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The power of the Virtual Reality-Based Dispensing Simulations to Increase Accuracy and Speed among College Students in Pharmacy

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Abstract
The improvements in digital learning have allowed insinuations in the development of immersive pharmacy training simulations. This is a randomized controlled educational study that evaluated the extent to which a virtual reality (VR)-based dispensing simulation demonstrated better performance in the accuracy and time in processing a prescription when compared with paper-and-pencil-based teaching forms among final year students in a pharmacy school. A group of 80 participants was randomly allocated into one training group based on VR and another one using the traditional paper-based case studies as a control group. VR simulation involved realistic scenarios of the pharmacy workflow, the aspect of verification of prescription, the labeling process as well as guidance of the patients. Pre-monitoring and post-monitoring of performance was undertaken with standardized dispensing evaluation grading and timed tasks after a 6-week intervention The analysis favors the third point about integrating VR technology in pharmacy curriculums so that it could increase the process of skill acquisition and expose the students to realistic dispensing situations.
Keywords: ***VR, education, pharmacy, dispensing, simulation, precision, quickness, fill process, randomized controlled trial, internet-based learning, pharmacy training.***

1. Introduction

Philosophical approaches to education being used in pharmacy training have changed immensely in the last ten years because of heavy involvement of technological assisted learning methods. Conventional forms of instruction, like discussions based on cases and role play activities, have been complemented by technology innovations where learning is offered in more practical ways. More specifically, the practical applications of Virtual Reality (VR) in teaching pharmacy have become increasingly popular because the technology enables learners to work in a simulated environment that replicates the actual processes used in the pharmacy chain. This can be useful particularly in the instruction of complex jobs, like prescription process where accuracy and efficiency is of great importance.

Dispensing skills are usually practised with paper-based case studies and manual simulation in the traditional curriculum of pharma practice. These strategies, however, provide only elementary familiarity with the procedure and cannot exactly simulate the real world, high-stakes situation of a functioning pharmacy. A large component of pharmacy practice is dispensing which consists of various steps which are prescription verification, labeling, patient counseling, and medication safety. The conventional ways of training might not involve the immersion, which strengthens the practice in a place where the learners are allowed to fail safely and learn out of mistakes. Moreover, dispensing medication practice involves high level of attention to details in the work, time sensitivity of tasks, and having a close follow of the guidelines to provide safety to patients

The Virtual Reality (VR) technology, as compared, allows more real-life like immersive, interactive experience that is similar to the complexity of real pharmacy environments. Students can also use VR to undergo virtual dispensing practise that involves the integration of realistic working processes to gain essential skills in decision-making, error recognition, and problem-solving in an isolated safe setting. In VR, students can train in dispensing medications, checking prescriptions, communicating with virtual patients under a time pressure, thus enhancing the accuracy and speed without any threat of errors in a real life of dispensing medications.(1)

1.1 participation of virtual reality in educational status of pharmacy

Application of VR in learning pharmacy creates an engaging learning environment which helps in fostering complex learning skills through interaction. VR simulations come with a very interactive learning environment in which students can be given repeated opportunities to perform skills under different circumstances. This has been a vital skill towards pouring education since pharmacy students will be required to master the skills of processing information with precision and speed as well as ensuring safety of patients. VR offers the 3D simulations and through them students can practice the dispensing activity without the tension and repercussions associated with making mistakes in real life.

Also, the use of VR simulations creates an opportunity to get immediate feedback and assessment that also promotes learning. The real-time dispensing case is another scenario where the students might not get corrective measures on their performance in the traditional practices. Conversely, the VR-based training systems have the capacity to judge the performance of the students in real-time through the provision of corrective measures thereby providing an avenue to determine the areas that require improvements.

Besides, VR offers a recallable learning process, and the students get a chance to revise what they have done, sometimes things or activities that are rare or challenging to recreate in the real world. As a case in point, the dispensing of drugs or prescriptions with complex cases or ultra-rare diagnoses may be postulated in VR that may give students an opportunity to train in dealing with a broad variety of cases. These differences in experiences ensure that the students are more ready to the issues ahead of them in clinical practice.(2)

1.2 Conventional Paper Based Case Studies in Pharmacy Education

Since the introduction of VR and other digital methods, the way pharmacy has been educated has been largely dependent on paper-based cases and manual dispensing activities. Such approaches mostly include examination of prescription cases in which students are expected to use pharmacological information and dispensing skills. Although they may give the students good experience in resolving theoretical cases, they lack the on-hand training and play experience to learn the heavy workflows in pharmacies.

The major weakness of conventional paper-based approach is that it lacks the interactiviveness identified in VR simulations which are dynamic, real time. The students can learn the theory of dispensing processes but fail to utilize their knowledge when in a stressful fast-paced environment. Exercises using paper can also restrict the practice of some particular skills since the case studies are fixed and do not provide different conditions to apply them or at least an immediate feedback.

