RESEARCH

Use of Capstone Experiences in Pharmacy Education to Synthesize and Apply Students' Knowledge and Skills

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Objective. To investigate capstone experiences in pharmacy education with the broad aim of better understanding how they are designed, used, and sustained.

Methods. Capstones were defined as culminating experiences that required Doctor of Pharmacy (PharmD) students to apply their knowledge and skills and demonstrate their ability to integrate, extend, and apply multiple components of their academic experience. This study was conducted in two phases. Phase one was a mapping review, which provided insight into the design of pharmacy capstone experiences, including the purpose they served and their associated outcomes. Phase two consisted of conducting follow-up interviews to explore the current status and sustainability of those capstone experiences. Qualitative methods with multiple coders were used to analyze the data.

Results. Five distinct purposes for capstone experiences were identified: preparation for advanced pharmacy practice experiences (APPEs), pharmacotherapy education, research, reflection on pharmacy school experiences, and immersive learning through an external organization. Wide variability was found in the design, purpose, and outcomes of capstone experiences. Study authors described the capstone experiences at their institution in terms of the viability, feasibility, desirability, and challenges faced.

Conclusion. Capstones can play an important role in assessing student progress and practice readiness in pharmacy education. The findings of this study can be used to help pharmacy schools design capstone experiences that are effective and sustainable.

Keywords: capstone, assessment, pharmacy education, APPE readiness, milestone

INTRODUCTION

Assessing student learning is critical to informing and promoting student and curricular development.¹ While pharmacy schools and colleges are required to demonstrate achievement of student outcomes in accordance with the Accreditation Council for Pharmacy Education (ACPE), they are afforded the flexibility and autonomy to develop and implement their own approaches for meeting that requirement. As such, pharmacy educators use a wide range of strategies to assess student learning, including but not limited to objective structured clinical examinations (OSCE), situational judgement tests, and peer observations.²⁻⁴ Designing assessments that accurately evaluate student ability is

imperative to ensuring students are developing the skills requisite for success in the practice of pharmacy.

Formal assessments specifically designed to evaluate students' ability to integrate, extend, and apply multiple components of academic experiences, also known as capstones, are increasingly common in health professions education.⁵⁻⁷ Capstone courses are often described as culminating experiences that require students to apply their knowledge and skills and demonstrate their ability to integrate, extend, and apply multiple components of the academic experience.⁷ Capstone experiences may be credit bearing (eg, a capstone course) or non-credit bearing (eg, a capstone experience not associated with a course) and always include some form of student learning assessment. In recent years, pharmacy educators have used capstone experiences to help students integrate cumulative learning in preparation for advanced pharmacy practice experiences (APPEs), demonstrate knowledge and skill through research, provide immersion experience for practice, and assess program-level outcomes.^{5,8-12}

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Wuller, for example, described a research-focused capstone APPE that required students to compose a graded research paper and create a poster presentation.¹¹

Capstone experiences can vary considerably in cost, style, format, scope, and scale.^{6,7} While previously published studies describe capstone experiences within Doctor of Pharmacy (PharmD) curricula, little is known about the similarities and differences between capstones, or the extent to which they have been sustained. Viability, feasibility, and desirability are design-based criteria generally considered necessary for sustainability and success.¹³ Understanding these criteria within the context of capstones could help educators tasked with designing and implementing capstones ensure that the assessment aligns with desired outcomes.¹⁴

The core design elements, and the subsequent sustainability of capstones, are incompletely understood in pharmacy education. The purpose of this study was to explore the use of capstones within pharmacy education with the broad aim of understanding how capstones are designed, used, and sustained. Two research questions guided this work: what are the common designs, purposes, and outcomes of published capstones within PharmD curricula, and to what extent do authors describe the value of viability, feasibility, and desirability as it relates to the design, success, and sustainability of pharmacy education capstones?

METHODS

This study was conducted in two phases. Phase 1 involved a mapping review, which provided insight into the landscape of pharmacy capstones, including the purpose they served and their associated designs.¹⁵ Phase 2 consisted of follow-up interviews with study authors to explore the current status and sustainability of those capstone experiences. The study was determined to be exempt from full review by the University of North Carolina Institutional Review Board.

PubMed was used exclusively to conduct the literature search in phase 1 because of its expansive collection of empirical research, reliability as a search engine, and inclusion of the health professions. A search was conducted in October 2018 using the search terms “capstone” and “pharmacy education.” Only peer-reviewed research articles describing capstones within accredited pharmacy schools were included. Abstracts, reviews, and non-peer reviewed literature were excluded. A start date of 2000 was used because that was the year that the ACPE ended accreditation of the bachelor’s degree in pharmacy in favor of the PharmD degree.¹⁶ Upon removing duplicate papers, 15 publications from 13 different institutions with

13 different corresponding authors were included in the review. Each study was reviewed by two members of the research team who extracted information about the purpose and placement of the capstone and the type of assessment and feedback provided to students. A third reviewer served as the tiebreaker in cases where consensus was not reached on which information to include.

