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Original article

# Pharmacy student's perceptions, behaviours and attitudes toward virtual reality simulation

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ABSTRACT

*Aims:* The definition of virtual reality simulation (VRS) used for study is the recreation of realistic simulation in a fully online situation with an immersive environment for learning an activity. The study aims to evaluate pharmacy students' perspectives, behavioral and attitude characteristics in the process of VRS course requiring practical skills.

*Materials and methods:* This cross-sectional study was based on quantitative questionnaires analysis. A five-point Likert Scale (rating from 1 = Strongly Disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly Agree) was utilized to measure the extent to which the students agrees on 30 statements comprised in A-E sections related to VRS. The validity and reliability of the questionnaire were studied by the Cronbach's Alpha calculation.

*Results:* A total of 119 junior and senior pharmacy students, aged 18–25, participated in this study. There is no significant gender difference ($P > 0.05$) and grade difference ($P > 0.05$) in mean perception score, mean attitude score, mean behavior score and comparison score respectively. Most pharmacy students had positive perception that VRS could help them in practical ability (61.4 %), autonomous learning (68.9 %) and theoretical knowledge (61.4 %). Nevertheless, less than half the students agreed that VRS courses were indispensable (44.5 %) and needed to be increased (42.9 %). Moreover, the 'disagree' statement (33.6 %) exceeded 'agree' statement (27.7 %) about the question of whether preferring VRS courses to lab teaching. Interestingly, a significant positive correlation that was observed between mean perception score and mean attitude score ($r = 0.76$, $p < 0.001$), mean comparison ($r = 0.68$, $p < 0.001$) and mean behavior ($r = 067$, $p < 0.001$), which revealed that students who thought VRS was beneficial were more likely to accept it.

*Conclusion:* The study highlights the need to establish an interactive, immersive and measurable VRS courses. It is suggested that good interaction between the faculty and student, technology improvement and blended programmatic assessment should be involved in challenges for implementing VRS courses.



## 1. Introduction

The COVID-19 pandemic affected education activities worldwide and impacted more than hundreds of millions of students (Chen et al., 2020). As a result, distance E-learning dominated teaching method and various virtual reality (VR) platforms boom up to maintain the continuity of education (Almetwazi et al., 2020). With the unprecedented dependence on online services and the popularization of virtual reality simulation(VRS) technology, simulation has never been closer to the real world. The rapid development of information technology represented by the Internet, big data, VR, artificial intelligence (AI) and block chain has brought great changes to the global healthcare education and

*Abbreviations:* VRS, Virtual Reality Simulation; VR, Virtual Reality; 3D, Three-dimensional; WUST, Wuhan University of Science and Technology; AR, Augmented Reality.

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social development (Senbekov et al., 2020). VR is defined as an artificial environment which is experienced through sensory stimuli (such as sights and sounds) provided by a computer and in which one's actions partially determine what happens in the environment (Coyne et al., 2019). VRS teaching is an important measure of adaption to new technological changes, which is of great significance to the development of universities (de Vries et al., 2019).Therefore, the problems facing the new educational model different from traditional ones should been drawn attention and given corresponding countermeasures.

In the past decades, the prevalence of simulation widely in medical education varies in different countries. Especially, simulation in pharmacy education can be found in various forms including simulation using electronic medical record and standardized patients, simulation with virtual community and hospital (See et al., 2018; Mai et al., 2019). In American, conducting real-time comprehensive clinic visits with mock patients aimed to assess the effect of incorporating virtual patient activities in a pharmacy skills lab on student competence and confidence (Taglieri et al., 2017). Additional, pharmacy students' perceptions of the value and relevance of virtual community and virtual hospital on-campus placement programs were explored and evaluated (Lucas et al., 2019). In China, many researches paid attention to the instruction of VR programmers, the illumination of advantages, and establishment of evaluation system. Many studies focused on that VRS reduced the operating costs of university laboratory projects, chemicalsolvents pollution, meanwhile, increased the efficiency of information sharing and the utilization of valuable equipment. However, few highlighted the students' feedback about their conception and preference, experiential understanding of learning, behavior judgement, and the VRS-practice gap between the application in VRS and in lab teaching from the students' point of view. So far, the systematic study aimed at pharmacy students' feedback toward virtual reality simulation is still limited.

