

**A PROPOSED VIRTUAL PHARMACEUTICAL MANUFACTURING ENVIRONMENT
AS AN ALTERNATIVE SOLUTION TO ENHANCE INDUSTRIAL PHARMACY SKILLS
AMID THE CURRENT CRISIS IN SUDAN****Abubakr A. A. Gassim^{*1}, Elnazeer I. Mohamed¹, Fatehalrahman Faris Magbool²**¹Department of Pharmaceutical Technology, Faculty of Pharmacy, Omdurman Islamic University, Omdurman, Sudan.²Associate Professor of Pharmaceutics, Red Sea University, Sudan.***Corresponding Author: Abubakr A. A. Gassim**Department of Pharmaceutical Technology, Faculty of Pharmacy, Omdurman Islamic University, Omdurman, Sudan. DOI: <https://doi.org/10.5281/zenodo.23118070>**How to cite this Article:** Abubakr A. A. Gassim^{*1}, Elnazeer I. Mohamed¹, Fatehalrahman Faris Magbool² (2026). A Proposed Virtual Pharmaceutical Manufacturing Environment As An Alternative Solution To Enhance Industrial Pharmacy Skills Amid The Current Crisis In Sudan. European Journal of Pharmaceutical and Medical Research, 13(10), 329–337.
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ABSTRACT

Industrial pharmacy education requires both theoretical knowledge and practical experience in pharmaceutical manufacturing, equipment, Good Manufacturing Practice (GMP), Quality Assurance (QA), Quality Control (QC), documentation and related industrial activities. However, the current crisis in Sudan has disrupted higher education, laboratory teaching and access to pharmaceutical manufacturing facilities, creating difficulties in providing students with adequate practical industrial pharmacy training. This study aimed to develop a proposed Virtual Pharmaceutical Manufacturing Environment (VPME) Framework as an alternative educational approach to support industrial pharmacy skills and bridge the gap between theoretical instruction and practical training during periods of disruption. A descriptive analytical framework was used to examine the educational requirements and potential feasibility of VPME from the perspectives of pharmacy students, academic staff and pharmaceutical-industry professionals. A model dataset was used to demonstrate the proposed analysis of current practical-training challenges, stakeholder perceptions of VPME, important pharmaceutical manufacturing processes, GMP, QA and QC requirements, potential educational benefits and implementation challenges. The model analysis included 150 responses, comprising 50 pharmacy students, 50 academic staff and 50 pharmaceutical-industry professionals. The model results indicated substantial perceived disruption to practical industrial pharmacy education. Stakeholders also showed generally positive perceptions of VPME as a complementary educational approach. Important areas identified for inclusion included weighing, mixing, granulation, drying, milling, compression, coating, packaging and quality control. GMP, QA/QC, documentation, deviation management and problem-solving were also identified as important components. The proposed VPME Framework integrates pharmaceutical manufacturing processes and equipment with GMP, QA, QC, interactive learning, assessment, feedback and curriculum integration. The framework is intended to complement rather than replace physical laboratory and industrial training. Further development and evaluation of a functional VPME platform are recommended.

KEYWORDS: Industrial Pharmacy, Pharmaceutical Manufacturing, Virtual Learning, Simulation, Virtual Reality, GMP, Quality Assurance, Quality Control, Sudan, VPME.**INTRODUCTION**

Industrial pharmacy is an important area of pharmaceutical sciences concerned with the formulation, manufacturing, quality assurance, quality control, packaging, storage and distribution of medicines. Pharmaceutical manufacturing requires graduates to combine theoretical pharmaceutical knowledge with practical skills, quality systems and regulatory

requirements (Aulton and Taylor, 2022; Allen, Popovich and Ansel, 2021). Modern pharmaceutical manufacturing increasingly involves advanced equipment, automation, process control, digital technologies and quality-management systems. Therefore, pharmacy graduates require an understanding of manufacturing processes, Good Manufacturing Practice (GMP), Quality Assurance (QA), Quality Control (QC), documentation and

industrial operations (International Council for Harmonisation, 2022; World Health Organization, 2014).