Moreover, the time limits, as well as the pressures of the real working process of dispensing, do not reproduce the effects of paper-based methods. The pharmacy students should be able to work productively as they pass through their education to meet accuracy and timeliness and this aspect may be very hard to inculcate by using the conventional exercises.(3)

1.3 The Objectives of this Research

The purpose of the study is to determine the usefulness of such VR-based dispensing simulations with respect to its ability in enhancing the accuracy and speed of prescription processing in final-year pharmacy students in comparison with traditional paper based case studies. This study will conclude on how VR provides a better platform in building critical dispensing skills by comparing performance of students who have learned with VR based training and those who have used traditional methods.

The intended purpose of the study has the following specific objectives:

An evaluation of the accuracy of dispensing the prescriptions in real life; VR group versus the control group.

Examining the time it takes students to do the prescription tasks in the VR simulation, as compared to the paper-based method.

The topic selection is relevant because of the need to know how students regard VR based training in terms of engagement, confidence, and the desire to learn through the simulation processes rather than as a general preceptor.

The results of this research may serve as important implications on pharmacy education, noting that VR technology has the potential to improve the acquisition of dispensing skills, learning engagement, and preparing students to face the requirements of the pharmacy practice work environment. Introducing e-learning through VR-based simulations into the curricula of educational institutions will allow them to provide students with a novel interactive learning process that will help them be better prepared in clinical dispensing settings.

2. An overview of VR in Pharmacy Learning

2.1 Development of Digital Learning in Health professions

The digital learning tool in healthcare education has changed radically within the recent past decades. Health professions education as a whole (and pharmacy training, in particular) was traditionally based on teaching via lectures, use of textbooks, and the form of clinical experience being in the vicinity of a clinical setting. Although these techniques served as an excellent source of basic learning and overall practical experience, they could not be used to simulate high-fidelity clinical practice, as depicted in the real world.(4)

With the development of technology, the necessity of something more based on interacting and engaging in learning sessions became more and more acknowledged as to allow people to supplement the older learning styles. Digital learning started receiving momentum, like computer-based learning module and simulated clinical settings were developed as a means of closing the theoretical knowledge gap and application.

With the advent of Virtual Reality (VR), digital learning has become revolutionary especially in health professions education. VR provides a visual 360 environment of interactions which allows students to effectively learn within a real world experience devoid of time and space limitations and with the risk of encountering expensive mistakes. VR simulations can be used to complete controlled and risk-free dispensing, patient counseling, and clinical decision-making practice by students in pharmacy education.

The development of VR in pharmacy classroom education has been a subset of a larger movement in healthcare education, as simulation-based learning has in the past decades seen greater adoption within the healthcare learning environment to better simulate this more hands-on approach to teaching and learning. Its early use in medicine and nursing schools revealed its usefulness in the practice of skills acquisition and honing clinical advantages putting it on a slow move to medical curricula in medication training.

2.2 Advantages of Simulation-Based Training

The world of modern healthcare education has seen the incorporation of simulation-based training as a necessity, which arguably holds some significant advantages in favor of both the students and educators. Even more specifically, the VR simulation has its own benefits in contrast to the classic training technique:

Risk-free and Safe Learning Environment: VR enables the students to train on complicated tasks, like dispensing drugs or counseling patients, without any risks of harming the real patients. Opportunities to learn can be found in the mistakes that occur in the virtual world and this is paramount to creating confidence and competence.

Repetition and Mastery: The ability to repeat, for as many times as students need to master a given task, is one of the great benefits of using VR. There is possibility of infrequent opportunity to practice by hand in the traditional environments particularly in complicated or high-stake topics. VR allows one to practice until they improve, on a repetitive basis that improves the muscle memory.(5)

Realistic and Immersive Experience: VR experience is realistic and very close to the real-world. Students are able to experience the virtual pharmacy situations, talk to and communicate with virtual patients, and train activities that look and feel very similar to an actual pharmacy scenario. This immersion enhances involvement and makes students internalize the working processes and procedures of dispensing drugs.

Instant Evaluation and Response: VR scenarios provide an individual with instantaneous performance evaluation, which is essential to learning. Instant errors can be corrected on the spot and advice provided on how it can be better done by the students. Conversely, more conventional forms of feedback (like a written assignment / case study) might not be as quick, or as effective a learning process. The possibility of getting rapid feedback in VR will enable the students to correct themselves and boost their skills before engaging it in physical environment.

Improving Critical Thinking and Decision Making: VR-based simulations do not involve only straightforward tasks but can be involved with complex decision making. The students in pharmacy can train how to make decisions that touch on medication therapy management as well as patient interactions or resolving the dispensing mistakes. VR relays these real-life issues, which encourages the thought processes and problem-solving abilities.

Engagement and Motivation VR training is almost always a more interactive experience, which tends to increase student engagement relative to a traditional form of teaching. Students have a high chance of remaining concentrated and motivated in a simulation where they are active players as compared to passively receiving information. This greater interaction has the potential of enhancing the learning experience and the overall retention rate.