Wuhan University of Science and Technology has a history of 64 years, and the Pharmacy department was established in 2005. Main pharmaceutical courses distributed mostly in the junior and senior years, composed of Medicinal Chemistry, Pharmacology, Pharmaceutics, Natural Products Chemistry, Medicinal Analysis, Clinical Pharmacokinetics and so on. The proportion of theoretical and experimental curriculum is basically equal. As a result, students gained an unprecedented amount of experience from intensive desktop VRS courses in the COVID-19 pandemic, which provides a necessary prerequisite for the research of virtual teaching.

Herein, this study focus on exploring an effective and accessible teaching method for pharmaceutical VRS courses of undergraduates, assessing the possible challenges, limitations potential improvements as well as. The study aims to evaluate pharmacy students' perspectives, behavioral and attitude characteristics in the process of VRS course. In addition, the results of this study may provide evidence to courses setting, outcomes evaluation and implementation guidelines for conducting pharmaceutical VRS.

## 2. Materials and methods

This study is a cross-sectional survey method consisting of Likert five-grade scale questions in the form of a structured questionnaire (Bin Saleh et al., 2015; Ramia et al., 2016). Data were collected from 119 junior and senior students major in pharmacy of Wuhan University of Science and Technology, who have took 20 or more online VRS sessions on national simulation platform. The questionnaire was comprised of five measurable domains such as demographic characteristics, perspectives, attitude towards VRS, behavioral characteristics and comparison between VRS and lab teaching. Section A of the questionnaire focused on demographic characteristics and open issues; section B with six questions was about students' perspectives regarding VRS; section C with 7 questions aimed to judge their attitude towards VRS; section D with 6 questions aimed to assess cognition comparison between VRS and lab teaching; section E with 5 questions aimed to assess behavior characteristics of the respondents. Students' responses were recorded with a 5-point Likert scale rating; 1 = Strongly Disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly Agree. The Likert scale was selected to enable students to evaluate their level of agreement accurately in a familiar format without any confusion. These questions were designed and revised by experienced teachers in VRS to ensure their feasibility and understandability. Objectives were explained to participants at the beginning of the questionnaire, and students gave consent to participate in the study. Then the final version was distributed to participants and study was proceeded based on the successful completed questionnaires.

### 2.1. Data collection method

The online questionnaire was distributed to all participating students anonymous in the form of online questionnaires and 119 students responded. The survey was voluntary completely and no incentives were provided. Participants were informed previously that the final results would be used for scientific purposes only. Sufficient measures were taken to ensure that students did not feel any pressure to participate in. To avoid any possible bias in filling out and processing the questionnaire, all responses are anonymous. The validity and reliability of the questionnaire were studied before data analysis.

A: Validity

It is the measure of the scale and content of the questions designed in the research tool (questionnaire). Content validity was used in the study and evaluated by the qualified individuals. Then necessary corrections were made for each question.

B: Reliability

In the current study, the internal consistency coefficient of the questionnaire item response was determined by Cronbach's Alpha (Table 1). The 'Perspectives' module scored 0.94, 'Attitude' module scored 0.92, 'Comparison' module scored 0.87, 'Behavioral' module scored 0.92. All areas have a Cronbach Alpha > 0.7 indicating reliability between items in each subsection.

### 2.2. Ethical issues

Before distributing and administering the questionnaires, permission was sought and granted by the institutional review board of Wuhan University of Science and Technology. The purpose of the study was informed and all the students agreed to participate voluntarily. The confidentiality and anonymity of the respondents were ensured.

