Designing Interactive Clinical Avatars for Pre-Registration Pharmacist Training

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Abstract

Background: Virtual patients are interactive computer-based simulations which are increasingly used in modern healthcare education. They have been identified as tools that can provide experiential learning and assessment in a standardised and safe environment. However, the study of high fidelity virtual patients, such as interactive clinical avatars, within pharmacy is limited.

Objective: The aim of this study was to design and test three interactive clinical avatar (ICA) case studies as part of validating the data collection questionnaire.

Methods: A multistep design approach was taken to create three interactive clinical avatar simulations on the topics of: (1) emergency hormonal contraception (EHC), (2) calculation of renal function and (3) childhood illnesses. All case studies were reviewed by registered pharmacists to establish internal content validity. The EHC case study and data collection questionnaire were also reviewed by a purposive sample of pre-registration trainees and newly-qualified pharmacists. The questionnaire utilised Likert ranking statements and open-ended questions to obtain users' feedback on the design, usability and usefulness of the ICAs as learning tools. Descriptive statistics and content analysis were undertaken on the data.

Results: Ten participants reviewed the EHC ICA and data collection questionnaire. The data collection questionnaire was associated with a high Cronbach's ? score (0.95), demonstrating good reliability. All three ICA simulations were reported as usable and appropriately designed for pre-registration training. Users perceived they were developing skills and knowledge from the simulations. The high-fidelity nature of the avatars and the relevance of the simulations to real-life practice were reported as aspects that encouraged the application of theory to practice. Improvements were suggested to ensure the simulations were user-friendly for the main study.

Conclusions: The design and creation of the three interactive clinical avatar simulations was successful. The multistep review process ensured validity and reliability of the simulations and data collection questionnaire. The in-depth explanation of the design process and the provision of a validated questionnaire may help widen the usage and evaluation of ICAs or other simulation tools. The ICAs were reported as novel learning tools which promoted experiential learning and allowed users to feel like they were engaging in real-life scenarios, thus developing transferable knowledge and skills. This may be potentially beneficial for many healthcare training courses as a way to provide standardised experiences which promote active learning and reflection.

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Abstract

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Objectives: The aim of this paper is to describe the design and review of three interactive clinical avatar (ICA) simulations as part of pharmacist pre-registration training.
Methods: A multistep design approach was taken to create three interactive clinical avatar simulations on the topics of: (1) emergency hormonal contraception (EHC), (2) calculation of renal function and (3) childhood illnesses. All case studies were reviewed by registered pharmacists to establish content and face validity. The EHC case study and data collection questionnaire were also reviewed by a purposive sample of pre-registration trainees and newly-qualified pharmacists. The

questionnaire utilised Likert ranking statements and open-ended questions to obtain users' feedback on the design, usability and usefulness of the ICAs as learning tools. Descriptive statistics and content analysis were undertaken on the data.
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Conclusions: The design and creation of the three interactive clinical avatar simulations was successful. The multistep review process ensured validity and reliability of the simulations and data collection questionnaire. The in-depth explanation of the design process and the provision of a questionnaire may help widen the usage and evaluation of ICAs, or other simulation tools, in pharmacy education. The ICAs were reported as novel learning tools which promoted experiential learning and allowed users to feel like they were engaging in real-life scenarios, thus developing transferable knowledge and skills. This may be potentially beneficial for many healthcare training courses as a way to provide standardised experiences which promote active learning and reflection.

Keywords

virtual patient; high fidelity simulation training; patient simulation; pharmacy education; pharmacy practice education; virtual reality

Introduction

Virtual Patients (VPs) are defined as "*a specific type of computer based program that simulates real-life clinical scenarios; [in which] learners emulate the roles of health care providers to obtain a history, conduct a physical exam, and make diagnostic and therapeutic decisions*" [1]. 'Virtual Patients' is an umbrella term that includes various computer-based tools, such as: still photos, video clips, avatars and immersive virtual reality simulations. The key element for a tool to be described as a VP, is that the simulation outcome must be dependent upon user input; their prime differentiation from other e-learning tools [2].

Interactive clinical avatars (ICAs) are classified as a high fidelity form of VP [3]. The avatar is a computer-generated, 3D animation which represents a patient or healthcare professional. Avatars can be either 'asynchronous', that is they can be accessed anytime and provide responses without the requirement for a tutor online, or 'synchronous' which are active in real-time and require input from multiple users or educators [4,5].

ICAs in pharmacy education and training have been evaluated less frequently than in other healthcare professions or other forms of VPs [2,6,7]. This may be as a result of potential barriers associated with their production and use including IT skills, cost and time constraints [6,8,9]. Evaluations of asynchronous avatars in pharmacy education have demonstrated significant positive outcomes in the development of students' knowledge, skills and confidence to interact with real patients [10-15]. The majority of this research has utilised self-reporting scales based on individual perceptions to evaluate outcomes. The drawbacks of such scales is their inherent subjectivity; only individuals' perceptions can be reported, with the appropriateness of statistical analysis to determine significance greatly debated in the literature [16,17].

Pharmacy pre-registration training in the United Kingdom is a workplace-based training year that is predominantly carried out in a community or hospital pharmacy. Within the pre-registration training year, there is a set of performance standards which trainees need to demonstrate their competence against in order to sit the pre-registration examination and become registered as a pharmacist. The experiences of pre-registration trainees can vary considerably and are dependent on multiple factors, such as sector of training, training site, tutor support and individual initiatives [18,19]. Notable differences in the quality of pre-registration training have established a disparity in pre-registration examination pass rates between the sectors of training (hospital vs community) [20]. The role of a pharmacist in the United Kingdom is evolving and, as such, training needs to adapt to ensure all individuals are qualifying with appropriate knowledge and skills to provide safe and effective patient care [21].

Simulation has the potential to reduce the variation in pre-registration training by providing standardised experiences, thus ensuring a more controlled development of trainees' competence. Miller's Triangle is the most commonly used model to measure competency development in pharmacist pre-registration training [22]. A benefit of simulation, especially that which is considered as high-fidelity, is the promotion of experiential learning which aids users' progression up Miller's Triangle to the 'shows how' level of competence; which was initially proposed as difficult to reach without real-world experience [23, 24]. Immersive simulations provide a safe environment for individuals to practice specific skills or knowledge without risk of harm to a real patient [25]. Evaluation of their use is essential moving forward with the increasing numbers of pharmacy students entering University, the changing role of a pharmacist and the problems with standardising placements [26]. Experience alone may not be enough for individuals to obtain mastery of clinical skills [27] and simulation-based learning can be instrumental in promoting experiential situated learning and bridging the gap between theory and practice without differences in educational outcomes [28].