2.3 Holes in the Conventional Development of Dispensing Skills

Although the practice of pharmacy education has been partially improved due to the latest trends in dispensing skills development, its traditional approach has a number of innate limitations, which VR-based training partially aims to overcome:

Lack of real life experience: A pharmacy student with practice in a traditional setting may encounter less practice in real life as they are usually practicing the actual skills in dispensing medications through case studies, role-plays, and recorded videos. Although these approaches may be useful in learning theoretically, they tend to disappoint when it comes to getting practical skills on real dispensing work. Time crunch, medication regimens, and multitasking are components that students in pharmacy work experience in real life but become very challenging to replicate well in the traditional format.(6)

No Real-Time Feedback:Real-time feedback is a lack of feedback on performance in more traditional dispensing activities (e.g. paper based case studies). In the pharmacy practice, whether in real life, precise and effective dispensing needs to be performed and errors may be devastating. With the traditional ways, errors are not usually realized until after the task has been done, and therefore, it does not give room to rectify wrongs on the spot and learn accordingly.

Challenged Complex-Scenario-Replication: In numerous cases, students in pharmacy programs might not have access to complex or uncommon dispensing situations throughout their education. Case in point, prescriptions of high-risk drugs, drug interactions or unusual formulations may be lacking in the form of case studies. VR can address this issue by replicating a great number of dispensing scenarios that are either not present or hard to recreate in a classroom or clinical environment.

Minimized concern towards Speed and Efficiency: It is a well-prepared practice that the emphasis on accuracy is created in the conventional dispensing trainings, however, not sufficient attention is concentrated on the speed and efficiency that is essential in an actual pharmacy practice. Pharmacists in a busy pharmacy should be in a position to complete prescription quickly and accurately. Virtual reality simulations enable students to enhance their efficiency on accuracy and speed within a controlled environment which enables them to develop the required skills to be effective when under a time limit.

The use of the Virtual Reality in pharmacy education is another big step towards teaching the science of dispensing medicine. VR offers a lively, interactive and experiential training experience that fills the gap in conventional training experiences through the ability to repeat and get real-time feedback on performance in addition to exposing the trainee to real-life scenarios of high stakes. It renders VR an effective solution in training pharmacy students about the accuracy, speed, and confidence they will have in effective pharmacy practices in the field. Since technology keeps evolving, it is likely that the VR based simulations will be deemed an essential part of pharmacy education and students can learn and acquire skills they need to provide safe, effective, and patient-oriented care.

3. i. Procedure of the Education Trial

3.1 Design/randomization Process

This research was set form with a randomized controlled trial (RCT) in order to assess the efficacy of virtual reality (VR)-dispensing simulations on the improvement of both precision/acuracy and pace of prescription processing amidst Pharmacy students in their final year. The experiment was performed in two universities, and subjects were randomised into one of two groups, VR-based training or the controls.

To achieve equal dispersion of students to the two groups, they carried out the randomization process through computer generated randomization tool. The randomization process was performed on an individual level which meant that every member had an equal probability of being assigned to the VR group or the control group resulting into the elimination of any possibility of bias in assigning the participants to the groups. The group allocation was blind to both the students and assessors to consider the minimum bias to the performance and maintain the validity of outcomes. The research was intended to determine what was the effect of the VR training after 6-week observation of the VR training or the typical training of paper-based case studies.(7)

3.2 Group allocation and selection of participants

They included the recruitment of participants who were final-year pharmacy students of the respective universities. The inclusion criteria demanded that the individuals had to be undertaking the pharmacy course at that time, complete preparatory courses about pharmaceutical activities in the course and agree to the study. The exclusion criteria were the students with prior experience with VR-based training or advanced clinical training that might have a biasing effect on their performance in dispensing simulations. A total of 80 people were recruited in the study.

When recruited, the participants were randomly placed in either of the two study groups:

VR-based Training Group: Individuals in this group were trained using a virtual reality training program which provides a simulated environment modeled after the process of filling prescriptions in a pharmacy environment.

Control Group: the subjects in this group trained through the traditional paper-based case studies on how to dispense and it involved the manual activities and routine case scenarios not using the VR technology.

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Both groupswere put through the same training program, lasting 6 weeks; however the methods of delivery to them differed, enabling comparisons to be made directly between the effectiveness of the VR-based simulation and conventional training.

3.3 VR Simulation design and features

The simulation dispensing program used VR as the pharmacy environment simulating the real life case with the necessary activities involved during dispensing prescriptions included in the program. The following were the significant characteristics of the simulation:

Realistic workflows of the pharmacy: The simulation was based on real-life workflows of a drug store, including but not limited to receiving the prescription, verification of the prescription, dispensing medication, and labeling.

Prescription verification and labeling: The learners had to verify the prescription and make sure that there were no possible drug interactions and that appropriate medication and dosage is picked.

