Comparison of Knowledge Retention between Case Studies Utilizing a Simulated EHR with Various Degrees of Simulated Experiences

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Objective. Interprofessional team-based care has become the standard for practicing clinical pharmacists. However, it is difficult to simulate every aspect of this environment in the didactic curriculum. The purpose of this study was to determine if the addition of standardized patients (SP) or interprofessional student teams with SPs, to the use of a simulated electronic health record (EHR) improved student knowledge retention and perceptions.

Methods. This was a prospective cohort study assessing three cohorts of first-year student pharmacists in pharmacy skills laboratory activities that occurred in 2018, 2019, and 2021. The primary objective of the study was to compare knowledge retention at 1-month related to the case material between groups. Each year an element of simulated experience was added onto the previous year’s case. In 2018, students completed the case using the EHR web application only. In 2019, an objective structured clinical examination (OSCE) with SPs was combined with the previous year’s experience. In 2021, student physician assistants were added to the 2019 experience. Case scores and student perceptions were also compared between groups.

Results. Of the 260 potential participants, 238 students were included in the primary analysis. Significant improvement was demonstrated in one-month knowledge retention assessments with the addition of interprofessional team-based care and SPs. Mean knowledge retention assessment scores were 63.8%, 71.7%, and 76.1% respectively. There was also significant improvement in student perceptions.

Conclusion. The addition of SPs and interprofessional team-based care to a pharmacy skills laboratory that utilizes a simulated EHR significantly improved student knowledge retention and perceptions.

Keywords: simulation; objective structured clinical examination; interprofessional education; electronic health record; knowledge retention

INTRODUCTION

Research indicates that simulated learning techniques increase student confidence, critical thinking skills, and clinical performance in health care education.1 These activities are utilized to improve student learning and familiarity with clinical experiences. Many techniques can be implemented to increase the realism of learning experiences including innovative uses of technology, integration of mock patient cases and standardized patient (SP) interactions, and low- and high-fidelity mannequins.

Most often, educational research has focused on evaluating a single simulation technique when determining the effects on students’ ability to retain knowledge. In terms of retaining information, the use of standardized patients and low-fidelity simulation mannequins can improve long-term knowledge retention in student pharmacists.2,3 Another technique that has demonstrated benefits on student learning and perception is the use of simulated electronic health records (EHR).4,5 However, to our knowledge, no study in pharmacy or interprofessional education (IPE) exists that couples a simulated EHR with live, SPs or interprofessional students to create a realistic, team-based care learning environment. Thus, the purpose of this study was to determine whether the addition of SP interactions, or SP interactions plus interprofessional student teams, to patient cases utilizing a simulated EHR improves student knowledge retention, case performance, and student satisfaction related to endocrine pharmacotherapy in first professional year (P1) Doctor of Pharmacy (PharmD) students.

METHODS

This study was a prospective cohort study assessing three cohorts of P1 student pharmacists: spring 2018, spring 2019, and spring 2021. In the fall of 2017, students in the PharmD program began utilizing a simulated EHR throughout three didactic years to enhance their learning and prepare them for their clinical rotations.6 The EHR is used most readily
throughout the Pharmacy Practice Skills (PPS) laboratories. The study was funded by an internal research grant and the study protocol was approved by the Campbell University Institutional Review Board under expedited review (Protocol #374).

This 3-iteration activity was developed as part of the PPS laboratory section that coincides with the endocrine therapeutics module in the pharmacy curriculum, which falls in the spring semester of the P1 year. Two patient cases were created by pharmacy faculty and built into the EHR: a male patient with type 2 diabetes presenting to urgent care with symptoms of a urinary tract infection (UTI) and a female patient with type 2 diabetes and hypothyroidism presenting for medication management after finding out she is pregnant. Case questions were developed for each patient case and students answered the questions and submitted them as a portion of their PPS grade for that module. The same two cases and case questions were used for all three cohorts, but they were applied differently each year. Only the first case was included for analysis in this study.

Students were included in the study if they were enrolled in the P1 skills course (2018, 2019, 2021) or the physician assistant program (2021) (Figure 1). Stay-at-home orders due to the COVID-19 pandemic required cancelling and reformatting the interprofessional OSCE originally scheduled for spring 2020; thus, the P1s enrolled during spring 2020 were not included. Two days prior to the laboratory, all cohorts of students were given access to the patient cases via the EHR. Case questions were provided to students the day of the laboratory. In the first iteration, spring 2018, student pharmacists completed the patient cases using only the information available to them in the EHR. They had a 1.5-hour laboratory period to work up their patients and answer the case questions.

In the second iteration, during spring 2019, student pharmacists were paired and given 10 minutes to conduct an interview during a SP interaction. The students then had 15 minutes to develop a plan for the SP, and 5 minutes to counsel them on the plan and any medication changes. Students then had one hour to complete the questions for the SP case (analyzed) as well as the second patient case for which they only had the information in the EHR.