There has been only one previous study that has evaluated ICAs in pharmacist pre-registration training [10]. This led to the creation of three ICA case studies covering different competencies within pharmacist pre-registration training for this piece of research. The ICA software utilised has three key parts associated with, and essential to its design: an electronic database containing the avatar's responses, a computer generated graphic and a system to link the two together [29]. The electronic database is classed as the 'brain' of the avatar and is based on a modified Markov Model design [30], which uses a decision tree to map the progress of a case. As a user progresses through a case, the database monitors the path through the decision tree and collates the positive and negative feedback to be given at the end of the simulation [31]. The computer-generated graphic is referred to as the 'body' of the avatar and is the 3-dimensional (3D) character. The 'heart' is the final part of the system which carries information from the 'brain' to the 'body' allowing a real-time, immediate response.

The aim of this paper is to describe the design and review of three interactive clinical avatar (ICA) simulations as part of pharmacist pre-registration training.

Methods

Intervention Development

A multi-step design approach was taken.

Case Design

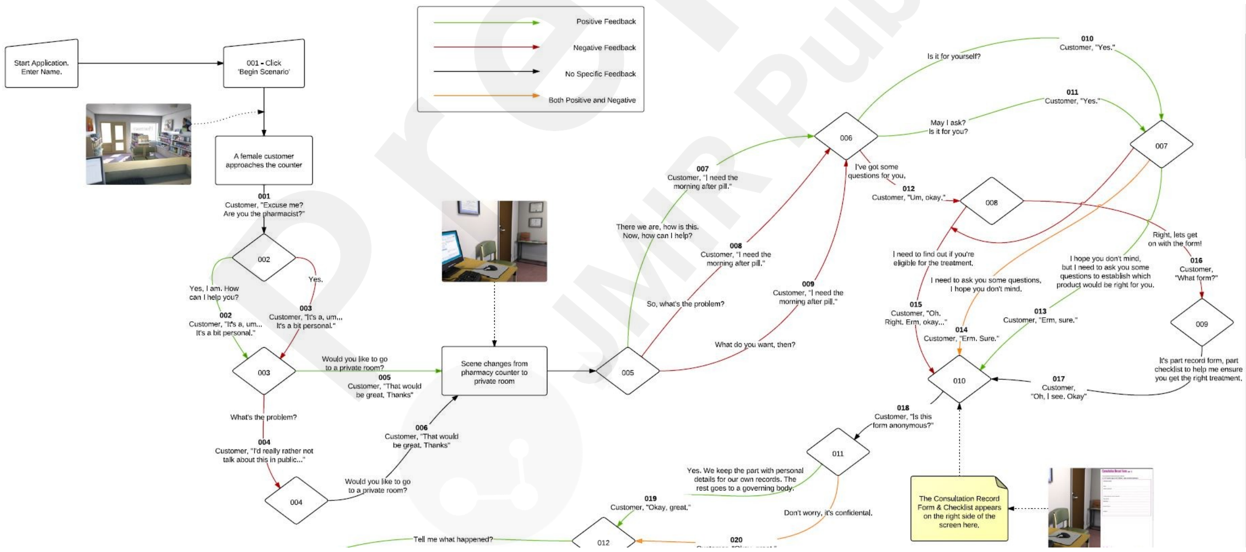
Case studies were designed and created by the research and digital development teams at Keele University School of Pharmacy and Bioengineering from a review of the literature, the pre-registration syllabus and discussions between the lead researcher (JT) and first year qualified pharmacists who had recently completed their training year. Three ICA simulations were created on the topics of: (1) emergency hormonal contraception (EHC), (2) calculation of renal function and (3) childhood illnesses, to develop a range of knowledge and skills essential to pre-registration training and future practice. The areas included those which trainees may find it difficult to show their competence in due to training variations. The clinical elements of the cases were based on appropriate guidelines and resources which pharmacists use in everyday practice.

A simulation on EHC supply was created because trainees who complete their pre-registration training in a hospital may be less likely to see or be actively involved in an EHC consultation than those in the community sector. Individuals training in a community pharmacy are also only able to observe a consultation, thus a simulation was created to provide an opportunity to actively advise on the use of EHC. The calculation of renal function was incorporated into the second simulation because hospital pharmacists calculate patients' renal function and adjust drug doses more often than those working in community pharmacy. It therefore provided these trainees with this calculation experience that they may be missing out on. The childhood illness case study was designed around measles because of its increasing prevalence in the United Kingdom and the need for pharmacists in either the community or hospital sector to have the knowledge to distinguish it from other conditions [32].

Script Design

The script for each ICA case was designed to meet pre-defined learning objectives and ensure equivalent user experiences. The scripts for all three cases were created in consultation with two registered pharmacists (in addition to the research team), who had the appropriate expertise; for example individuals with community pharmacy experience were approached for the EHC case, whereas the renal function case was created with input from hospital pharmacists. The scripts were reviewed and amended according to the principles of constructive alignment based on face-to-face meetings and email feedback, until realistic and accurate simulations were created that aligned with the intended learning outcomes (ILOs) [33]. A decision tree of the script for each case was developed, which detailed it from start to finish and established key points and decisions. Each case had an ideal pathway and decisions were categorised as more or less favourable compared to this (figure 1).

Figure 1. Snapshot of the Markov Model decision tree for the EHC simulation.



Different script styles were created depending on the simulation ILOs. Standard navigation through VP simulations is via pre-defined menu inputs [34], however different inputs were utilised in the design to widen the scope of the ICAs used and evaluate user preferences in a bigger study (36). Multiple-choice inputs were selected for communication skill development, whereas free-text input were used to encourage knowledge development [36-38]. The ICA's were designed to provide feedback to users. This feedback specifically laid out what a user had done well and how they could improve. The feedback was spoken by the avatar and was also provided in textual format. This provision hoped to encourage a reflective approach to leaning, as did the ability for a user to repeat the simulation and change their path to receive a different patient outcome and feedback.

Avatar Design

The scripts and the avatars themselves were designed to be realistic but not to the detriment of falling into the ‘uncanny valley’ as described by Mori (2012) [39], who suggested that objects portraying human characteristics may be viewed positively, up to a certain point beyond which the degree of visual similarity to real humans becomes unsettling and can trigger negative thoughts [40-42]. All avatars were designed to express humanistic characteristics through simple body language, movements and pre-recorded voice replies. As an example, the avatar in the EHC simulation was animated to blush when asking for the “morning after pill”, as may happen in real practice due to the sensitive nature of the topic.