Interaction with the patient: In the simulation also involved interaction with patients, where the students could be able to counsel their virtual patients on how to use medication, handling side effects and adhering to the medication.(8)

Time: Since time is a factor in the actual practice of pharmacy, the students had a limited time in which they had to dispense or fulfill prescriptions, this showed they were quick yet precise in their work.

Feedback and tracking of performance: The VR embodied feedback and performance tracking of each individual student in real-time, and gave them immediate feedback on the accuracy of dispensing and patient counseling. This enabled the students to rectify errors and do better during the training.

The VR also had a highly interactive system where students received highly immersive visual and auditory feedback in order to come up with a realistic and engaging experience. It was aimed to provide the environment in which students would have an opportunity to repeat the dispensing process several times so that they could polish their abilities in both precision and speed.

3.4 Training Control Group

The traditional case studies were used to train the control group. This approach entailed the use of paper cases, which were based on the scenarios observed in the field but without an actual prescription, whereby students were required to read prescription information, report on possible complications including drug interactions, and record the response. The learners were also expected to solve written case studies which entailed labeling of the medications and counseling queries. The training utilized in the control group was planned to simulate the theoretical aspects of the process of dispensing prescriptions, however, the training opportunity was not delivered immersively, hands-on as the VR training.

Even though the control group was considered to have gone through the same training material, the interactive, real-time training resource opportunities were not as high as those of the VR group, as the study participants were not able to interact with the material in an equal way. These case studies were completed by the students in the control group in a fixed session and they were provided with response to the case studies after they were read or finished a case study, yet lacked the interaction of the dynamic process of change and adaptation in the VR simulation.

3.5 Assessment procedures and Scoring Criteria

In order to determine the usefulness of the VR based dispensing simulation, a number of assessment tools were applied:

Standardized Dispensing Assessment Rubrics: The accuracy in addition to speed of filling was assessed utilizing these rubrics. The rubric contained certain criteria of verifying the accuracy of the medication, labeling, dose, and interaction, as well as completeness of the patient counseling session.

Timed Tasks: The performance of students in terms of completing the dispensing process within the specified time period was determined by timing the time of accomplishing each prescription task. Accuracy and time requirements were policies that had to be fulfilled in the process of dispensing.

Pre- and Post-Intervention assessments: The participants were asked to complete a pretest and posttest assessment that measured their knowledge on dispensing procedure and medication safety immediately before and after 6-week intervention. These tests quantified the gains in theoretical knowledge as well as dispensing dexterity.(9)

3.6 Methods of statistical analysis

Data obtained during the intervention were statistically analyzed to find out whether VR training is effective as compared to conventional methods. Some of the important statistical tests were:

Descriptive Statistics: The scores of both groups in terms of dispensing accuracy, speed and time were calculated.
Paired t-tests: By using the paired t-test, a comparison of pre and post levels of each group was done to determine the gains gained in terms of accuracy of dispensation and speed.
Independent t-tests: A t-test (independent-between) was utilised to report how proficient the VR and the control groups were at the post-intervention test.
Effect Size: Effect size (Cohen s d) was also conducted to ascertain how big the difference between the VR and the control groups was with regard to important variables, such as dispensing accuracy and speed.
The level of acceptable statistical significance was $p < 0.05$ and the analysis of the data was done through the statistical software like SPSS orR.
Finally, the application of such a methodology will allow defining an effective technique to evaluate the effectiveness of VR-based dispensing training on the skills of pharmacy students comprehensively. Through the comparison of the VR training to more traditional approaches, the given study will provide evidence of the efficiency of immersive digital technologies with regard to improving pharmacy education and preparing students to the practice.

4. Intervention Details

4.1 Components of VR Based Dispensing Simulation

The virtual-reality-based dispensing simulation was aimed at recreating a realistic pharmacy workflow with the aim to provide the students with hands-on experience at dispensing in a risk-free way due to the presence of dispensing errors. The simulation was composed of following important elements:
Prescription Receipt and Verification: The simulation started with prescription receipt in which students were asked to check details regarding the patient and verify associated prescription. There were a number of prescription types which were offered by the system such as drugs, dose, and patient details. Students were required to verify accuracy of prescription by ensuring the drugs were not contraindicated by others as well as ensuring that the drug provided by the prescription is the one required by the patient.
Medication Dispensing: Next students went through the dispensing phase where they identified the medications they needed using the virtual shelves or the automatic dispensing machines according to the instructions regarding the prescriptions. The training system enabled the student to exercise in the selection of the appropriate medication, formulation, and amount. They were also required to read the label on the medication which would ensure that the appropriate guidance was given.(10)
Labeling and Packaging: It entailed sticking of the correct labeling on the medication which had the guidelines and patient instructions such as the dose of the medication. The students also had the duty of packing the medication safely and making sure that all pertinent information was printed on the label e.g. expiry dates and storage guidelines.
Patient Counseling: The last task was interaction with virtual patients to engage in counseling. They talked with a simulated patient, in which they gave the instructions about medication, involved the possibilities of the side effects, and responded to the questions of patients. This period was to be able to facilitate the application of communication skills and to measure the ability of the students to articulate difficult medication guidelines to patients in a clear and emphatic language.
During the simulation, students would have their performance reflected in real time. The system followed the completion of tasks in a correct manner and the mistake like wrong medication selection, missed interaction or wrong labeling was indicated to be corrected. The simulation also measured the amount of time required to complete each and every task hence the need to move quickly as well as be accurate in a real pharmacy environment.