### 2.3. Data analysis

The obtained data were analyzed using SPSS (IBM Corporation, NY, USA, version 26) for descriptive and inferential analysis, and frequency and percentage were reported as well. The internal consistency of items under each module was assessed by Cronbach's Alpha. Then mean scores had been got respectively for each item of perspectives, attitude, comparison, behavioral characteristics

**Table 1**
Cronbach's Alpha coefficient.

| Variable | items | Cronbach's Alpha score |
|---|---|---|
| Perspective | 6 | 0.94 |
| Attitude | 7 | 0.92 |
| Comparison | 6 | 0.87 |
| Behavior | 5 | 0.92 |

in the VRS process (Table 1). There is no significant gender difference ($P > 0.05$) and grade difference ($P > 0.05$) in mean perception score, mean attitude score, mean behavior score and comparison score respectively. The date also exhibited skewness and correlation computed by Spearman's Rho. The differences of gender and grade were tested by Wilcoxon test. A $P$-value less than or equal to 0.05 was considered statistically significant. Data were reported as mean and standard deviations.

## 3. Results

The total numbers of respondents were 119, consisted with female (68.9 %) and male (31.1 %). Majority of the students was between 21 and 23 years (97.5 %). Respondents (98.3 %) dealt with the problem proactively if they were stuck in the process of VRS. However, only 21.9 % of the respondents agreed VRS increase memorization over the time than lab teaching. Most of the students (80.7 %) believed that VRS could help them get familiar with experimental process and operation, but few (38.7 %) admitted that their hands-on ability have been improved. How do they select favorite VRS projects in the course bank management system? The most reason is they (75.6 %) would like to try that were impossible to be carried out in lab (Table 2).

**Table 2**
Demographic characteristics and experiences of respondents. (n = 119).

| Demographic variables | n (%) |
|---|---|
| **Gender** | |
| male | 37(31.1) |
| female | 82(68.9) |
| **Age** | |
| 18 ~ 19 years | 1(0.8) |
| 20 ~ 21 years | 66(55.5) |
| 22 ~ 23 years | 50(42.0) |
| 24 ~ 25 years | 2(1.7) |
| **If stuck in the process of VRS, I will** | |
| Ask the teacher for help | 2(1.7) |
| Ask classmates for help | 46(38.7) |
| Change another VRS project | 14(11.8) |
| Try to solve it by myself | 55(46.2) |
| Stop VRS | 2(1.7) |
| **Compared with lab teaching, VRS increase memorization over the time** | |
| extremely longer | 4(3.4) |
| longer | 22(18.5) |
| almost | 46(38.7) |
| shorter | 43(36.1) |
| extremely shorter | 4(3.4) |
| **What will I gain from VRS (including but not limited to)** | |
| I am more familiar with the process and operation | 96(80.7) |
| I master the important and difficult points and matters that need attention | 70(58.8) |
| I further understand the knowledge points in the books | 66(55.5) |
| My hands-on ability have improved | 46(38.7) |
| Expand my knowledge scope and gain new knowledge | 71(59.7) |
| **Reasons for selection of VRS projects in the course (you can choose more than one).** | |
| I will engage in related professional job in the future | 33(27.7) |
| I will choose a postgraduate program in a related major | 43(36.1) |
| The operation is simple, easy to understand and complete | 60(50.2) |
| I think it is very interesting | 55(46.2) |
| I will expand my knowledge of pharmaceutical specialty | 42(35.3) |
| I would like to try that cannot be carried out in lab | 90(75.6) |

### 3.1. Perception

There is no significant gender ($P > 0.05$) and grade difference ($P > 0.05$) in mean perception score. To assess the perception of students about the advantages of VRS, six questions about their responses were asked and shown in Table 3. More than half of the students gave "agree" and "strongly agree" on the first four questions. About 60 % of the students thought that VRS increased their interest in learning pharmacy, which achieved the highest mean score among perception item. They also approved highly that VRS could help them in the ability of practical (61.4 %), autonomous learning (68.9 %) and theoretical knowledge (61.4 %) respectively. At the same time, of the respondents, 44.5 % agreed that VRS was indispensable in the teaching process and 42.9 % agreed that the VRS course should be added appropriately. Meanwhile, "neutral" answers to these two questions was given the highest, with 43.7 % and 42.0 % respectively. On both issues, the proportion of "neutral" was almost equal to that of "agreement".