Practical education is important because it allows students to connect theoretical knowledge with professional practice. Experiential learning can support technical competence, problem-solving, critical thinking and professional confidence (Kolb, 2015). In industrial pharmacy, practical training enables students to become familiar with manufacturing equipment, production processes and quality requirements. However, access to practical education may be affected by limited laboratory facilities, financial resources, equipment availability and access to pharmaceutical manufacturing facilities. These difficulties can become more serious during armed conflict and humanitarian crises (International Pharmaceutical Federation, 2021; UNESCO, 2023).

The current crisis in Sudan has created significant disruption to higher education, laboratory-based teaching and opportunities for practical industrial pharmacy training. Damage to educational infrastructure, restricted access to laboratories and reduced opportunities for industrial placements can limit students' exposure to pharmaceutical manufacturing processes and equipment. Such disruption may increase the gap between theoretical education and the practical competencies required for pharmaceutical-industry work.

Digital educational technologies provide a potential approach for supporting practical learning when access to physical facilities is restricted. Simulation and virtual laboratories can provide controlled environments in which learners can practise activities, make decisions and receive feedback. They may also provide opportunities for repeated practice without continuous access to physical laboratories (Lateef, 2010; Reeves and Crippen, 2021; Sellberg, Nazari and Solberg, 2024). Virtual and computerbased simulation have increasingly been used in pharmacy and health-professions education to support experiential learning and practical preparation (Gharib *et al.*, 2023; Phanudulkitti *et al.*, 2023). Virtual reality may additionally provide immersive environments in which learners can interact with simulated equipment and processes, although implementation may be affected by cost, infrastructure, device availability, technical support and usability (Radianti *et al.*, 2020; Pottle, 2019).

Blended learning provides another relevant approach by combining conventional teaching with digital learning activities. Evidence from health-professions and pharmacy education suggests that digital approaches can complement face-to-face education and provide additional opportunities for learning and revision (Liu *et al.*, 2016; Balakrishnan *et al.*, 2021). In pharmaceutical manufacturing, developments associated with Industry 4.0, including automation, data analytics, Internet of Things technologies and digital twins, have also increased the use of digital technologies within manufacturing environments (Arden *et al.*, 2021; Ntamo

et al., 2022). Although an educational virtual environment would not function as a commercial industrial digital twin, these developments provide relevant concepts for representing manufacturing processes and equipment in an educational setting.

Pharmaceutical manufacturing education requires students to understand interconnected production activities, including weighing, mixing, granulation, drying, milling, compression, coating, packaging and quality control. GMP, QA, QC, documentation and quality-related decision-making are also important because quality must be considered throughout the manufacturing process rather than as a separate activity (World Health Organization, 2014; International Council for Harmonisation, 2022). A virtual learning environment could therefore combine manufacturing processes with equipment identification, quality systems, simulated deviations, decision-making, assessment and feedback.

Although simulation and virtual learning have been investigated in several areas of health and pharmacy education, there is comparatively limited evidence concerning an integrated virtual environment specifically focused on pharmaceutical manufacturing education. There is a need to consider how manufacturing processes, equipment, GMP, QA, QC, documentation and industrial pharmacy competencies could be brought together within one educational environment appropriate to the Sudanese context. Recent evidence concerning pharmacy education in Sudan has also highlighted the effects of the current crisis on educational institutions and the importance of alternative approaches to maintaining education (Altayeb *et al.*, 2026; Almahdi, 2026).