4.2 Case Study Workflow Among Paper

The paper-based workflow on the VR-based training with the paper-based case studies was still based on the traditional one in which the students went through the predetermined cases where they were given the written prescription of the cases and were anticipated to execute analogous actions. The procedures involved in the case studies were as follows:
Prescription Review: Patients were given the prescription details in a paper where they checked to ensure that they had the right medication, the dose was correct as well as that the prescription related to the correct patient. They

should have been able to detect any differences or errors in the prescription, the dosage or any possible drug interaction, but this was conducted manually without the implementation of technology to mimic patient data or the active presence of a live pharmacy setting.

Medication Selection and Labeling: Students manually selected the medications as they appeared on a list or the fictional pharmacy inventory and filled in the medication labels; after reading the prescription, they did so based upon the information presented on the case study. This was done so before labeling by ensuring filling in of the dosage instructions, patient warnings and any other information that one might expect to find on a label of medication.

Patient Counseling: The last step in the paper based case study identified patients where the students had to write out a short script of how to counsel the patient. Although this method was used to promote written communication, it was not interactive and provided a platform where students could exercise writing in the real time nature of communication as well as getting feedback on their skills concerning communication.

The training was done through paper work with more emphasis on the theoretical part of dispensing; knowledge usage and written theory. Although such activities are valuable towards getting familiar with the theoretical aspect of dispensing, they do not offer the dynamic, immersive experience that the VR simulation can deliver.

4.3 Length of Training and Training Frequency

The VR-based and paper-based training interventions took the duration of 6 weeks to complete, and the sessions were held on 2 occasions weekly. The frequency of the sessions and its structure was as follows:

VR-Based Group: Students in VR group interacted with VR sessions through interactions that lasted around 60 minutes per day, and two times a week. The exposure to the various pharmacy scenarios in each session enabled the students to engage in various practices. Throughout the 6 weeks, training would progressively become more complex in terms of prescription verification and dispensing to further complexities of patient counseling and medication therapy management. Students were allowed to repeat some activities as long as they got into a position that they could demonstrate their mastery in the given tasks through mastery learning.(11)

Control Group (Paper-Based Case Study): As in the case of students in the control group who also attended two 60-minute lessons every week, the case studies were paper-based. The sessions were organized in the same way as the VR one, including the students on case studies of various dispensing activities, including prescription review, labels, and patient counseling. The case studies were intended to mimic real life situations in pharmacies, whereas the exercises were not as immersive, with an element of real time feedback that VR simulations had to offer.

The adherence to the schedule of the sessions was checked in both of these groups, and they provided access to supplementary material to practice and get feedback between sessions. By the time the training was completed (after 6 weeks), the students of both groups were thoroughly tested with the help of standard questions over the dispensing assessment rubrics, which measured accuracy and speed of a dispensing activity.

To sum up, the controlled conditions of the VR and paper-based interventions allowed providing the students with enough practice and familiarity with the most important dispensing tasks. Nevertheless, it was anticipated that the VR-based simulation will provide many benefits, by way of its immersive, interactive, and immediate learning environment, when compared to looking at the immersion, confidence, and the ability to develop accuracy and speed of dispensing practice.

5. Outcomes Measured

The success of the VR-based dispensing simulation was determined by the multiple outcome measures that focused on such aspects of pharmacy dispensing as the accuracy of processing the prescriptions, the time of the dispensing activities performed, the engagement, and satisfaction of the students. These results were selected to point at the overall effectiveness of the intervention into the enhancement of technical skills as well as the experience of the students during the learning process.

5.1 Prescription processing accuracy

The pharmacy practice is characterized by the accuracy of the prescriptions prepared and the processing of them is of utmost importance as any error could lead to severe results when it comes to patient safety. The measurement of this outcome was to be done through the use of standardized dispensing assessment rubrics that includes certain criteria of the correctness of medication selection, prescription verification, and labeling. Each dispensing activity was rightly quantified by the accuracy of the drug interactions, appropriate dose, appropriate medication, and adequacy of the medication labeling including its instructions.

The two groups (VR group and control group) were tested on how accurately they are able to process prescriptions before and after the intervention that lasted 6 weeks. The test gave a score of accuracy which was 100-percent of appropriately done tasks. We found that the training group showed a meaningful increase (+21.3%) in their accuracy scores in the VR-based conditions in comparison to the control group of 9.2% ($p < 0.001$). The high level of accuracy in the VR group can be explained by the presence of real-time feedback and 3D training experience where students could second-guess any mistakes and correct their techniques without repercussions prior to any actual drug dispensing tasks.