The simulations were stored online and created using standard Hypertext Mark-up Language (HTML). Javascript functions were used to handle page logic, including processing button clicks for both the free-text input and multiple-choice questions. For the ICA simulations using free-text inputs, once the 'speak to patient' button was clicked the text was sent to a web service hosted on the same server to process the text. This then returned a code to the site which was processed on the client side via JavaScript (using the jQuery library) to determine what animation to play and how the case should continue. When multiple-choice input was used, all processing occurred client side; skipping the web service step. The avatars were modelled, textured and animated using Autodesk's Maya 3D package. Still images were rendered using the Mental Ray package supplied with Maya and were then composited using Adobe After Effects to create the final .mp4 animation files. The avatars’ verbal responses were audio-recordings of a voice actor who was chosen to match the avatars' characteristics.

The avatar in the EHC simulation was a young woman who presented to a community pharmacy requesting the "morning after pill" (see figure 2). The user had the option to invite the avatar into a consultation room to ensure a private, confidential conversation and the simulation background would change to show this. The simulation utilised a mix of multiple-choice and free-text input. To aid the consultation and mirror real-life, a consultation form was built into the simulation. This was included as a separate tab, which could be opened and completed by the user as they progressed through the consultation, to help them make a decision on the appropriateness of EHC supply.

In the renal function simulation, users played the role of a hospital pharmacist and interacted with an avatar of a doctor on a hospital ward via multiple-choice input (see figure 3). The simulation integrated hospital notes and a drug chart which could be accessed throughout the simulation and contained the same sort of information as would be expected in a real set of hospital notes, including test results and medication history. Users were required to calculate the patient's renal function using the information provided and adjust drug doses accordingly, to help improve their calculation and clinical skills.

The childhood illness simulation utilised two avatars: a grandmother and her grandson (see figure 4). The simulation was set in a community pharmacy and users interacted with both avatars via free-text input. The grandson avatar presented with measles. When users asked to look at the rash, an enlarged image of the child's arm appeared showing a more detailed image of the rash associated with measles; similarly if the user requested to look inside the child's mouth, an enlarged image of the oral cavity appeared showing Koplik spots. These images remained available throughout the simulation and demonstrated the high-level fidelity of the technology. The user was directed to make a diagnosis, and upon a successful one, they were directed to recommend appropriate licensed medicines and self-care advice.

Each of the avatars is not based on a real patient. Any resemblance to a person, living or dead, is coincidental.

Figure 2. Screenshot of the EHC avatar simulation.

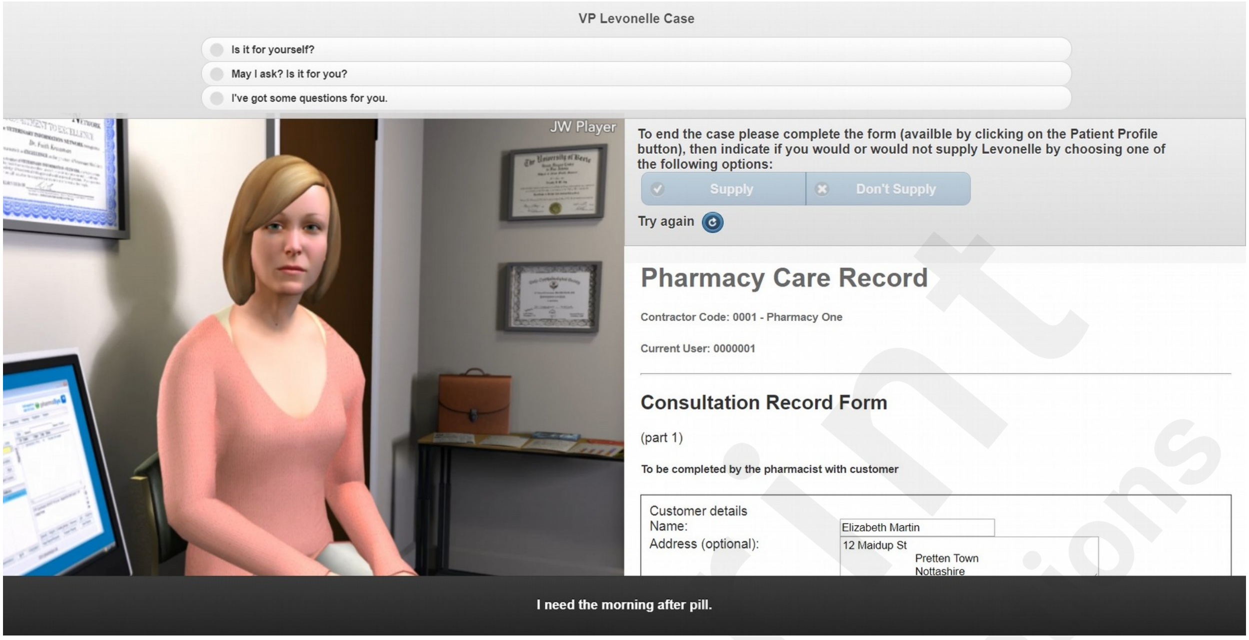


Figure 3. Screenshot of the renal function avatar simulation.