Therefore, this study was undertaken in response to the disruption of practical industrial pharmacy education and the resulting limitation of students' access to manufacturing facilities and practical training in Sudan. The study proposes a Virtual Pharmaceutical Manufacturing Environment (VPME) to provide an additional opportunity for students to practise manufacturing processes, understand equipment and apply GMP, QA and QC principles within a controlled learning environment. The proposed approach is intended to support educational continuity and reduce the gap between theoretical instruction and practical industrial pharmacy preparation. VPME is proposed as a complementary approach to physical laboratory and industrial training rather than as a replacement for them.

MATERIALS AND METHODS 2.1 Study Design

A descriptive analytical framework was used to investigate the educational relevance and potential feasibility of the proposed Virtual Pharmaceutical Manufacturing Environment (VPME). The proposed framework considered perspectives relevant to pharmacy students, academic staff and pharmaceutical-industry

professionals regarding practical industrial pharmacy education, manufacturing training requirements and the potential role of virtual learning.

For transparency, the quantitative results presented in this paper are based on a model analysis dataset of 150 responses prepared for the development and presentation of the proposed research framework. These results should therefore be interpreted as model findings rather than as results from verified field data collection.

2.2 Study Setting

The study was situated within the context of pharmacy education and pharmaceutical manufacturing in Sudan, with relevance to Omdurman Islamic University, Faculty of Pharmacy. The research considered three connected areas:

1. pharmacy education.
2. pharmaceutical manufacturing practice; and
3. digital learning for practical education.

2.3 Stakeholder Groups

The proposed study considered three stakeholder groups:

- pharmacy students.
- academic staG; and
- pharmaceutical-industry professionals.

Students were considered in relation to practical learning and exposure to pharmaceutical manufacturing. Academic staG were considered in relation to educational and curriculum requirements, while industry professionals were considered in relation to pharmaceutical manufacturing, Good Manufacturing Practice (GMP), Quality Assurance (QA), Quality Control (QC) and graduate competencies.

2.4 Model Dataset

For the model analysis presented in this paper, a dataset containing 150 responses was prepared and distributed equally across the three stakeholder groups.

Stakeholder group	Number	Percentage
Pharmacy students	50	33.3%
Academic staG	50	33.3%
Industry professionals	50	33.3%
Total	150	100%

2.5 Data Collection Tools

The proposed data collection framework included a structured questionnaire designed to assess the following areas:

- current practical industrial pharmacy training.
- challenges aGecting practical education.
- perceptions of virtual learning.
- manufacturing processes considered important for inclusion in VPME.
- GMP, QA and QC requirements.
- potential benefits of VPME.
- anticipated implementation challenges; and
- preferred features of the proposed VPME.

Semi-structured questions were also designed to obtain professional perspectives from relevant academic and industry stakeholders.

2.6 Development of the VPME Framework

The proposed VPME framework was developed through five main stages.

Stage 1: Identification of Educational Needs

The study considered diGiculties aGecting practical industrial pharmacy education and the need for additional opportunities for practical learning when access to physical facilities is restricted.

Stage 2: Identification of Manufacturing Processes

The proposed virtual environment included the major pharmaceutical manufacturing processes considered relevant to industrial pharmacy education.

- weighing.
- mixing/blending.
- granulation.
- drying.
- milling.
- compression.
- coating.
- packaging; and • quality control.

Stage 3: Integration of GMP, QA and QC

GMP, QA and QC were incorporated throughout the proposed manufacturing workflow rather than being treated as separate topics. This approach was intended to demonstrate the relationship between manufacturing activities and quality requirements.

Stage 4: Educational and Interactive Components

Potential VPME activities included:

- interactive manufacturing workflows.
- equipment identification.
- step-by-step production activities.
- GMP decision-making.
- simulated deviations.
- quality-related scenarios.
- knowledge assessment; and
- feedback.

Stage 5: Review and Refinement

The proposed framework was structured around the identified educational needs, pharmaceutical manufacturing requirements, literature evidence and stakeholder perspectives. The framework was designed as a conceptual basis for future development and evaluation of a functional virtual learning environment.

