already seen serious games used for training indicate that serious games in healthcare is a growing industry and that there is a market for more serious games to be developed.

One example of a serious game used to train healthcare students is 'Virtual Patient*'*, which has been developed at Keele University [23]. It is a free web-based game which allows pharmacy students to practise their interaction with customers in a virtual pharmacy environment. The student can choose between a number of questions which the virtual patient replies to. The student's performance is measured on the relevance of their questions and a score is given when the virtual patient's query has been resolved. The way in which Keele University has visualised the conversation and the features, allowing the user to communicate with the virtual patient, will be considered in the design of this project.

The Pharmacology Digital Clinical Experience is a serious game developed by Shadow Health [24]. It is based in a 3D hospital setting where pharmacy students can practise patient interaction, administration of drugs and more through various scenarios. The game has similarities to the game proposed in this project. The visualisation of interaction, the administration of drugs and checking if drug dosages are correct can all be used for inspiration.

Nurse Training: Trauma Unit [25] is another serious game which has similarities to this project. In the game, nursing students can practise their knowledge in trauma scenarios in a 3D hospital environment. The user can perform several types of actions such as patient interaction, patient assessment and checking of tests, through a menu bar on the user interface. The user interface from this serious game will be taken into consideration when designing the user interface in this project.

Additionally, the game-mechanics in virtual pet games such as Nintendo's Nintendog series [26] and the popular Tamagotchis [27] were also be used for inspiration for this project. In the games mentioned, the player is interacting with pets by feeding them, putting them to sleep, playing with them, etc., and the virtual pets react accordingly. Similar game-mechanics can be used in this project as a virtual patient can react according to the player's input, for example, an inappropriate medication dose resulting in the patient's heart rate increasing.

III. REQUIREMENTS FOR "PHARMACOMM" SERIOUS GAME

The requirements for "PharmaComm" were gathered through discussions with colleagues from the School of Pharmacy and Biomolecular Science (LJMU). In addition, an observation of a 'Simulation Day' for pharmacy students at Aintree Hospital Training and Development Centre has provided details on methods currently used to teach patient interaction and drug administration through simulated exercises, which helped in defining the requirements for "PharmaComm".

The proposed "PharmaComm" serious game will allow pharmacy students to practise their skills and knowledge with a virtual patient in a hospital environment. The scenario will begin with a virtual patient that has just been admitted to the hospital and it is the responsibility of the user, who takes the role of a pharmacist, to take the correct actions in administering drugs and drug dosages. The user will get their information from interacting with the virtual patient by presenting them with various options of questions to which the virtual patient responds accordingly. Patient vital signs (heart rate, blood pressure and oxygen saturation), patient personal details, admission details, current prescribed medicines and patient background story, will also be available to the user for them to base their actions on. When the user takes an action, the virtual patient will react accordingly (for example drop/increase in heart rate). At the end of the scenario the user will be presented with feedback on their actions.

IV. Development of PharmaComm Serious Game

The prototype for the proposed serious game was developed in Adobe Animate (formally known as Adobe Flash) which is supported on nearly all desktop computers and its functionality was deemed appropriate for this project.

Game objects were identified for the implementation of the requirements. The identified game objects includes *vital signs* (Heart rate, Blood pressure; two objects – systolic and diastolic, Oxygen), *admission form* (an object for each piece of patient admission information), *medication chart* (arrays which store information for each type of medicine; medicine name, medicine dose {morning, midday, teatime, bedtime}, course length, route, indication, special instructions, pharmacist signature), *notes* (date and text), *patient interaction* (information gathered – a list of dialogue), and *timer* (a timer to set variation in vital signs).

These game objects are manipulated when the user updates the medications (medication is added, removed or current dose is edited), interacts with the virtual patient or decides to stop the scenario. When a medication is updated, the current dose for each medication is updated and it is checked to see if it is at an overdose level. If it is not at an overdose level, the vital signs are updated. If any medication is at an overdose level, in-game feedback is provided. When the user interacts with the virtual patient, the information is gathered and stored. Finally, feedback of the game session gathers all the data from the game objects to provide a summative feedback to the user's actions during the game.

The logic of the game mechanics are displayed in a flowchart in Fig. 1.