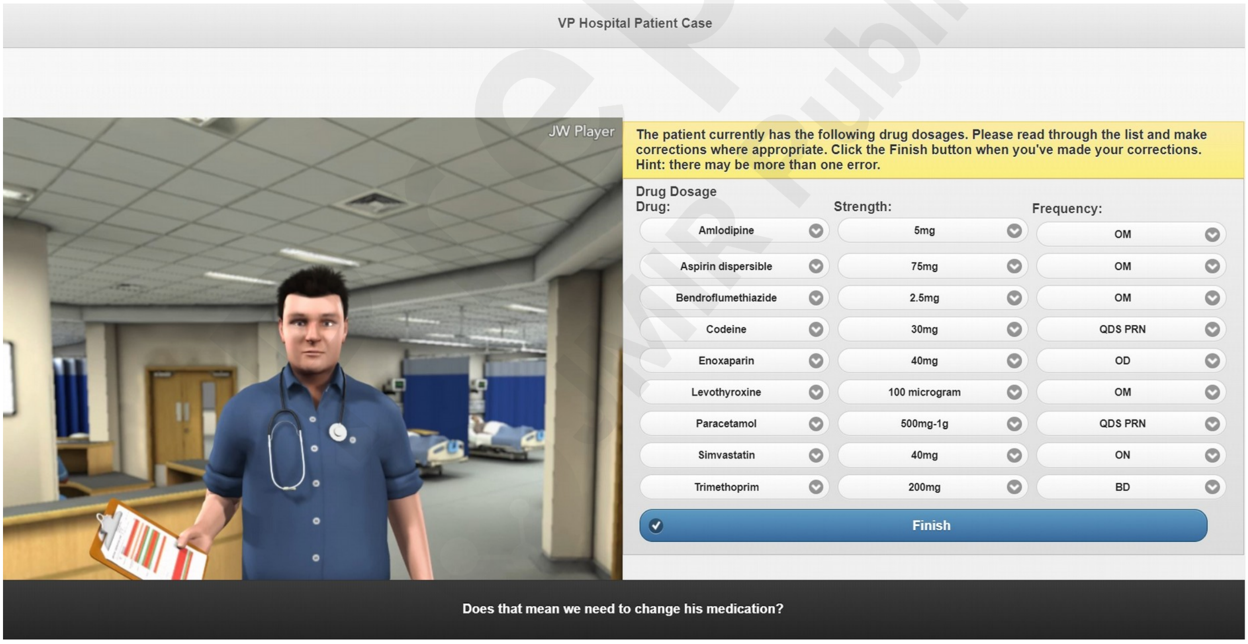
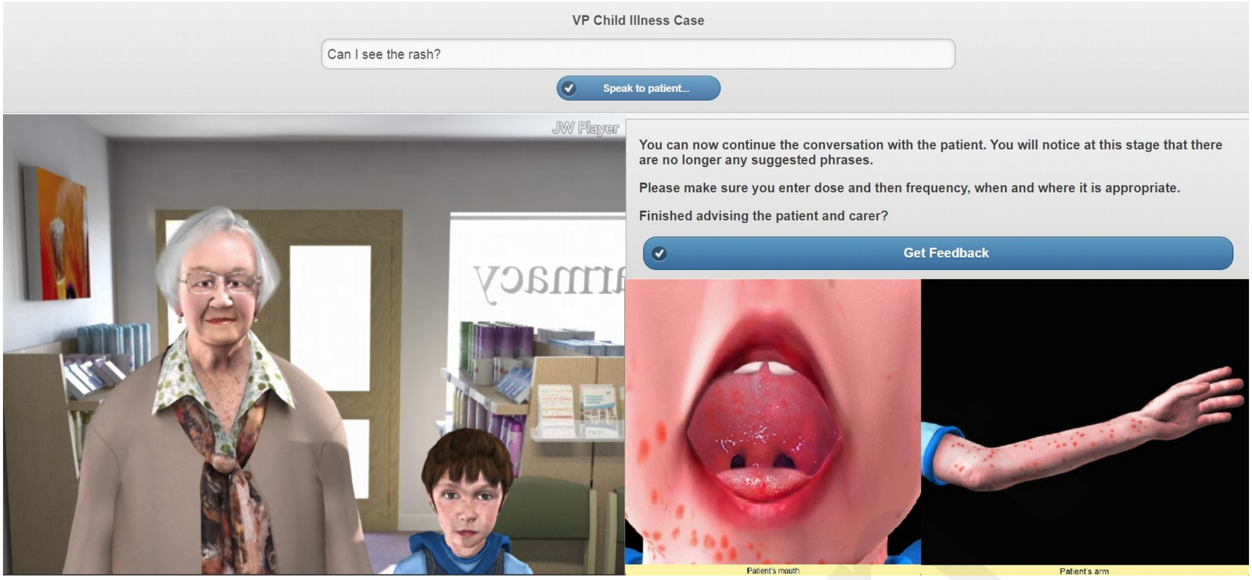


Figure 4. Screenshot of the childhood illness avatar simulation.



A YouTube video has been created as a demonstration of the EHC avatar simulation [43] (see multimedia appendix 1).

ICA Evaluation

Design

During the initial design phase, an internal review took place within the research team with advice from the digital development team and feedback from registered pharmacists. The three ICA simulations were tested by pharmacists within the School of Pharmacy and Bioengineering at Keele University; all members of staff who were pharmacists were contacted, including those who had assisted with the initial script design. Links to the ICA simulations were sent via email, and pharmacists were asked to provide electronic or face-to-face feedback on any areas of the case studies, including clinical and pedagogical aspects.

In addition, the EHC case study and data collection questionnaire were reviewed by a sample of pre-registration trainees and newly-qualified pharmacists (NQPs). Ethical approval was granted by the Keele University Ethical Review Panel.

Sampling and Recruitment

A purposive sample of thirty pre-registration trainees and NQPs who were Keele University alumni (n=10) or members of the British Pharmaceutical Students' Association (n=20) were invited to participate over social media. Consideration was given to the sample size based on the pool of available participants and the required sample size for the wider study (44). Previous literature has identified a range of sample sizes for studies designed to review data collection materials with a minimum of ten established as appropriate to evaluate adequacy of instrumentation [45]. A range of views were sought for this evaluation, thus recruitment included individuals who had studied at different Universities, were in different stages of their education and who were currently completing or had completed their pre-registration training in a community or a hospital pharmacy. The study used a sample that best represented those with knowledge of the research topic, in this case current pre-registration trainees and individuals who had just finished pre-registration training. Only one round of recruitment occurred as saturation of themes was reached [46].

Data Collection

Participants were asked to complete the ICA case study on the knowledge and law of supplying EHC and a questionnaire to gather their feedback on the simulation and the data collection tool. Evaluative questionnaires are an established method to compare thoughts on different learning tools [47,48] but a review of the literature identified a lack of validated instruments to evaluate ICAs as learning tools [49]. A data collection questionnaire was therefore created for this research by adopting questions from validated evaluation instruments found in the educational literature to provide a tool to evaluate perceptions of VPs in pharmacy education for future studies [50-52].

This questionnaire consisted of 20 Likert scale ranking statements (1= strongly disagree, 2= disagree, 3= undecided, 4= agree, 5= strongly agree) and a series of open-ended questions. This was subject to measurements of reliability and validity. Review by the supervisory team, practicing pharmacists, pre-registration trainees and NQPs ensured its content and face validity, and internal consistency [53-55].

Data Analysis

Quantitative data from the Likert scale were analysed descriptively. Qualitative data from the open-ended questions were subject to content analysis [56]. All comments provided by participants were imported into a Microsoft Excel spreadsheet for coding. The content analysis process involved the identification, organisation and indexing of comments to provide frequencies of coded theme [57]. The lead researcher (JT) conducted the initial content analysis. These codes were reviewed by the research team and discussed to reach consensus, providing researcher triangulation. Cronbach's coefficient alpha (α) measured internal reliability of the data collection tool [58].