2.7 Data Analysis

Quantitative data were organised using descriptive statistics, including frequencies, percentages, means and standard deviations. Where comparable stakeholder responses were available, responses were considered across the relevant stakeholder groups.

Qualitative information was intended to be examined thematically using the principles of thematic analysis described by Braun and Clarke (2006).

2.8 Ethical Considerations

The proposed research design considered informed consent, voluntary participation, confidentiality and responsible handling of participant information for any future field implementation. The model analysis presented in this paper did not involve direct

participation of human subjects. No patients, clinical interventions or pharmaceutical products were involved.

RESULTS 3.1 Current Practical Industrial Pharmacy Training

The model analysis indicated generally low levels of agreement that current practical industrial pharmacy education provides sufficient preparation for pharmaceutical industry work.

Table 1: Assessment of Current Practical Training.

Assessment area	Students Mean $\pm$ SD	Academic Sta\ Mean $\pm$ SD
Sufficient practical training/preparation	1.40 $\pm$ 0.60	1.80 $\pm$ 0.70
Adequate access to manufacturing equipment	1.60 $\pm$ 0.70	1.50 $\pm$ 0.60
Adequate manufacturing-process exposure	1.80 $\pm$ 0.80	—
Adequate GMP training/exposure	1.50 $\pm$ 0.60	2.00 $\pm$ 0.80
Adequate QA/QC exposure	1.50 $\pm$ 0.60	2.00 $\pm$ 0.80
Preparation for pharmaceutical industry work	1.30 $\pm$ 0.50	—
Development of industrial pharmacy competencies	—	1.70 $\pm$ 0.70

The model results indicate perceived limitations in practical training, access to manufacturing equipment, exposure to manufacturing processes and preparation for pharmaceutical-industry work.

3.2 Challenges Affecting Practical Training

The main challenges identified in the model analysis were disruption caused by the current crisis, disruption of educational infrastructure, restricted access to pharmaceutical manufacturing facilities, limited laboratory facilities and equipment, and financial limitations.

Table 2: Major Challenges Affecting Practical Training.

Challenge	Students n (%)	Academic Sta\ n (%)
Current crisis	49 (98%)	48 (96%)
Educational infrastructure disruption	46 (92%)	45 (90%)
Limited access to manufacturing facilities	45 (90%)	41 (82%)
Limited laboratory facilities/equipment	43 (86%)	41 (82%)
Financial limitations	—	41 (82%)
Academic/technical staG availability	—	41 (82%)

The current crisis was the most frequently identified challenge among both students and academic staG in the model analysis.

3.3 Effect of the Current Situation

The model analysis showed high agreement that the current situation negatively affected practical pharmacy education.

The mean score for the relevant statements among students was 4.80 $\pm$ 0.40, while academic staG recorded a mean score of 4.70 $\pm$ 0.50.

These model results indicate a perceived increase in the gap between theoretical education and practical industrial pharmacy skills during the current situation.

3.4 Perceptions of VPME

Stakeholders demonstrated generally positive perceptions of the proposed VPME in the model analysis.

Table 3: Stakeholder Perceptions of VPME.

Statement	Students Mean $\pm$ SD	Academic Sta\ Mean $\pm$ SD	Industry Mean $\pm$ SD
VPME could provide additional practical learning	4.50 $\pm$ 0.60	—	—
Virtual simulation could support repeated practice	4.80 $\pm$ 0.40	—	—
VPME could improve equipment understanding	4.60 $\pm$ 0.50	—	4.40 $\pm$ 0.60
VPME could improve GMP understanding	4.40 $\pm$ 0.70	—	4.50 $\pm$ 0.60

VPME should complement conventional training	4.60 ± 0.60	4.50 ± 0.60	4.80 ± 0.40
VPME could prepare students before industrial training	—	4.60 ± 0.50	—
VPME could support learning when facilities are unavailable	—	4.80 ± 0.40	—

Students particularly supported the potential for repeated practice, while academic staG strongly supported the use of VPME as a complementary resource when physical facilities were unavailable. Industry professionals also supported the complementary role of VPME.