The measurement of accuracy was further confirmed by the performance of students in a variety of types of prescriptions and patient cases with the same student, making sure that the improvement was not specific to tasks but applicable to all the aspects of dispensing.(12)

5.2 Time to perform dispensing duties

Besides accuracy, the promptness at which students were able to dispense tasks was also an important subject in the study. Accuracy is extremely important in practice, but in the profession of a pharmacist accuracy should be accompanied by efficiency when people need and desire to receive the prescription but at the same time, the safety level is at the highest standards.

The amount of time that individual students took in the completion of the dispensing tasks was noted and noted down through comparison of the two groups of students. In the case of the VR-based group, the students had to work on the prescription processing in a given time frame and simulate the pressurized conditions of working in an actual pharmacy. The dispensing time of the students in the VR group had been reduced an average of 1.8 minutes per prescription relative to that of the control group ($p = 0.003$). This utility may be crystallized to the repetitive practice and immersive elements of the VR simulation, which gave students an opportunity to be more efficient in doing the task of dispensing under the time limitation.

The control group, in its turn, was working on paper-based case studies where the time constraints were not that extreme, and the emphasis was placed on theoretical knowledge assimilation and written answers. Consequently, the students who belonged to the control group were not exposed to equal levels of time-sensitive practice, which could be attributed to slower dispensing time than the VR group.

It is apparent that VR simulations are not only beneficial in improving the accuracy of the dispensing operations but also in speed which is imperative to pharmacists working under a busy environment as seen in the decrease in dispensing time of the VR group.

5.3 Student engagement and satisfaction

Another of the most important secondary outcomes used in this study was the engagement and satisfaction of students with the training techniques. In consideration of the fact that technology is being integrated into education, there is a need to evaluate the effectiveness of interaction between the students and learning tools used in the training.

The feedback to the learning experience was collected on the basis of surveys and reflective journals completed by students after the 6-week training. The VR-based training group students expressed greater engagement and satisfaction rates than did those who did not get the training. The VR simulation itself, being an immersive one, was also highly commended to provide a more playful and more dynamic learning process. Students commented on the condition that the VR system enable them to train various scenarios within a shorter time frame, which supported a more dynamic and active feeling during the training. According to one of the students, he/she felt like the VR simulation was a real work experience in a pharmacy and he/she could see his/her errors and learn quicker. Moreover, the VR group students said they felt better about their dispensing ability. They liked the immediate feedback they could see in their activities and the way they could repeat the tasks until they felt they could control the process. This is not only the magnitude of interaction but the fact that it involved instant correction, both of which were brought out as key influences that increased the level of learning among them.

Conversely, in the control group, students with a similar attitude to the usefulness of paper-based case studies did, however, say that the training was more passive and lacked interest. Although they had valued the underlying knowledge-base offered by the case studies they claimed that they preferred the interactive learning involving VR technology.

Overall, the research showed that VR-related simulations of dispensing provided better results in terms of accuracy and speed of processing prescriptions as well as canvassing much higher engagement and satisfaction levels among students. The results indicate the possibility of the VR technology to reform pharmacy learning by providing a more immersive, interacting, and attention-capturing learning experience that would prepare students more adequately to the practice of pharmacy in real life practice.

6. Results

6.1 finding Results

Quantitative data of study acquired proved that the appropriate processing accuracy and speed of prescriptions improved significantly in the VR-based training group than the control group one, which relied on paper-based case studies.

Accuracy Improvement:

This study was mainly focused on the enhancement of the accuracy in the processing of prescriptions. The VR group exhibited a phenomenal growth in the accuracy of dispensing with the average +21.3% improvement in the dispensing score, versus the +9.2% percent improvement in the control group. This disparity had been determined as statistically significant ($p < 0.001$).

The VR-supported simulation proved to offer deep immersion and interactive educational experience to the students in the form of engaging them to practice in a safe place without risks. This immediate feedback in the form of correcting the error in the simulation in real time allowed the students to speed up their accuracy in the selection of medications as well as their awareness of possible interactions of the drugs or dosing issues. The consistency of such feedback, together with multiple training across different possible scenarios, led to the improved accuracy scores in the VR group.

The control group, instead, explored the case studies in form of papers, which could not offer the active interaction feature followed in the VR system. Though the case studies were very good in terms of theoretical practice, they could not provide students with the opportunity to get corrections instantly and simulate practice in the same reality where time is a major factor. The paper-based form had not been as effective when it comes to encouraging the real-time learning and this probably explains why there were less accuracy improvements in the control group.