Results

Demographic Results

Ten participants reviewed the EHC ICA and data collection questionnaire; four were Keele University alumni and six were from the British Pharmaceutical Students’ Association, who had studied at four different Universities. The remaining 20 participants who were invited to participate did not respond to the invitation. Four of the participants were pre-registration trainees and six were first-year qualified pharmacists. Seven of the participants were female and three were male. All participants were in the age range 20-25 years. Participants were of White British (n=7), Indian (n=1) and Chinese (n=2) ethnicities. An equal number of participants were from hospital and community practice. A greater proportion of participants (n=6) reported no previous experience of ICA simulations.

Questionnaire Validation

Initial reliability testing of the instrument consisted of establishing content and face validity. The research team as pharmacists had first-hand knowledge of the construct of interest from practice and they could advise on the questionnaire content and language. The review of the questionnaire by three qualified pharmacists contributed to addressing the content validity of the instrument.

This resulted in minor typographical changes, but was otherwise reported as appropriate to measure users' views on the ICA simulations.

All pre-registration pharmacists and NQPs reported the questions and Likert statements to be clearly written and unambiguous, further confirming internal validity of the data collection tool.

A Cronbach's α score of 0.95 was obtained which demonstrated a high level of internal consistency, which in turn suggested that the Likert scales were reliable to be used in a bigger study (44).

Quantitative Analysis

The statements from the Likert ranking scales, their descriptions and the associated median agreement scores are shown in table 1. For all Likert ranking statements, participants' median agreement scores were in the 'agree' or 'strongly agree' categories. Fewer participants ranked themselves as 'undecided' and only on five occasions did participants 'disagree' with a statement. No participants ranked themselves as a 1 ('strongly disagree') for any statement.

The fidelity of the simulation was reported as realistic by 80% of participants, with it making them feel as if they were the pharmacist and were making the same decisions as in real practice (70% and 90% agreement, respectively). The simulation was reported as enjoyable (90%), interesting (100%) and set at the right level for pre-registration training (90%). The majority of participants reported that the simulation was easy to access (90%) and the ILOs were easy to understand (70%), indicating high usability as a learning tool.

The level and specificity of the feedback was reported as adequate for participants' learning needs (100%). The development of skills for future practice from the simulation was reported by 80% of participants; with clinical reasoning skills being developed to a greater extent than problem-solving or decision-making skills (90% vs 80%). There was high agreement regarding the development of and application of knowledge from using the simulation (100% and 80%, respectively). Participants reported feeling more confident in caring for patients (90%), collaborating with other healthcare professionals (80%) and practicing as a pharmacist (80%) after completing the simulation.

There were some differences between data received from pre-registration trainees and NQPs. Pre-registration trainees agreed/strongly agreed with the majority of Likert statements; one participant (25%) was ‘undecided’ with statements two and three relating to really feeling like the pharmacist in the simulation. Two NQPs (33%) also ranked themselves as ‘undecided’ on statement two. NQPs were reportedly more ‘undecided’ as to the simulation aiding the development of skills for practice (33%) and allowing the application of theory to practice (33%). There were a few statements which saw NQPs disagree: aiding the development of problem-solving and decision-making skills (17%), individual responsibility to learning (17%), collaborating with patents (17%) and healthcare professionals and increasing confidence for practice (33%).

Table 1. Participants’ perceptions of the ICA simulation reported as median agreement scores with the interquartile range (IQR).

Statement Number	Statement description	Median Agreement Score	IQR
1	The simulation provided a realistic patient simulation	4.5	1
2	When completing the simulations I felt as if I were the pharmacist caring for this patient	5.0	1.75
3	When completing the simulations I felt I had to make the same decisions as a pharmacist would in real life	4.5	1
4	The simulations were interesting	4.5	1
5	The simulations were enjoyable	4.5	1
6	The difficulty of the simulations were appropriate for my level of training	4.0	0.75
7	The feedback I received was adequate for my needs	5.0	1
8	The objectives for the simulations were clear and easy to understand	4.0	0.75
9	I was able to access the simulations at my convenience	5.0	1
10	The simulations helped develop my clinical reasoning skills	4.5	1
11	The simulations helped develop my problem-solving and decision-making skills	4.0	1
12	The simulations have helped me to put theory into practice	4.5	1
13	I am confident I am developing skills from the simulations that will be required in practice	4.0	0.75
14	I am confident I am gaining knowledge from the simulations that will be required in practice	4.5	1

15	It is my responsibility to learn what I need to know from the simulations	5.0	1
16	Completing the simulations has improved my confidence for the pre-registration exam	4.5	1
17	I feel better prepared to care for real-life patients	4.0	0.75
18	I feel more confident about collaborating with patients and other healthcare professionals	4.0	0
19	The simulations have increased my confidence about practicing as a pharmacist	4.0	0.75
20	Overall, the experience has enhanced my learning	4.5	1

Qualitative Analysis

Four key themes emerged from content analysis of the open-ended questions on the questionnaire: (1) use of the case studies as learning tools; (2) utilisation of the case studies in the pre-registration training year; (3) limitations of the case studies; (4) suggestions for improvements of the case studies. Themes and frequencies from the content analysis can be found in multimedia appendix 2. Participants reported the ICA simulation as enjoyable and easy to use as a learning tool. It was described as providing a "different format of learning" and the realism and relevance to practice of the simulation promoted experiential learning.

> *"I liked that there was a selection of answers to reply to the patient, more than just a 'yes' and 'no' … I feel this is how I would communicate with a patient politely, and it made the experience a lot more realistic."* P4, Pre-registration trainee

One participant specifically commented that the level of feedback was helpful to identify what they did well and how they could improve, whilst drawing on the repeatable aspect of the simulation.

> *"It helps put learnt knowledge into practice… in a safe and non-pressured environment. I could make a mistake and learn from it; learn how to do a proper, effective consultation without compromising patient care in real life."* P2, Pre-registration trainee

Participants reported that the ICA could be a useful learning tool in pre-registration training; it was primarily thought of as an individual revision aid or a group learning tool. A small number of participants commented on the use of the ICA as a tool to help prepare or examine an Objective

Structured Clinical Examination (OSCE).

> *"This case study would fit well in an OSCE scenario...more realistic than a written station and you wouldn't need to bring in an SP."* P7, NQP

Participants reported some perceived limitations of the ICA. The most frequent concern related to the free-text part of the simulation.

> *"At the end of the case study where I had to ask questions. I didn't realise that this section could also be used to counsel and give advice to the patient. I felt this wasn't made clear."* P3, NQP

The free-text entry was also associated with software recognition problems.

> *"It was difficult to enter information as the programme often didn't recognise these. It became frustrating thinking how to reword things to make the programme recognise them."* P5, NQP

Four improvements were suggested: providing an example simulation, including a help button or email address for technical issues, including key learning points at the end of the case study; the most commonly reported related to increasing the size of the question bank.