The SPs in this second iteration acted as the patient described in the EHR records. In preparation for their role, they underwent a one-hour training session with a pharmacy faculty member immediately prior to the event in spring 2019 and 2021 to answer any questions they had about the case scenario and script, which they received one week prior to the interaction. All SPs received payment through the internal grant funding and had served as SPs through the college previously. The purpose of the SP interaction was to gather any additional information needed from the patient and communicate the plan based on the patient’s presentation.

Finally, in spring 2021, a third iteration added an interprofessional component. Student pharmacists were randomly paired with 1 first-year student physician assistant (PA) in 1:1 or 2:1 groups and completed the SP interaction as described in the paragraph above. The endocrine module for the PA and pharmacy curriculum coincide during the semester, so an IPE activity during this module was a natural fit. In this cohort, the student PAs performed the physical examination and worked with the student pharmacists to develop a plan. After the SP interaction, the student pharmacists still had the remainder of the 1.5-hour laboratory session to complete the questions for the SP case and the case that was solely in the EHR.

In addition to SP training and interaction, the grant was also utilized to fund the EHR web application for the PA program. One week prior to the event, EHR training was provided to the student PAs. As in previous years, the EHR information was posted two days before the laboratory, along with the list of student groups. Students were instructed to discuss the two patients with their partner(s) at their convenience before the laboratory.

One month after completion of the activity, all cohorts of student pharmacists completed a 25-question multiple choice knowledge retention test which contained questions on the disease states reviewed during the patient case activities. The questions regarded guidelines and medication treatment of these endocrine disorders, but not specific questions about the patients themselves. At the end of the knowledge-retention test, there was a short, 6-item survey (rated on a 5-point Likert scale) on student perception of the learning techniques used throughout the activity. Students completed this activity during their 50-minute pre-laboratory class at the end of the semester. All student pharmacists who were present in the three cohorts participated in the activity and were invited to take the knowledge retention test. The grade on the knowledge retention test did not contribute to the laboratory grade for any of the students participating in the activity.

The primary objective of the study was to assess one-month knowledge retention test scores across all three cohorts. Secondary endpoints included case scores across the cohorts and results of the student perception survey included at the end of their knowledge-retention test. Statistical analysis was conducted using JMP-14 Pro (SAS, Cary, NC). A p value of <.05 was considered statistically significant. Continuous data were assessed using ANOVA and ordinal variables were assessed using the Kruskal-Wallis test.

RESULTS
Of 260 total students enrolled among the 3 pharmacy student cohorts, 257 (98.8%) participated in the case component of the study, and 238 (91.5%) completed the one-month knowledge retention assessment and perceptions survey. The available baseline characteristics were similar between groups with the only statistically significant difference being in pharmacy work experience with 76.0%, 57.0%, and 69.1% in the spring 2018, 2019, and 2021 cohorts respectively \((p=.04)\). There were no significant differences in final course grades, type of work experience, or age (Table 1).

For the primary endpoint of one-month knowledge retention test scores, there was significant improvement with the addition of SPs and student PAs as compared to SPs and the use of the EHR web application alone. The spring 2021 cohort achieved a mean score of 76.1% versus 71.7% and 63.8% for the 2019 and 2018 cohorts respectively, \(p<.01\) (Table 2).

Improvements in case scores, although not statistically significant, were also noted as the cohorts progressed with a mean of 81.1%, 84.4%, and 85.4% in the spring 2018, 2019, and 2021 cohorts respectively, \(p=.05\). A survey was used to assess student perception of the activity; most student pharmacists either agreed or strongly agreed that the use of simulated learning activities positively benefited learning. Additionally, student perception significantly improved in each cohort (with the addition of standardized patients and interprofessional team-based care) in 4 of the 6 survey questions (Table 3). Although not compared statistically, the student PAs participating with the spring 2021 cohort also reported high levels of satisfaction (Table 3).

**DISCUSSION**

In this prospective cohort study, we demonstrated benefit in student knowledge retention and perception with simulated learning activities, including interprofessional team-based care. A significant difference was found between one-month knowledge retention \((p<.01)\) and a trend towards improvement in case scores was noted \((p=.05)\). Additionally, student perception regarding the impact of simulated EHR with or without SP interactions and interprofessional collaboration improved for most categories. This study highlights the benefit for implementation of multiple simulated learning techniques facilitate student learning and retention of knowledge.