### 3.2. Attitude

There is no significant gender ($P > 0.05$) and grade difference ($P > 0.05$) in mean attitude score. Students' attitudes towards VRS were presented in Table 4. Most students (75.6 %) agreed they would try it again if they didn't do well in the first round and they (70.6 %) responded that they were able to complete on time. Simultaneously, they (54.6 %) could think carefully about the questions of VRS and they (59.7 %) felt the immersive sense of VRS was strong. In a conclusion, they (48.7 %) liked VRS. Almost a half of students (49.6 %) agreed that the score of VRS was reasonable. However, there were quite a few neutral responses when asked whether they felt pleasant when operating simulation (46.2 %) and be willing to recommend excellent VRS to others (44.5 %). Therefore, the mean of both questions appeared as the lower scores.

The answers related with the comparison of VRS and lab teaching were shown in Table 5. Of the respondents, 61.4 % admitted that they had less stress while performing VRS. More than half of students (60.5 %) agreed that the virtual experiment's was easier to operate. Nearly half of students thought their scores of VRS were relative higher (55.5 %) and VRS course was more conducive to writing experimental report (47.1 %). Nevertheless, students still gave a 'neutral' statement (38.4 %) when asked whether they prefer VRS to lab teaching. Moreover, the 'disagree' statement (33.6 %) exceeded 'agree' statement (27.7 %) in this item.

### 3.3. Behavior

There is no significant gender ($P > 0.05$) and grade difference ($P > 0.05$) in mean behavior score. Students' behavior in VRS were shown in Table 6. More than two-third of students (68.1 %) agreed that they would watch the leading demonstration video, and they could think about related theoretical knowledge (62.2 %). Furthermore, over half of students (63.0 %) were able to avoid doing meaningless things consciously and they (60.5 %) knew how to operate. It is worth noting that, of the respondents, 38.7 % thought they were more attentive than in pharmaceutical lab teaching, meanwhile almost half of students (48.7 %) held the neutral view on this issue.

A significant positive correlation was observed between mean perception score and mean attitude score (r = 0.76, $p < 0.001$), mean comparison (r = 0.68, $p < 0.001$) and mean behavior (r = 067, $p < 0.001$) (Table 7). It reflected that students who thought

**Table 3**
Respondents' perception towards VRS.

| | Participants' response, n (%) | | | | | Mean | Std. Div. | n |
|---|---|---|---|---|---|---|---|---|
| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree | | | |
| It increases my interest in learning pharmacy | 3 (2.5) | 9 (7.6) | 36 (30.3) | 41 (34.5) | 30 (25.2) | 3.72 | 1.008 | 119 |
| It is useful for my ability of autonomous leaning and problem-solving | 3 (2.5) | 12 (10.1) | 34 (28.6) | 39 (32.8) | 31 (26.1) | 3.7 | 1.046 | 119 |
| It is good for clinical and practical skills | 3 (2.5) | 13 (10.9) | 30(25.2) | 46 (38.7) | 27 (22.7) | 3.68 | 1.025 | 119 |
| It is good for theoretical study | 3 (2.5) | 11 (9.2) | 37 (31.1) | 42 (35.3) | 26 (21.9) | 3.65 | 1.005 | 119 |
| It is essential in the process of teaching | 5 (4.2) | 9 (7.6) | 52 (43.7) | 31 (26.0) | 22 (18.5) | 3.47 | 1.015 | 119 |
| We need more VRS courses | 7 (5.9) | 11 (9.2) | 50 (42.0) | 36 (30.3) | 15 (12.6) | 3.34 | 1.012 | 119 |