> *"Have a bigger question bank so the simulation can recognise what you are asking and make it easier to progress through the case…it makes you not want to carry on with the consultation."* P9, Pre-registration trainee

Discussion

Principal findings

The aim of the study was to describe the design and review of three interactive clinical avatar (ICA) simulations as part of pharmacist pre-registration training. Creating the three ICA simulations involved multiple reviews and subsequent amendments to ensure the content and face validity of the cases. Further measures of criterion or construct validity were considered and dismissed as not appropriate because of the lack of validated instruments and therefore the inability for findings to be correlated with those from another instrument. A sample of pre-registration trainees and NQPs reviewed the EHC simulation and reported it to be an effective learning tool; suggesting improvements to increase its usability. The wording, relevance and difficulty of the ICA was reported as being appropriate with no changes required. The data collection questionnaire was found to be reliable, as indicated by the high Cronbach's α score.

There has been only one previous study evaluating ICAs in pre-registration pharmacy training [10], which focused on improving users' knowledge and confidence of a single community pharmacy service. In contrast to our study, there were few specifics on the simulation design process or validity of the self-rating scale. Previous literature reviews [2, 6, 7, 59, 60] concluded the need for further research to be undertaken on the role of virtual patients in postgraduate and continuing pharmacy education. The design of the ICAs in this paper goes some way to filling this gap in current research and provides a rationale for a combination of input styles to determine the range of skills and knowledge that can be developed from these ICA simulations (35,44).

This study indicated a high level of satisfaction by pre-registration trainees and NQPs with the use of ICAs as a learning tool, mirroring the wider literature [12, 13, 61-65]. Providing engaging and enjoyable learning environments are key components of the learning process [66]. Participants in this study reportedly enjoyed completing the EHC simulation, describing it as a "novel learning tool" which had not been widely used in participants' undergraduate education. The increasingly digital native generation of students justifies the creation and evaluation of these more interactive learning tools that may promote self-directed and distance learning, potentially increasing the scope of students who can use them [67].

Participants commented on the realistic design and relevance of the scenarios to real practice, implying high levels of cognitive realism (68). The interactivity and fidelity of the ICA may have added to users' immersion in the simulation and their experiential situated learning; such learning has previously been proposed to occur only with real-life or concrete experiences [69]. Participants reported that the ICA provided them with a means to explore higher order skills such as clinical reasoning. In contrast, the development of the more simple skills (such as problem-solving or decision-making) were not reported as freely, especially by NQPs. This is not necessarily an issue, as previous studies have found that lower order skills can be acquired through straight forward rote-learning, but it remains essential to ensure that any learning tool is created with the level of learners and ILOs in mind [70]. Although VPs have been established as tools to develop healthcare professionals' clinical reasoning skills [2, 8, 28,71,72], little work has been conducted within the pharmacy profession or evaluating ICAs specifically. Findings from this study also mirror the wider literature regarding knowledge development post-VP use, with pre-registration trainees and NQPs reporting the development of knowledge required for future practice after completing the ICA simulation [10, 13,73-79]. Resources which allow users to immerse themselves in a scenario and behave as they would in real practice is extremely beneficial in aiding the development of knowledge, skills and confidence, and may bridge the gap between theory and practice in pre-registration training [80].

It is essential that any learning tool reflects the level of education that individuals are at and allows a spirality of content to ensure that new learning is linked to previous learning and students' competence can develop in-line with the difficulty of task [81]. ICAs may add little value when learners are at the lower levels of Bloom's taxonomy [82], and they should instead be used when knowledge is combined with skills and applied in problem solving scenarios, or when direct patient contact is not possible. This may explain why pre-registration trainees were more agreeable to the simulations allowing an opportunity to put theory into practice, developing skills, improving confidence for real-life practice and collaborating with patients and healthcare professionals; NQPs may have had this experience in real-life practice. This demonstrates that ICAs are able to help promote progression up the levels of Miller's Triangle, as per other simulation-based learning [83].

The integration of a decision tree into simulation design allows users to dynamically control the case study and assures outcomes are directly determined by user input, to encourage a greater sense of realism and responsibility. ICA simulations provide a safe environment for users to repeatedly practice, change the simulation outcome, receive the appropriate feedback and reflectively learn. This was noted as being particularly beneficial in pre-registration training as it would allow individuals to learn from experiences they may not otherwise have.

Strengths and Limitations

All ICA case studies were reviewed by the research team and qualified pharmacists to increase their validity. The EHC simulation was also reviewed by a sample of pre-registration trainees and NQPs. The sample size of 10 may be considered small and findings may be due to chance, but the purpose was to review the design of the ICA simulation and data collection tool, for which data saturation was reached. All comments received were useful regarding the ICA design, in particular the improvements suggested related to features consistent for all three case studies, such as: providing an example ICA simulation, signposting for help and listing key points relating to the topic. The improvements regarding the question bank and recognition of the avatar can also be translated across the ICA simulations where free-text input is used.

Perceptions of the ICA were obtained via a questionnaire. The self-reporting aspect did not show whether participants' knowledge or skills related to carrying out an EHC consultation did actually improve, only their thoughts of such. The primary focus of the questionnaire was to obtain participants' perceptions relating to the avatar simulation rather than evaluating its ability to promote knowledge or skill development; this will be part of a larger study.

Conclusions

The design and creation of the three interactive clinical avatar simulations was successful. The multistep review process ensured validity and reliability of the simulations and data collection questionnaire. The in-depth explanation of the design process and the provision of a questionnaire may help widen the usage and evaluation of ICAs or other simulation tools.

The ICAs were received favourably as a novel learning tool which reportedly promoted experiential learning and allowed individuals to feel like they were making real-life decisions; developing transferable knowledge and skills. Improvements were suggested to increase the utilisation of the ICAs, and amendments will be made for further, larger-scale evaluations. The use of ICAs as learning tools can provide potential benefits to many healthcare training courses because they provide standardised simulations that allow active learning and reflection.

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Author Contributions

Conceptualization, J.T. S.W. and S.C.; methodology, J.T. S.W. and S.C.; software, J.T. S.W. and S.C.; validation, J.T. S.W. and S.C.; formal analysis, J.T.; investigation, J.T.; resources, J.T.; data curation, J.T.; writing—original draft preparation, J.T.; writing—review and editing, S.W. and S.C.; visualization, J.T. S.W. and S.C.; supervision, S.W. and S.C.; project administration, J.T.; funding acquisition, not applicable. All authors have read and agreed to the published version of the manuscript.