Several reasons exist which may explain the increase in knowledge retention at varying levels of simulated realism. The process for collecting and assessing information in the first iteration of this study was well known to the students in all cohorts as the use of the EHR for case studies is commonplace at our institution. The use of technology for simulated patient cases and EHRs has been shown to improve student satisfaction, perception of preparedness, and performance.\(^8-10\) A study from Smith and colleagues demonstrated student pharmacists found use of a simulated EHR improved perception of preparedness for clinical practice \((p<.01)\).\(^6\) In this study, however, there was no performance improvement when comparing advanced pharmacy practice experience grades. Likewise, Bernaitis and colleagues demonstrated increased student satisfaction and significant improvement in final examination scores with use of simulated technology.\(^9\) Similar to the results of the current investigation, Bernaitis and colleagues did not find a significant difference in scores on a short-term assessment (mid-semester exam), but did find significant improvement on end of semester examination scores \((p<.01)\).\(^9\) This study utilized computer-based oncology cases designed using DecisionSim\(^{TM}\) technology in final year pharmacy students.\(^7\) Our study reiterates the finding that simulation technology is beneficial throughout the pharmacy didactic curriculum with positive impacts in first through final year students.

Similarly, the use of SPs has been shown to improve performance in skill-related courses and knowledge retention in student pharmacists.\(^2-3\) These studies demonstrated the benefit of utilizing SPs for first-year pharmacy students learning inhaled device and insulin injection techniques.\(^2-3\) Like our study, the addition of SPs not only improved the student skills and counseling, but also their knowledge retention of the topic at one month.\(^3\)

Additionally, results published by Simko and colleagues showed a significant increase in perception of the importance of interdisciplinary roles and knowledge when pharmacy and nursing students participated in an IPE course.\(^10\) A study by Maerten-Rivera and colleagues analyzed pharmacy and PA student confidence in applying the Pharmacists’ Patient Care Process (PPCP) to a patient case and their perceptions toward interprofessional collaboration.\(^11\) This study significantly increased students’ confidence in performing the PPCP, but did not show changes in attitude toward interprofessional collaboration. However, both PA and pharmacy students reported high scores in interprofessional perceptions both before and after the interprofessional education activity.\(^11\)

Lastly, a study by Mitzel and colleagues, paired pharmacy and PA students in their final didactic year to collaborate in an interprofessional OSCE that reviewed orders for an inpatient case.\(^12\) This study sought to assess the OSCE’s impact on perceptions regarding IPE and to determine if simulated patient outcomes improved with interprofessional collaboration. This study demonstrated higher scores on correct patient recommendations with the IPE group and increased perceptions of the benefit of interprofessional patient care.\(^12\)
Despite the relative abundance of literature surrounding classroom technology, SPs, and IPE, the combination of these elements, which created a more realistic case scenario and required additional preparation for students, has not yet been studied. For example, for students to adequately prepare for their interaction with the SP, they needed to prepare questions in advance and be ready to provide follow-up questions if needed. Additionally, when student PAs were added as an additional realistic element, the expectations that the student pharmacists would be viewed as the medication experts on the interprofessional team may have influenced their preparation. Preparation, however, may have only been a portion of what accounted for improved knowledge retention, as additional preparation did not result in statistically significant differences in case grades (Table 2). Thus, the activities themselves may have contributed to a more memorable learning experience and resulted in improved knowledge retention.

While the use of simulated EHR, SPs, and interprofessional education have been demonstrated to improve learning and student satisfaction individually, to our knowledge, this if the first study in pharmacy education that combines these strategies.

Limitations
Duplicating this model for interprofessional team-based care across other didactic curriculums and in other therapeutic modules may be limited as the timing of disease states taught will not always coincide across different professional programs. Additionally, there was a 1-year gap in the study period (spring 2020) due to implementation of remote and virtual learning models during the COVID-19 pandemic and inability of students and SPs to meet in person. Since we were unable to obtain some data related to academic performance, such as grade point average and Pharmacy College Admission Test, we cannot rule out academic success as a confounding variable. Future studies should assess impact of this model on retention of knowledge and performance on clinical rotations.

CONCLUSION
The addition of SPs and interprofessional team-based care to a pharmacy skills laboratory that utilizes a simulated EHR web application significantly improved student knowledge retention. These additions also demonstrated a trend toward improving immediate performance on cases and led to increased perceptions of the simulated learning environment and interprofessional education. While it may not be feasible to integrate interdisciplinary learners regularly, this study supports the benefit gained by introducing team-based care early in the pharmacy curriculum.