3.5 Manufacturing Processes Required

The model analysis indicated that stakeholders considered a broad range of pharmaceutical manufacturing processes important for inclusion in the proposed VPME.

Table 4: Manufacturing Processes Considered Important for VPME.

Manufacturing process	Students	Academic Sta\	Industry
Weighing	86%	84%	80%
Mixing/blending	84%	86%	82%
Granulation	90%	86%	88%
Drying	82%	82%	80%
Milling	80%	80%	78%
Compression	94%	90%	92%
Coating	88%	86%	86%
Packaging	84%	82%	80%
Quality control	92%	88%	96%

Compression and quality control were among the most frequently identified areas for inclusion in the proposed VPME.

Industry professionals showed strong emphasis on GMP, QA/QC and problem-solving.

3.6 GMP, QA and QC Requirements

GMP, QA and QC, documentation, deviation management and problem-solving were identified as important components of the proposed virtual environment.

These model results support the integration of quality-related decision-making into pharmaceutical manufacturing simulations rather than presenting quality systems as isolated theoretical topics.

Among students, QA/QC was identified by 94% and GMP by 92%. Among academic staG, QA/QC was identified by 96% and GMP by 94%.

3.7 Expected Benefits

Table 5: Expected Benefits of VPME.

Expected benefit	Students n (%)
Continue learning during disruption	48 (96%)
Repeated practice	45 (90%)
Improved equipment understanding	43 (86%)
Improved manufacturing-process understanding	42 (84%)

The ability to continue learning during disruption was the most frequently identified potential benefit in the model analysis, followed by repeated practice.

3.8 Implementation Challenges

The model analysis identified several anticipated challenges that would need to be considered before implementation of VPME.

Table 6: Anticipated Implementation Challenges

Challenge	Students n (%)	Academic Sta\ n (%)
Internet/connectivity	46 (92%)	42 (84%)
Suitable devices	42 (84%)	42 (84%)
Financial limitations	35 (70%)	—
Academic staG training	—	44 (88%)
Curriculum integration	—	40 (80%)
Technical support	—	42 (84%)

The model results indicate that implementation would require attention to internet connectivity, suitable devices, academic staG training, technical support and curriculum integration.

3.9 Key Findings

The main findings relevant to the proposed VPME framework were:

1. Practical industrial pharmacy training was perceived as limited.
2. The current crisis was identified as a major barrier to practical education.
3. Stakeholders showed generally positive perceptions of the proposed VPME.
4. Manufacturing processes should be represented as an integrated workflow.
5. Compression and quality control were among the most frequently identified processes for inclusion.
6. GMP, QA/QC, documentation, deviation management and problem-solving were identified as important requirements.
7. Repeated practice and educational continuity were identified as important potential benefits.
8. Connectivity, device availability, staG training and technical support were identified as major implementation considerations.

DISCUSSION 4.1 Discussion

The model analysis supports the importance of practical industrial pharmacy education and indicates that disruption to educational infrastructure may create a gap between theoretical knowledge and practical preparation. This is consistent with the broader principle that pharmacy education should develop both theoretical knowledge and professional competencies. Practical and experiential learning allows students to apply theoretical knowledge to professional situations (Kolb, 2015).

The model analysis also supports the potential role of simulation as a complementary educational approach. Previous literature has identified virtual and computer-based simulation as approaches that can support experiential learning in pharmacy and health-professions education (Gharib *et al.*, 2023; Phanudulkitti *et al.*, 2023).

The high level of support for repeated practice is particularly relevant to the VPME concept. Unlike conventional lecture-based learning, a virtual manufacturing environment could allow learners to repeat activities, make decisions, receive feedback and attempt activities again. This feature may be particularly relevant when access to physical laboratories or manufacturing facilities is restricted.