Abbreviations

3D – Three-Dimensional
EHC – Emergency hormonal contraception
ICA – Interactive clinical avatar
JT – Jessica Thompson
NQP – Newly qualified pharmacist
OSCE – Objective structured clinical examination
VP – Virtual patient

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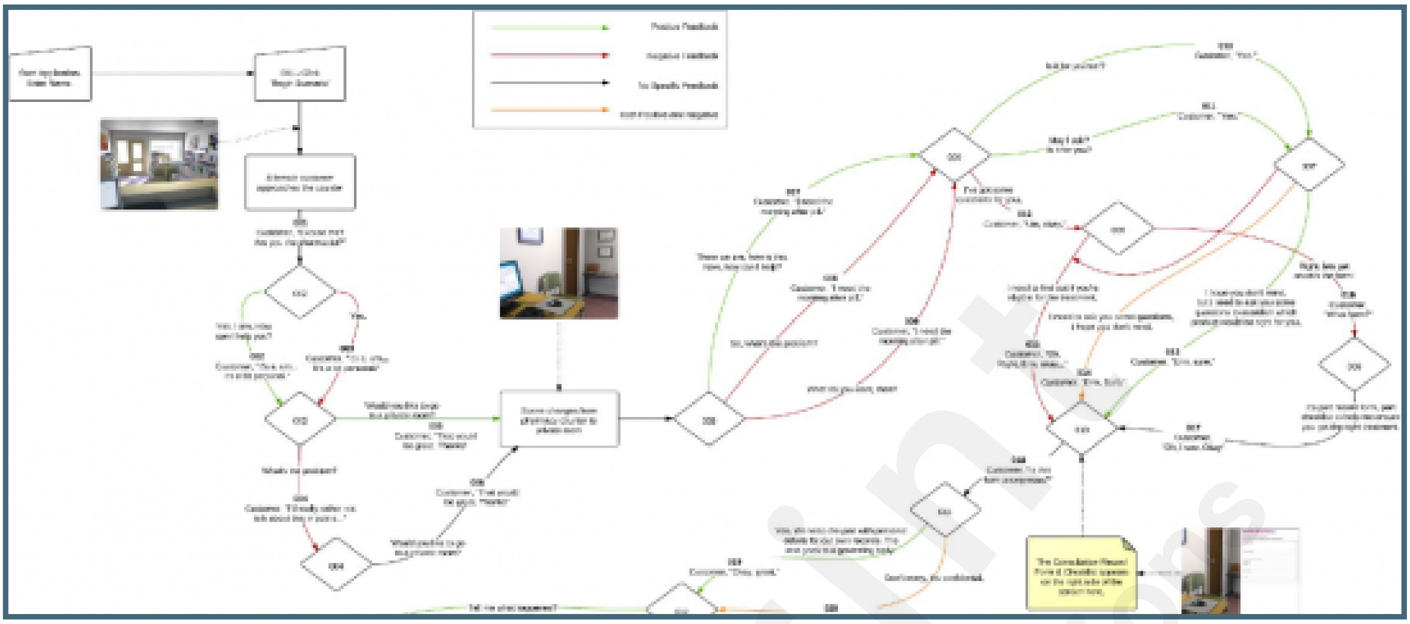
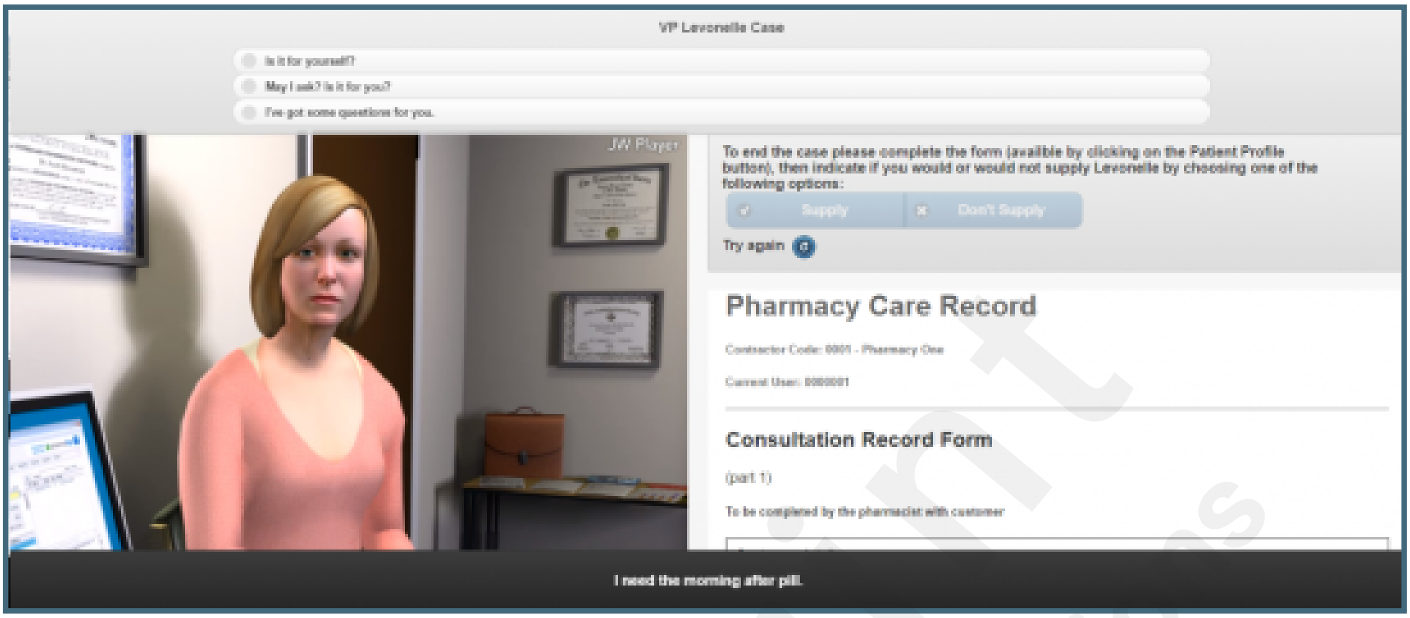
Supplementary Files