ACKNOWLEDGEMENTS
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REFERENCES


<table>
<thead>
<tr>
<th>Table 1. Baseline Characteristics</th>
<th>2018 – EHR(^a) Only (N=96)</th>
<th>2019 – SPs(^b) + EHR (N=93)</th>
<th>2021 – IPE(^c) + SPs + EHR (N=68)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pharmacy Work Experience, n (%)</td>
<td>73 (76.0)</td>
<td>53 (57.0)</td>
<td>47 (69.1)</td>
</tr>
<tr>
<td>Type of work experience, n (%)</td>
<td>54 (74.0)</td>
<td>40 (75.5)</td>
<td>36 (76.6)</td>
</tr>
<tr>
<td>Community</td>
<td>14 (19.2)</td>
<td>11 (20.8)</td>
<td>8 (17.0)</td>
</tr>
<tr>
<td>Hospital</td>
<td>5 (6.8)</td>
<td>2 (3.7)</td>
<td>3 (6.4)</td>
</tr>
<tr>
<td>Age-years, mean ± SD</td>
<td>24.0 ± 4.3</td>
<td>24.3 ± 5.0</td>
<td>24.7 ± 5.5</td>
</tr>
<tr>
<td>Final Course Grade mean ± SD</td>
<td>90.6 ± 4.92</td>
<td>94.5 ± 4.64</td>
<td>95.1 ± 2.94</td>
</tr>
</tbody>
</table>

\(^a\)EHR – Electronic Health Record; \(^b\)SP – Standardized patients; \(^c\)IPE – Interprofessional Education

<table>
<thead>
<tr>
<th>Table 2. Knowledge Retention and Patient Case Scores</th>
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<tbody>
<tr>
<td>Knowledge Retention Test</td>
</tr>
<tr>
<td>Mean(%) ± SD</td>
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<tr>
<td>Patient Case Score</td>
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<tr>
<td>Mean(%) ± SD</td>
</tr>
</tbody>
</table>

\(^a\)EHR – Electronic Health Record; \(^b\)SP – Standardized patients; \(^c\)IPE – Interprofessional Education
Table 3. Perceptions Survey

<table>
<thead>
<tr>
<th>Survey Item</th>
<th>2018 (N=83)</th>
<th>2019 (N=87)</th>
<th>2021 (N=68)</th>
<th>2021 – PA (N=53)*</th>
<th>p value</th>
</tr>
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<tbody>
<tr>
<td>This activity allowed me to better understand my role in a clinical setting</td>
<td>3.98 ± 0.82</td>
<td>4.15 ± 0.80</td>
<td>4.35 ± 0.72</td>
<td>4.20 ± 0.88</td>
<td>.02</td>
</tr>
<tr>
<td>I can obtain important information from a patient</td>
<td>4.27 ± 0.70</td>
<td>4.32 ± 0.60</td>
<td>4.46 ± 0.73</td>
<td>4.48 ± 0.65</td>
<td>.07</td>
</tr>
<tr>
<td>Having a discussion with a patient allows me to better develop a valuable</td>
<td>4.23 ± 0.70</td>
<td>4.28 ± 0.63</td>
<td>4.52 ± 0.66</td>
<td>4.55 ± 0.69</td>
<td>.01</td>
</tr>
<tr>
<td>therapy recommendation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A simulated clinical environment should be used more throughout the</td>
<td>4.14 ± 0.83</td>
<td>4.08 ± 0.69</td>
<td>4.34 ± 0.80</td>
<td>4.28 ± 0.72</td>
<td>.03</td>
</tr>
<tr>
<td>curriculum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I feel like this experience allowed me to make recommendations that take</td>
<td>3.99 ± 0.83</td>
<td>4.20 ± 0.67</td>
<td>4.42 ± 0.70</td>
<td>4.36 ± 0.72</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>patients’ personal preferences into consideration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I felt this experience was a valuable use of human and technology resource</td>
<td>4.06 ± 0.92</td>
<td>4.16 ± 0.83</td>
<td>4.32 ± 0.87</td>
<td>4.18 ± 0.90</td>
<td>.11</td>
</tr>
</tbody>
</table>

Survey Response Scoring: 1=Strongly Disagree, 2=Disagree, 3=Neither Agree nor Disagree, 4=Agree, 5=Strongly Agree.

*Student PAs not included in statistical analysis.

Figure 1. Study Design

- **Spring 2018**
  - P1 PharmD students
  - EHR cases only (30 minutes)
  - 1-hour to submit answer to case questions

- **Spring 2019**
  - P1 PharmD students
  - OSCE with SPPs on EHR case (30 minutes)
  - 1-hour to submit answer to a case questions

- **Spring 2021**
  - P1 PharmD and 1st year PA students
  - 1-hour EHR training with PA students
  - 1-hour SP training
  - IPE OSCE with SP on EHR case
  - 1-hour to submit answer to case questions (PharmD only)

- 1-month knowledge retention assessment: 25 multiple choice questions regarding case topics
- 6-item perception survey regarding activity

*PharmD P1 – First-year Doctor of Pharmacy; OSCE – Objective Structured Clinical Examination; PA – Physician Assistant; SP – Standardized Patient; IPE – Interprofessional Education*