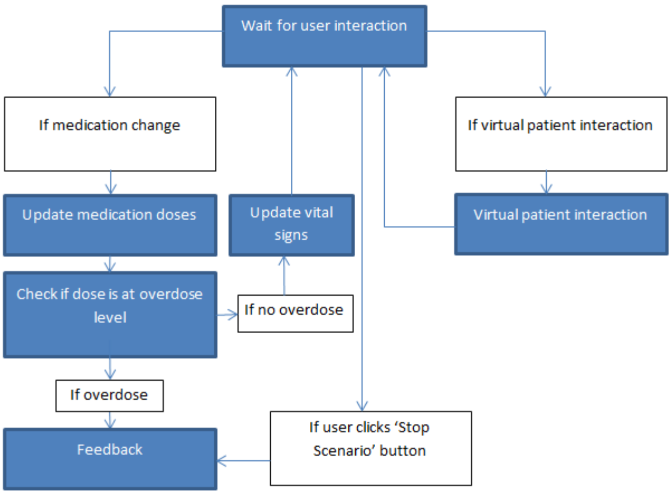

Fig. 1. Game Mechanics Flowchart

When the user runs the application they are presented with a screen asking them to enter their name. They are then given information on the scenario and instructions on how to use the application. At the user starts the scenario they are presented with a virtual patient lying in a hospital bed. Vital signs are displayed on a vital signs monitor and the user can interact with the patient by choosing between pre-defined questions. The decisions of the user in the patient interaction are recorded by storing the user's actions in an array.

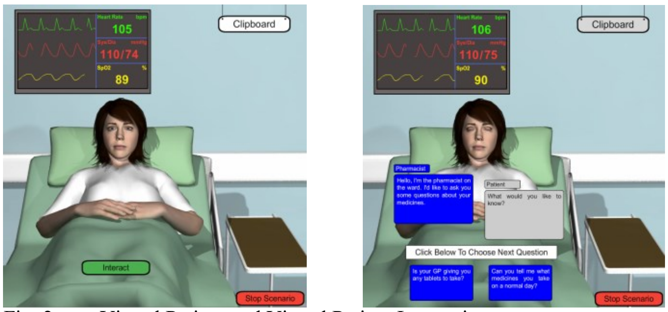

Fig. 2. Virtual Patient and Virtual Patient Interaction

The user can navigate to a clipboard menu to access an admission form, a medication chart as well as notes functionality. The admission form allows users to access admission information, while the medication chart lets them see medicines currently prescribed to the virtual patient. It also enables users to make amendments to the prescriptions. The notes functionality allows users to create notes and view previously created notes.

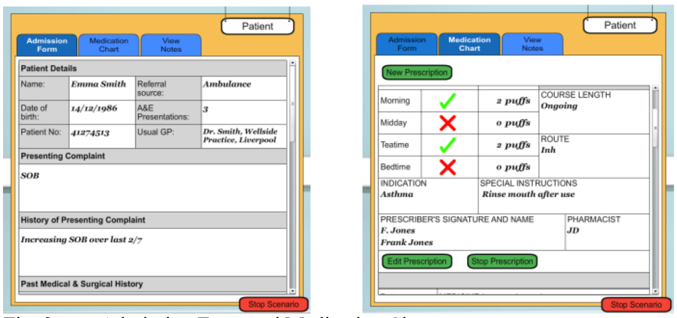

Fig. 3. Admission Form and Medication Chart

Once the user decides to end the scenario, a feedback screen is shown as displayed in Fig. 4. The feedback is given on the user's actions during the patient interaction, as well as their decisions on the prescribed medicines.

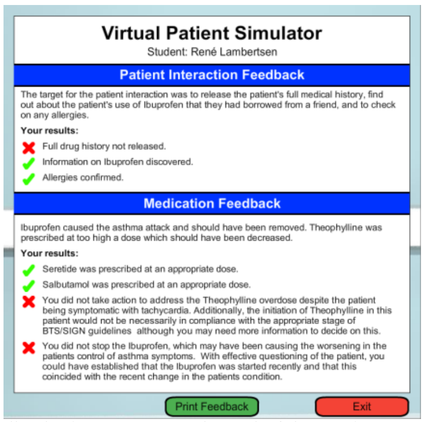

Fig. 4. Feedback given to user at the end of the session

Data such as initial vital signs values, admission form data, medicines, medicines reactions, initial prescriptions, patient interaction and feedback information, are all loaded from an XML file at the beginning of the scenario. This allows for different scenarios to be created without making changes to the game mechanics, making the application more flexible as well as making it more efficient to create new scenarios. Attributes are assigned with patient interaction tags in the XML file which makes it possible to check if certain questions have been asked by the user. When the feedback screen is loaded, the questions asked and the prescribed medicines in the scenario are checked to generate appropriate feedback.

V. Experiment and Expert Review

A. Experiment

The experiment carried out consisted of two parts: an experiment where participants used the application, and a focus group where participants discussed their experience.