Figures

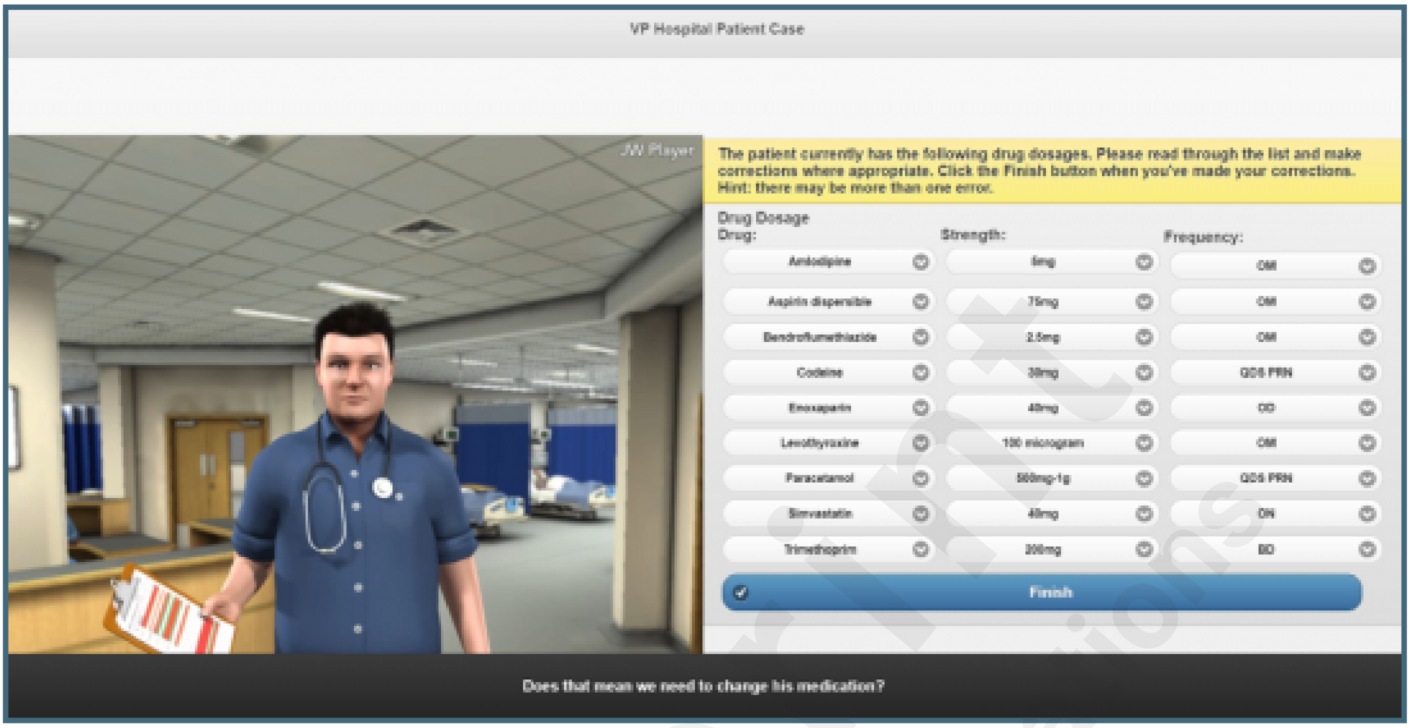
Snapshot of the Markov Model decision tree for the EHC simulation.



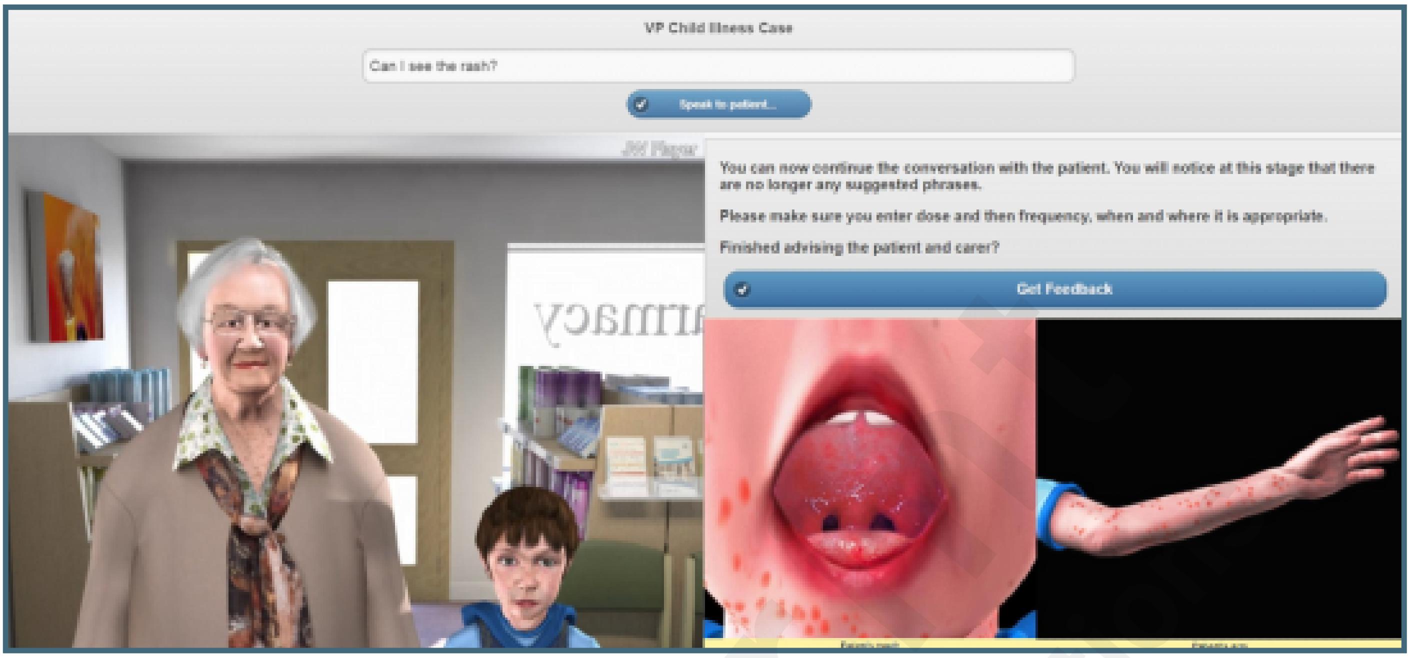
Screenshot of the EHC avatar simulation.



Screenshot of the renal function avatar simulation.



Screenshot of the childhood illness avatar simulation.



Multimedia Appendixes

EHC interactive clinical avatar demonstration.
URL: https://asset.jmir.pub/assets/5d8a3547c4c72771cfa41a7fe41b7ff2.mp4

Content analysis themes and frequencies.
URL: https://asset.jmir.pub/assets/16f039bd8a234a6ea2460bd0f12947c7.pdf

Related publication(s) - for reviewers eyes onlies

Related publication.
URL: https://asset.jmir.pub/assets/b5287efad0a826fec86b8e39c693b571.pdf

Related publication.
URL: https://asset.jmir.pub/assets/4ca017de8a947ffdf4fb4a95fbf3b72c.pdf

TOC/Feature image for homepages

EHC avatar.