**Table 4**
Respondents' attitude towards VRS.

| | Participants' response, n (%) | | | | | Mean | Std. Div. | n |
|---|---|---|---|---|---|---|---|---|
| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree | | | |
| I will try again if I failure | 1 (0.8) | 4 (3.4) | 24 (20.2) | 46 (38.7) | 44 (37.0) | 4.08 | 0.885 | 119 |
| I could complete it on time | 2 (1.7) | 3 (2.5) | 30 (25.2) | 46 (38.7) | 38 (31.9) | 3.97 | 0.911 | 119 |
| I'm willing to think over the questions of VRS | 1 (0.8) | 11 (9.2) | 42 (35.3) | 47 (39.5) | 18 (15.1) | 3.59 | 0.887 | 119 |
| The real sense of VRS is strong | 3 (2.5) | 8 (6.7) | 37 (31.1) | 61 (51.3) | 10 (8.4) | 3.56 | 0.84 | 119 |
| I like VRS | 4 (3.4) | 10 (8.4) | 47 (39.5) | 40 (33.6) | 18 (15.1) | 3.49 | 0.964 | 119 |
| The VRS score is reasonable | 4 (3.4) | 11 (9.2) | 45 (37.8) | 41 (34.5) | 18 (15.1) | 3.49 | 0.973 | 119 |
| I will recommend excellent VRS to others | 3 (2.5) | 15 (12.6) | 53 (44.5) | 30 (25.2) | 18 (15.1) | 3.38 | 0.974 | 119 |
| I feel pleasant when operating simulation | 6 (5.0) | 12 (10.1) | 55 (46.2) | 28 (23.5) | 18 (15.1) | 3.34 | 1.019 | 119 |

**Table 5**
Comparison of VRS courses and lab teaching.

| | Participants' response, n (%) | | | | | Mean | Std. Div. | n |
|---|---|---|---|---|---|---|---|---|
| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree | | | |
| I have less stress in VRS courses | 3 (2.5) | 9 (7.6) | 34 (28.6) | 45 (37.8) | 28 (23.5) | 3.72 | 0.991 | 119 |
| VRS is easier to operate | 5 (4.2) | 8 (6.7) | 34 (28.6) | 46 (38.7) | 26 (21.9) | 3.67 | 1.026 | 119 |
| My VRS score would be higher than that of lab teaching | 4 (3.4) | 4 (3.4) | 45 (37.8) | 44 (37.0) | 22 (18.5) | 3.64 | 0.936 | 119 |
| The VRS course is more conductive to write a report | 4 (3.4) | 15 (12.6) | 44 (37.0) | 40 (33.6) | 16 (13.5) | 3.41 | 0.986 | 119 |
| I prefer VRS courses to lab teaching | 8 (6.7) | 32 (26.9) | 46 (38.7) | 19 (16.0) | 14 (11.8) | 2.99 | 1.085 | 119 |

VRS was beneficial were tended to accept it easier in the comparison of VRS and lab teaching. Students who enjoy VRS tend to be more self-conscious and focused during VRS.

## 4. Discussion

This study discussed pharmacy students' perspectives, attitude, comparison and behavioral characteristics in the process of VRS in Wuhan University of Science and Technology during the COVID-19 pandemic. In the post-epidemic era, virtual education has become the new norm and understanding students' needs will be a challenge (Almetwazi et al., 2020).

VRS applied in pharmaceutical courses provide vivid demonstration and rich teaching resources (Smith et al., 2018). Engagement in VRS activities has been shown to assist learners in developing knowledge and skills (Coyne, 2021). VRS used in favorable cooperation pharmaceutical education possesses advantages of safety, economy, practice, and repeatability and *etc*. Moreover, the diversity of VRS courses provides students with the possibility of adaptability to a variety of pharmaceutical scenes, including community pharmacies, clinical pharmaceutics, pharmaceutical company, research and development of new drugs and etc. Students could choose freely diverse VRS courses beyond limited classroom teaching and laboratory teaching curriculum. Additionally, participants indicated positive attitude on most items towards

**Table 6**
Respondents' behavior while operating VRS.

| | Participants' response, n (%) | | | | | Mean | Std. Div. | n |
|---|---|---|---|---|---|---|---|---|
| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree | | | |
| I watch the leading demonstration video before VRS carefully | 1 (0.8) | 7 (5.9) | 30 (25.2) | 38 (31.9) | 43 (36.1) | 3.97 | 0.965 | 119 |
| I will think about related theoretical knowledge carefully | 1 (0.8) | 5 (4.2) | 39 (32.8) | 42 (35.3) | 32 (26.9) | 3.83 | 0.905 | 119 |
| I am able to avoid doing meaningless things consciously | 1 (0.8) | 7 (5.9) | 36 (30.3) | 43 (36.1) | 32 (26.9) | 3.82 | 0.927 | 119 |
| I know how to operate VRS | 1 (0.8) | 11 (9.2) | 35 (29.4) | 45 (37.8) | 27 (22.7) | 3.72 | 0.947 | 119 |
| I am more focused than in the classroom | 1 (0.8) | 14 (11.8) | 58 (48.7) | 31 (26.1) | 15 (12.6) | 3.38 | 0.883 | 119 |