1) Experiment Design

The primary objective of the experiment was to learn if the application could be used as a learning tool in pharmacy education at university level. An experiment was conducted where participants use the application and their behaviour were observed by researcher and a domain expert who was later interviewed to provide a comparison on current teaching methods. The domain expert also provided the participants with advice on domain specific questions when required during the course of the experiment.

A focus group was run after the experiment to obtain feedback on the participants' experience. Questions were asked in a neutral manner to avoid influencing the participants, and it was attempted to keep the discussion open and friendly to make participants feel at ease. The domain expert was not present during the focus group as his presence might have influenced the comments of the participants.

2) Participants

The participants recruited were Level 6 students, age 20-25 years old, studying a pharmaceutical course as they were required to have knowledge on the prescription of medicines volunteering to take part in the study. The recruitment of the participants was carried out by the colleagues from the School of Pharmacy and Biomolecular Sciences who teaches on the pharmacy programme.

3) Experiment Setup

Before the experiment began, participants were given a brief introduction to the project and the aim of the experiment. Participants were then asked to use the application for around 30 minutes exploring all of its features. They were observed throughout the experiment and observations were recorded through note taking using an observation chart.

4) Focus Group Setup

Focus group took place right after the experiment. Participants were organised to sit in a circle. The aim of the focus group was described and guidelines were given. Researcher then asked questions to guide the discussion and follow-up questions were used to gain further information from participants when required. The main questions were:

i. Was there anything you particularly liked about the application?
ii. Was there anything you particularly disliked/found frustrating about the application?
iii. How did you find using a video game as a learning tool?
iv. How would an application like this impact your motivation to learn?
v. How challenging did you find making appropriate decisions when interacting with the virtual patient and prescribing medicines?
vi. How would you feel about using a video game such as this one as part of your learning experience at university?
vii. How would you feel about using an application such as this one to cooperate with students from other courses such as nurses and medics?
viii. Can you think of ways in which the application could be improved?

B. Expert Review

An expert review was also carried out to gather an insight into how pharmacy education is currently taught at LJMU and how a domain expert sees the merit of using a video game application as a learning tool.

One of the main benefits mentioned by the domain expert is the fact that the application allows students to practise the skills they have been taught in the classroom. It is common for students to lack confidence when asked to demonstrate their skills in simulated exercises and in the classroom. However, it is believed that the serious game proposed in this project would allow students to build confidence as they can practise their skills in a low-pressure environment. As the application could be deployed onto portable devices, students being able to practise at times that are suitable to them was also mentioned as a potential advantage. This could also increase the engagement of students.

Although the application could be valuable and educational to the students, it is not considered that it could replace any of the current teaching methods. The face-to-face experiences are incredibly valuable and it would not be possible to replace those experiences with a video game application. That being said, it is believed that an application such as the one developed for this project potentially has a place in the future teaching of pharmacy education as a valuable supplementary tool to current methods.

VI. Findings and Analysis

In the pilot study, six pharmacy students took part in the experiment and focus group. It was observed that four of the six participants were interacting with other participants, discussing their experiences and helping each other. It is likely that the collaborative learning elicited was more apparent for participant 3 and 4 as they knew each other previously and therefore felt comfortable asking each other for advice. Not being familiar with the person sitting next to them might also be the reason for participant 1 and 2 not engaging with each other and for participant 5 and 6 only doing it to a limited degree. It could also be a result of some students preferring to explore the application on their own and some students preferring to share their experience.

No frustration was observed during the experiment. This might be because it is difficult to see if a person is frustrated if they do no indicate this clearly or it could be due to participants not feeling particularly frustrated during the experiment. Enjoyment is difficult to observe too, as participants could be enjoying the experience without showing it outwardly. The enjoyment recorded was when participants were laughing, which occurred towards the end of the experiment when they tried to make the 'wrong decisions' in the application such as administering an overdose to the patient. It is believed that the comments in the focus group will provide a better measure of the frustration and enjoyment of using the application than the observation.

The participants were highly engaged in the experiment with every participant looking focused throughout. Several factors might play a part in this. It might be due to participants being presented to something new, which is likely to generate an interest. It could also be a result of them wanting to do their best in helping to test the application and therefore being more engaged than they normally would. It is possible that they found the application to be interesting and were naturally engaged as well. It is considered likely that the high engagement is a mix of the different reasons mentioned. Indications to the reason for the high engagement of the participants are likely to be given in the focus group too.