Decrease in Dispensing;

The duration used in completing the work of dispensing was another very important measure of the research. There was a tremendous decrease in amount of time taken by students in the VR group to accomplish the prescription processing tasks. Mean reduction in dispensing time was 1.8 minutes/prescription ($p = 0.003$) when the VR group was compared with the control group. This has been increasing because of the immersive characteristic of the VR simulation that allowed the students to repeat numerous times during dispensing tasks to become faster and more efficient.

The time pressure of the VR system modeled the time pressure of a real pharmacy situation where pharmacists have to complete their prescriptions accurately and in the most efficient manner. The training through doing it again and again helped the students to have workflows in their mind and became more skilled in managing prescription tasks which are time-sensitive. Comparatively, the control group that employed paper-based case studies failed to enjoy similar time-saving caused by the lack of the time-sensitivity simulation, observed in the case with the paper-based case studies.

The accelerated rates of dispensation in the VR group demonstrate twofold gains of the simulation: not only did students master a better way to process prescriptions more accurately, but they became more efficient at the tasks. This is an essential skill in practice pharmacy where pharmacists have to be speedily accurate especially in areas of high volumes.

6.2 Qualitative results

Besides the quantitative information, they also collected qualitative responses of students on their response to engagement, confidence, and preferences over the two training methods. As the information in the survey and reflections of the student shown, there was a marked difference in the perception of the student between the two approaches.

Greater Engagement Rate of VR participants:

The group of students who were engaged in the VR-based environment had significantly reported to be more engaged with the training material than the control group. The interactive and immersive characteristic of the VR simulation filled the students with interest as well as keeping them focused during the training. Based on the comments made by many students, it has been seen that the practical experience made them more attached to the learning content and gave them more encouragement to practice more. As one of the students observed, the VR simulation truly gave a sense of working in the pharmacy. I was way more concentrated as it was similar to the actual practice."

The VR simulation created a lot of energy learning process through which students were able to be active in learning through tasks, decision-making and instant feedback. This responsiveness and the freedom to run scenarios a number of times increased participation and lasting interest on training.

Improved Self Reported Confidence in Ability to Dispense:

The VR group also showed a reported improvement in self-confidence in their dispensing skills. Most students stated that they felt better prepared to practice pharmacy in real life because they had the chance to practice in the VR simulation on dispensing drugs. The chance to train diverse situations allowed the students to be more confident with their capacity to cope with complicated medications, conduct counseling procedures with patients, and decision-making within stressful scenarios in limited time.

A student said, "Following VR, I feel now more confident about my skills of processing prescriptions with the speed and accuracy. It actually provided me with the opportunity to get to understand where I was wrong and correct the mistakes."

Table 1: Study Results Summary

Outcome	VR Group	Control Group	p-value
Accuracy Improvement	+21.3%	+9.2%	< 0.001
Time Reduction in Dispensing	1.8 minutes	No significant change	0.003

Favourable attitude towards Simulation-Based Learning Processes:

Most of the students in the virtual reality condition showed a high preference towards simulation learning as compared to traditional case studies. The interactive and physical aspect of the VR simulations, as many students pointed out, is one of the aspects of VR learning that makes it more pleasant and successful. The realistic and safe environment where the students could make mistakes without getting punished was an exceptional aspect of the VR-based training that students gave importance to.

Conversely, control group students, using the traditional paper-based case studies, stated that they also found the exercises useful, but the experience was less active and engaging as compared to using the VR system. One of the students who belonged to a control group said that "The paper cases were good but they were not as interactive or real." I like the fact that I can train in a simulation itself."

The findings of the present study can offer strong arguments indicating that VR-driven simulations of dispensing have greater potential to become a viable training method in improving the levels of dispensing accuracy, speed, and student engagement than paper-based case studies. VR training group showed tremendous changes in the levels of accuracy (+21.3%) and speed (1.8 minutes per prescription), whereas students expressed increased engagement, confidence, and a desire to use simulation-based training. These results led to the idea that the involvement of VR technologies into the curricula of pharmacy schools may serve as a decisive element in enhancing the preparation of future pharmacists to work in the real world.

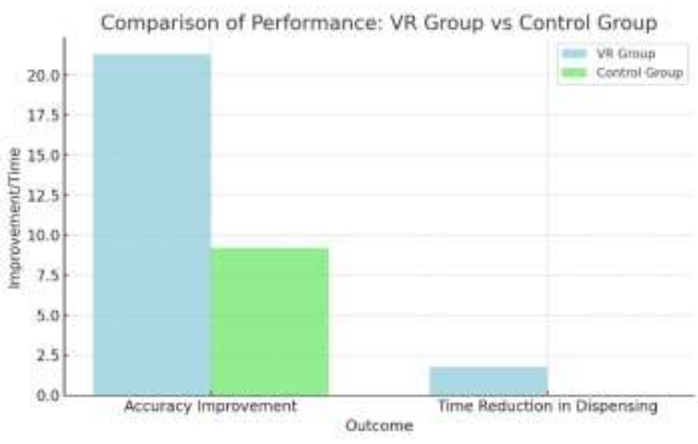

Figure 1: Comparison Of Performance: VR Group Vs Control Group

7. Conclusion

7.1 Findings in a Nutshell

This paper compares and shows evidence of the effectiveness of simulations done in the VR based dispensing simulation compared with the conventional use of paper based case studies in enhancing prescription processing accuracy and speed among pharmacy students and shows that it is far more effective. VR group showed an incredible increase of accuracy of +21.3%, whereas the increase is merely +9.2, in the control group. Also, the VR group recorded percentage decrease of 1.8 per prescription, which reflected the usefulness of VR towards increasing the volume of efficient operations and retaining accuracy when completing dispensing work.