**Table 7**
Correlation between perception, attitude, behavior and behavior score.

| Variable | Correlation coefficient | *P*-value* |
|---|---|---|
| Perspective-Attitude | 0.76 | 0.001 |
| Perspective-Comparison | 0.68 | 0.001 |
| Perspective-Behavior | 0.67 | 0.001 |

* Correlation significant at $P < 0.01$ levels (2 tailed).

VRS. The study exhibited correlation between item of 'Cognition' and 'Comparison', 'Attitude' and 'Behavior' by pair-wise comparison calculation, which indicated that students who liked VRS were inclined to be more conscious and attentive in the process of VRS. It can be regarded a model of useful positive feedback (Hammad et al., 2022).

Good interaction between faculty and student could be considered as one of major challenges for implementing VRS courses. Our survey clearly showed hardly any students would ask teachers for help, meanwhile most of students tended to solve problems by themselves. Most students insisted that they prefer operation in lab and indicated a reluctance to increase VRS courses online even if they admitted the advantages of VRS, such as improving learning ability, bringing less pressure and enhancing experimental skills. Therefore, it is suggested that the interaction between faculty and student should be sufficient and the immediate feedback should be effective (Hammad et al., 2022). Traditional teaching courses may be involved in individual coaching or lab presentation based on in-person skills focused on communication (VanLangen et al., 2021). The research showed that the closer the relationship between faculty and student, the higher the level of students' ability development (Pianta et al., 2021). Teachers could give instant judgement about students' attitude and behavior, for example, finding out timely whether students are fully engaged in learning or not. Additionally, these results showed some participants prefer self-directed learning over traditional didactic teaching. The reality is that due to the lack of physical contact in virtual classrooms, a good collaborative lab environment will be more popular with young college students. This might explain why they liked VRS and admitted so many benefits of them, but they still couldn't be willing to regard VRS as an alternative of offline education. Therefore, the decreased student–teacher interaction and student engagement in virtual education was the imperative matter of concern (Singal et al., 2021). Lectures, team work and seminar activities in pre-VRS period should be encouraged to be involved in order to improve the students' communication and psychomotor skills and divergent thinking. It is also suggested to establish an appropriate teach-back system in order to strengthen the communication between faculty members and students. The students might recognize VRS as a pleasant even funny journey, and be willing to recommend and share excellent ones with others.

Another foreseeable goal is to improve VRS immersion involved new technology equipment. It should be noted that majority considered the VRS memory didn't increase memorization over a short time and about a half of students need to be attracted to focus more on VRS courses. Nowadays, the common style of VRS curriculum are usually 3D-desktop screen and keyboard with the characteristic of feasible and well-accepted in China. However, it is inferior to immersive VRS based on head-mounted VR immersion technology in terms of engagements, interactivity, and enjoyment. China promotes the competency-oriented education and teaching reform, pushes the deep integration of information technology and medical education, cultivates first-class medical talents, and serves the construction of healthy China (Wang et al., 2021). At present, most universities can achieve the goal of desktop VRS teaching, and share the VRS projects on laboratory platform websites designated by the Ministry of Education, even in remote underdeveloped areas of China. However, only a few pharmaceutical institutions could provide head-mounted virtual equipment for undergrads, nor our department had yet. VRS implemented on network technology can gradually upgrade with Augmented Reality (AR) technology, aiming to enhancing the reality technology and intelligence, and improving the breadth and depth of experimental teaching information (Kawaguchi-Suzuki et al., 2020). It can be foreseen that infrastructure-building and significant investment in VRS will strengthen the integration of experimental teaching and information technology in the near future.