The manufacturing-process results also indicate that VPME should not focus on one isolated manufacturing activity. Instead, the proposed environment should represent a connected workflow from material preparation through processing, packaging and quality

control. Such an approach would allow learners to understand how individual manufacturing stages are related to one another.

The strong emphasis on GMP, QA and QC is consistent with the importance of quality systems in pharmaceutical manufacturing. WHO GMP principles emphasise appropriate personnel, premises, equipment, production controls, quality control and documentation (World Health Organization, 2014). Incorporating these elements throughout the virtual manufacturing workflow could therefore help students understand that quality considerations are relevant across the manufacturing process.

The model analysis also identified several potential implementation barriers. Connectivity, suitable devices, technical support and staG training would need to be considered during development. Digital education cannot be assumed to overcome educational disruption without considering the technological and institutional environment in which it is implemented.

Overall, the model analysis provides a basis for proposing a VPME that combines manufacturing processes, equipment, GMP, QA, QC, interactive scenarios, assessment and feedback. However, the proposed environment remains conceptual, and its actual educational effectiveness would require development and formal evaluation.

4.2 Proposed VPME Framework

Based on the literature considered in this study and the stakeholder requirements represented in the model analysis, the proposed VPME consists of the following major components.

Component 1: Virtual Manufacturing Environment

The environment should represent a pharmaceutical manufacturing facility containing appropriate production areas and relevant manufacturing equipment. The design should allow students to navigate between diGerent stages of the manufacturing process.

Component 2: Manufacturing Workflow

The proposed manufacturing workflow should include the following sequence.

Raw materials → Weighing → Mixing → Granulation → Drying → Milling → Compression → Coating → Packaging → Quality Control

This workflow is intended to provide students with an understanding of the relationship between individual manufacturing stages and the overall production process.

Component 3: Equipment Interaction

Students should be able to identify relevant manufacturing equipment and understand the purpose of equipment used at diGerent stages of pharmaceutical production. Where technically feasible, the environment

could allow learners to interact with simulated equipment and observe the consequences of incorrect operation.

Component 4: GMP and Quality Systems

GMP, QA and QC should be incorporated throughout the manufacturing process rather than presented as separate topics. Documentation, quality checks, deviation management and quality-related decisions should be incorporated into appropriate manufacturing activities.

Component 5: Interactive Scenarios

Students should encounter simulated situations such as],

- incorrect weighing.
- manufacturing deviations.
- documentation errors.
- equipment problems.
- quality failures; and
- decisions concerning appropriate corrective actions.

These scenarios could allow students to practise decision-making within a controlled learning environment.

Component 6: Assessment and Feedback

Students should complete questions, practical tasks and decision-making activities within the virtual environment. The system should provide feedback on performance and identify areas requiring further learning or practice.

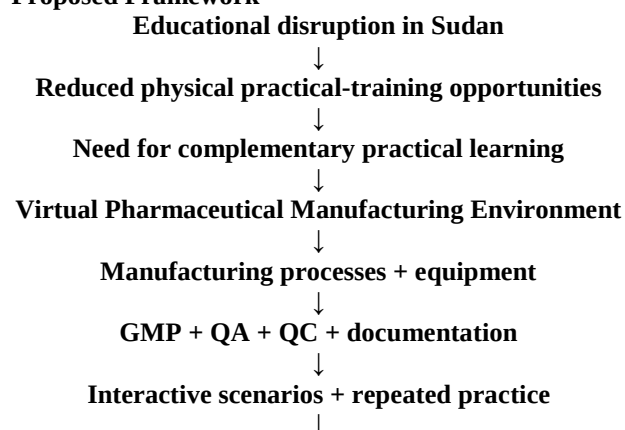
Component 7: Competency Development The proposed VPME should support development of:

- manufacturing-process understanding.
- equipment awareness.
- GMP application.
- quality-related decision-making.
- problem-solving.
- documentation awareness; and
- preparation for industrial pharmacy practice.