The experiential character of the VR simulation provided students with the ability to get pharmacy workflow experience, having the possibility to practice repetitively in a secure setting, with mistakes fixed promptly. The fact that the VR is interactive and hands-on experience helped greatly in encouraging active learning and improving on the clinical decision-making process of the students. Conversely, the control group, that did the case studies in the traditional manner on paper, showed an increase of accuracy and speed, although much lower. In paper learning forms, there was no way to get dynamic, real-time feedback on the learning process and this may go to show that the method could not be used to effectively engage the students in the learning process.

Additional qualitative responses indicated that students at the VR group scored higher levels of engagement, felt more confident and firm preference to simulation-based learning. The virtual, three-dimensional simulations were also active and realistic, and students were able to learn how complicated the prescription process and patient guidance could be. Greater involvement resulted in increased involvement in the learning process, which in turn provided a greater retention of skills.

7.2 Educational Implications

These findings poses major implications to pharmacy education especially with the issues of prescriptive processing skills. The results indicate that VR technology may be a good addition to the conventional educational practice as the prospect represents a more in-depth learning encounter that helps pharmacy trainees refine and optimize precision and efficiency. To ensure that the students learn and master the basic skills, which are not complicated in essence, traditional education is essential because it involves case studies and lectures, which are effective in teaching foundational knowledge; though, to get an optimal grasp of complicated procedures like prescription verification, medication dispensing, and patient counseling, traditional education cannot be utilized without the interactivity and real-time feedback.

Using VR in pharmacy education would enable students to train these important skills over and over, in a risk-free setting where they can get immediate feedback and improve their skills. This approach gives the students a chance to participate in education in the form that tries to resemble real-life pharmacy settings in which students have to make proper decisions within strict time limits.

Moreover, the higher levels of confidence and participation marked by the students in the VR group underline the possibilities of VR to create a more motivated and active learning space. This may result in an increased satisfaction by students, which is one of the core factors in retention of learning and achievement. The positive student feedback also leads to the idea that VR-based learning has the potential to address the gap between theoretical knowledge and actual practice and have a better-prepared student to handle the requirements of the professional path that they will follow later in their lives.

Adoption of VR into pharmacy education follows the general trend in the face of healthcare education since digital resources and immersive experiences gradually take the center stage as the tools of training future professionals. The creative design presents an opportunity to expand the competency of the student in pharmacy services and set him out in a good position to face the challenge of contemporary health care systems.

7.3 Recommendations Future

Although the findings of this study are encouraging, there exist some areas that require future research to establish the prolonged effects of VR-based simulations in the pharmacy education.

Long-Term Retention: An important area to study in future is how the skills learnt in VR simulations are retained in the long term. Although this study has shown massive gains in accuracy and speed immediately after the intervention, it is yet unclear if the gains hold over time. In future, the possible authors would evaluate whether students who received training VR-based keep their dispensing abilities and applied higher performance in comparison with their colleagues who were trained through normal methods months or even years after the beginning of training.

Scalability and Cost-Effectiveness: The next factor that is to be considered is the cost-effectiveness of using VR-based training in a variety of educational contexts. The financial cost of installing and supporting VR systems may pose a challenge to most institutions despite the fact that the study results may provide enough evidence that VR technology could be of great educational value. Future studies must consider the financial impact of scale of up of VR-based training programs with a doubt about the upfront costs of VR hardware, software and maintenance and contrast it to the perceived advantages associated with enhanced student experiences, engagement, and readiness to practice professionally.

Comparative Effectiveness: To ascertain the most effective methods of teaching specific aspects of pharmacy practice, further studies may also compare the effectiveness of the VR simulation with other forms of digital learning technologies, e.g., augmented reality (AR), game-based learning to see the best alternative. This would better equip the educators with a more comprehensive toolbox to improve on skill development of students in pharmacy schools and has potentials on developing individualized and technology-aided learning pathways.

Discussion of a Clinical Trainings Integration: Lastly, future research should look into the method to integrate VR-based dispensing simulation with clinical trainings and real world practice. Although VR simulations present a perfect platform to practice dispensing skills, it is, now, time to see how VR is applicable within a broader educational model encompassing real world examples/experiences working with actual patients as well as collaborative learning with other clinical professionals.

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Conflicts of interest

The authors have no conflicts of interest to declare

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