In addition, although quite a few students insisted VRS is easy and the score is higher, the current assessment standards, which consist mainly of final completion and attendance online, should be greatly reformed. During the period, real-time dynamic process were not recorded, nor were the mid-term and deep engagement evaluated. Efforts should be made to introduce the mutual supplementing of the programmatic assessment and competency-based assessment in VRS, structuring a framework of "Blended Programmatic Assessment" (Mahajan et al., 2021). Multiple assessments can be carried out online coupled with feedback such as problem-based interactive learning, case-based exercises, online discussion. Meanwhile, clear and measurable assessment offline could be designed and implemented as a part of integrated evaluation, for example, collaboration projects and communication offline through text, pictures, video and other media. Summative e-examinations can be conducted using a hybrid model to complement the conventional assessment methods (Coyne et al., 2021; Mahajan et al., 2021). Undoubtedly, Programmatic Assessment (PA) necessitates a diverse set of assessments tolls and strategies. Great efforts need to be adopted suitable measures to formulate guidelines for such endeavors and be taken to tackle VRS assessment collectively.

VRS can be a good supplement with the reality so as to quickly meet the pharmaceutical teaching needs (Michael et al., 2006; Dost et al., 2020). Therefore, there is a need to build a mixed hybrid

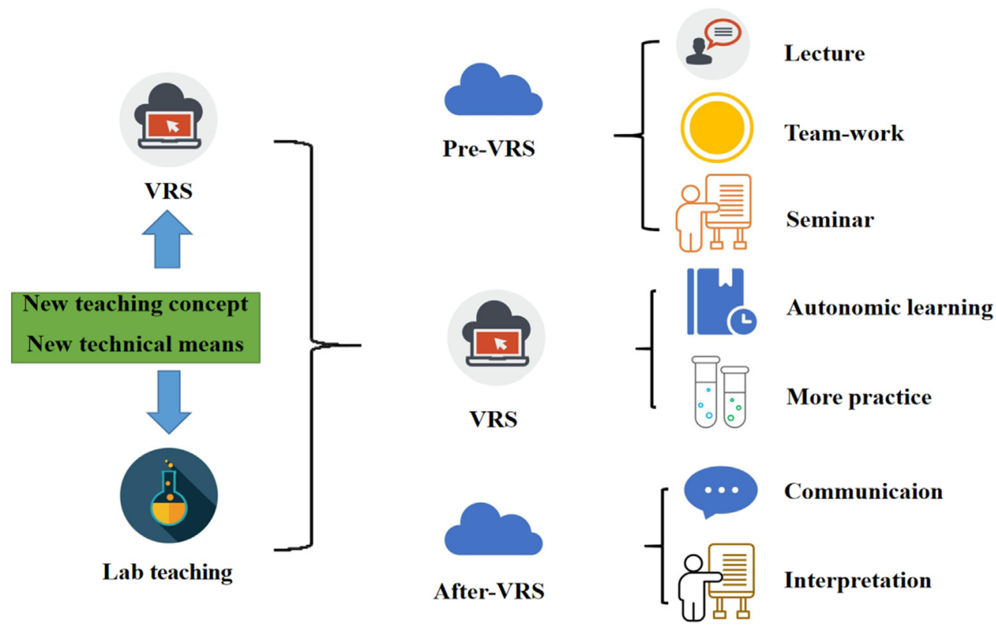


**Fig. 1.** Schematic diagram of pharmaceutical virtual simulation learning paradigm.

model of learning that combines traditional face-to-face and e-learning approaches in the post-lockdown phase. The ideally pattern is to plan a benign paradigm of "reality-virtual reality-reality", combining VRS, e-assessment, online and offline feedback with classroom teaching throughout the whole course (Fig. 1).

## 5. Conclusion

Intensive VRS courses has been an indispensable approach in pharmaceutical education with considerable growth rate during epidemic, which will exert influence on the future of pharmacy education. Our study highlights the need to establish an interactive, immersive and measurable VRS course. Therefore, it is suggested that good interaction between the faculty and student, technology improvement and blended programmatic assessment should be involved in challenges for implementing VRS courses, which will be beneficial to instruct an open, extensible and forward-looking VRS pharmacy education in the future.

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## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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