Component 8: Curriculum Integration

VPME should be incorporated into industrial pharmacy education as a complementary digital learning tool. It should support, rather than replace, physical laboratory activities and industrial training.

Proposed Framework



Assessment + feedback

Industrial pharmacy competency development

Blended integration with physical laboratory and industrial training

The proposed framework provides a conceptual basis for future development of a functional VPME platform. Its eGectiveness cannot be established from the present model analysis alone and would require subsequent technical development, usability testing and educational evaluation.

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

This study addressed the challenge of maintaining practical industrial pharmacy education during a period of significant educational disruption in Sudan. The model analysis indicated perceived limitations in access to practical training, manufacturing facilities and equipment.

The stakeholder perspectives represented in the model analysis showed generally positive perceptions of a proposed Virtual Pharmaceutical Manufacturing Environment as a complementary educational approach. Manufacturing processes, GMP, QA, QC, documentation, deviation management and problem-solving were identified as important areas for inclusion. Repeated practice and continued learning during periods of disruption were also identified as potential benefits.

The proposed VPME framework integrates pharmaceutical manufacturing processes and equipment with GMP, QA, QC, interactive scenarios, assessment, feedback and curriculum integration. The framework is intended to provide a structured approach for supporting practical learning when access to conventional facilities is restricted.

The proposed VPME is not intended to replace physical laboratory or industrial experience. Instead, it is proposed as a complementary educational approach that could support preparation, practice and educational continuity. Further research is required to develop the conceptual framework into a functional platform and evaluate its usability, feasibility and educational eGectiveness.

5.2 Limitations

The proposed VPME was not developed as a fully functional software platform. Therefore, its actual technical performance, usability and eGectiveness in improving practical skills were not established.

The quantitative results presented in this paper are based on a model analysis dataset rather than verified field data collection. Consequently, the reported numerical findings

should not be interpreted as evidence of actual participant responses or population level outcomes.

The study is also situated within the Sudanese educational and pharmaceutical context, and the proposed framework may require adaptation for other institutions or settings.

Implementation may be affected by internet connectivity, electricity availability, device access, financial resources, technical support and academic staff training.

Finally, virtual simulation cannot fully reproduce physical interaction with pharmaceutical equipment, materials and industrial working environments. VPME should therefore be considered a complementary learning approach rather than a complete substitute for physical practical training.

5.3 Recommendations

Based on the proposed framework and the model analysis, the following recommendations are made:

1. The proposed VPME should be developed into a functional educational platform.
2. VPME should be integrated into relevant industrial pharmacy courses as a complementary learning resource.
3. Major pharmaceutical manufacturing processes should be represented within the virtual workflow.
4. GMP, QA and QC should be integrated throughout the simulated manufacturing activities.
5. The platform should provide opportunities for repeated practice and feedback.
6. Academic staff should receive appropriate training before implementation.
7. Technical infrastructure, device requirements and connectivity should be assessed before implementation.
8. VPME should be used alongside physical laboratory and industrial training.
9. The completed platform should undergo formal evaluation of usability, feasibility and educational effectiveness.

5.4 Future Research

Future research should focus on:

- development of a functional VPME platform.
- usability testing.
- evaluation of student engagement.
- assessment of knowledge and practical understanding.
- comparison with conventional teaching approaches.
- evaluation of student confidence.
- investigation of long-term educational outcomes; and
- testing and adaptation of the framework across different pharmacy institutions in Sudan.

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APPENDICES Appendix A: Student Questionnaire

The approved student questionnaire should be attached in its original form.

Appendix B: Academic Staff Questionnaire

The approved academic staff questionnaire should be attached in its original form.

Appendix C: Pharmaceutical-Industry Professionals Questionnaire/Interview Guide

The approved pharmaceutical-industry questionnaire/interview guide should be attached in its original form.