All of the participants used other sources to make decisions in the scenario presented to them. A BNF (British National Formulary – an academic handbook which gives information and advice on prescribing and pharmacology) was consulted by every participant and all participants consulted the domain expert for advice as well. Blended learning was noted when participants asked the domain expert for advice. Here, the role of the lecturer was changed from a leading role in the learning of the students, to a supportive role in the game-based learning environment. The engagement of the students showed in their use of other sources to make decisions on their actions in the application. Collecting information from different sources before making a decision can facilitate deep learning as it indicates high levels of engagement in a task.

In the focus group, the behaviours observed during the experiment were confirmed through the feedbacks from the participants. All of the participants liked the fact that they were able to get instant feedback on their actions through the vital signs, that the animation made the application look realistic, the nature of the communication was realistic, and the medication chart was clear and looked realistic.

A comment that was reiterated by the participants was the fact that they could practise their skills without being afraid of making mistakes. Normally, they would be nervous when practising in a simulated environment, but practising in a virtual environment meant that they could practise their skills without being nervous and prepare themselves for doing it in the simulated environment. The application was described as a *"computerised version of the simulation"* by one participant. The participants suggested that they were happy to try things in the application and to make a mistake, whereas in the classroom or on simulation days they would avoid answering questions if they were not certain they were correct. It was commented that by being able to practise their skills in a stress free way, they would be able to build up their confidence. The application offers an environment in which students can practise their skills, which prepares them and builds up their confidence for current teaching methods such as simulated scenarios.

The fact that the application provides a stress free way of learning was part of the reason why participants felt that the application would have a positive impact on their motivation to learn. It was also commented that the participants enjoyed using the application, and that they were more likely to use it at home rather than reading a book as it was more enjoyable. The participants agreed that it was fun to use the application with one participant commenting that they really enjoyed it and if it was possible, they would use it on the bus. Several participants suggested that although the application was educational, it did not feel like they were learning while using the application, although that was actually the case. One participant commented how they had been excited to use their BNF to look up the medicines and their effects, and then tried to make changes to the prescriptions in the application to see how they influenced the vital signs. This is evidence that the application does play a role in motivating students to engage in deep learning and it can create a fun learning environment.

Overall, the participants responded positively to the use of PharmaComm as part of learning at university. They also commented that they felt it would be helpful to interact with other healthcare professions in PharmComm. It was commented that the application helped the participants put their learning into practise, and has helped them remember things they would not normally remember when being taught in class. The participants felt it would be useful to use the tool in collaboration with other health care professions as they were often unsure of what the job tasks of other professions are. It was suggested that it would be helpful to gain more practical experience with other health care professions as they are likely to work with them closely in their future careers.

VII. DISCUSSIONS

This project suggests that a serious game can be used to teach pharmacy education. In the pilot study, students were highly engaged while using the application and commented that they felt the application would help them practise and improve their skills before using them in real life situations. This supports the consensus of experts who argue that students can use games to practise for real-life events. The fact that students can practise their skills in a safe environment without fear of making mistakes was also highlighted by the participants in the focus group. This indicates that the tool would offer an environment where students can build up their confidence for real-life experiences in a manner which is currently not available. The domain expert also felt it would be a useful tool and commented that he saw a place for it in the future of pharmacy education as a supplementary tool to current methods, where it can be used to prepare students for face-to-face experiences in a low-pressure environment.

The experiment and focus group carried out also suggest that it is possible to make it fun to learn about pharmacy. Participants did state that the interactive experience offered by the application is more enjoyable and fun than reading a book. This suggests that it is possible to make it fun to learn about pharmacy through the use of game-based learning.

The participants were highly engaged while using the application and discussed how they felt motivated to learn while using it. Several participants described how they did not feel they were learning while using the application although this was in fact the case. This might suggest that they were experiencing *flow* and their comments in the focus group do indicate a deep engagement in the learning process, which suggests that playing games for entertainment can be turned into learning and thereby make it productive to play games.

VIII. CONCLUSION AND FUTURE WORKS

Our proposed PharmaComm serious game is showing great promises on the positive impact it can bring about to pharmacy education. In its current state, the application is only relevant to pharmacy students. Furthering this project, the aim is to expand the scope to include online multi-user functionality with different versions that relate to specific professions would facilitate students practising their interprofessional skills. For example, one version of the application could allow pharmacists to perform their job tasks, another version could allow nurses to perform tasks relevant to their job role, and the same for other professions. A virtual patient could then be given to a group of students from different professions who can perform different tasks. This would enhance their skills in collaborating across professions as well as improve their understanding of tasks of other job roles than their own.

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