For phase 2, interviews were conducted with the corresponding authors of the studies included in phase one. Following an email recruitment effort, 11 authors agreed to be interviewed (85% response rate). Eight participants were interviewed via Zoom videoconferencing software (Zoom Video Communications, Inc, San Jose, CA) and three opted to respond to interview questions via email. Two members of the research team completed the interviews in January and February of 2019. Authors were asked about the current status of their capstone experience, resources used, challenges encountered, goals and outcomes, changes, and future steps.

Qualitative methods were used to analyze interviews because of the level of depth and nuance of information needed about each capstone experience. Interviews were transcribed and analyzed deductively using MaxQDA (VERBI Software, Berlin, Germany) qualitative software.¹⁷ Four broad codes were developed and defined based upon our research questions: viability, feasibility, desirability, and challenges (Table 1). Viability was defined as the acceptability of a capstone within the curriculum, the commitment of the school to support the capstone, and any changes that were made to the capstone over the years. The feasibility of a capstone involved the scope and resources needed for the capstone to remain functioning. Desirability was defined by the author’s perceived effectiveness or success of the capstone at achieving defined learning outcomes. A challenge was any circumstance identified by the authors as an obstacle to the implementation of the capstone.

Three members of the research team coded three interviews together to build consensus and consistency in applying the codes to the transcripts. After achieving consensus on the definition and application of the codes, the remaining eight transcripts were coded by at least two of the researchers. Any coded transcripts for which agreement was less than 80%, as indicated by MaxQDA, were collaboratively reviewed by the research team until agreement exceeded 80%.

After application of the four broad codes was complete, the coded segments were summarized and synthesized via pattern coding to reveal subthemes within each of the four broad codes.¹⁸ Three members of the research team independently reviewed coded sections of the transcripts to describe the patterns with a phrase or sentence.

Table 1. Definitions of Thematic Codes Used in a Study Regarding Capstone Experiences in Pharmacy Education

Code	Definition
Viability	Whenever a participant mentions the acceptability of their capstone (ie, it's worthwhile, fun, well-liked). The school's commitment (ie, whether or not the capstone is still happening), Any changes (redesigning) that are made to the capstone course over the years.
Feasibility	When a participant discusses the scope, and resources. Oversight, anytime someone talks about being in charge of running the capstone. The number of individuals needed for the capstone to function (both faculty and students). The space and time needed for the capstone. The money/cost of the capstone. The relationship between the capstone and the curriculum. Courses needed for capstone.
Desirability	When a participant discusses learning outcomes, integrated learning, effectiveness (ie, goals) or the success of their capstone.
Challenges	Any challenges that the participants mention with regards to the capstone. This includes but are not limited to time, money, space, personnel, etc.

Finally, one member aggregated the themes, reviewed them, and summarized the common ideas across interviews.

RESULTS

Fourteen capstone experiences were described in the 15 papers included in this review. The papers were published between 2007 and 2017 and originated from nine public and four private US pharmacy schools. One school had two publications about their capstone experience, and another school had two publications describing two different capstone experiences at the school. Most capstone experiences were held in the latter part of the curriculum (n=9, 69%), primarily during the third professional year or immediately preceding APPEs.

Five distinct purposes for capstone experiences were identified: APPE preparedness; pharmacotherapy education; research-focused experiences; reflection on pharmacy school experiences; and an immersive learning experience through an external organization (Table 2). Thirteen of the 15 capstone experience (87%) were assigned course credit within the institution's curriculum

and were described in the paper as resource-intensive in terms of faculty hours required for development and execution. Capstone experiences varied by the type of assessment used (eg, student self-assessments, objective structured clinical examinations (OSCEs), project-based assessments), and student incentives or consequences associated with the assessment (eg, high-stakes with remediation, low-stakes with no remediation). Assessments were used to evaluate the clinical rotation readiness of pharmacy students (n=6, 40%), detect areas of weakness for targeted student feedback and remediation (n=5, 33%), and inform curriculum development and optimization (n=7, 47%).

The authors who agreed to be interviewed were from seven public and four private US schools of pharmacy (Table 2). Most participants (n=9, 82%) reported that the capstone experiences were ongoing. The following section provides a summary and illustrative quotes from the author interviews.

Viability

Two subthemes related to viability emerged from the interviews: faculty/administrative buy-in and curricular change. Faculty members' buy-in and commitment to working with students was identified as a crucial element for capstone success, with one author stating, "You need a champion for this project to succeed." Along the same lines, authors of discontinued capstones described low faculty buy-in as a factor in the school's decision to end the capstone course. One stated, "I think from a faculty perspective it was a big-time commitment on their part, and not every student was passionate about their research. [Which] meant you were dragging students along to get them to graduation."

Authors from seven schools mentioned that their PharmD curriculum had gone through or was currently going through changes, and that this had impacted capstone design and implementation. For instance, one school was implementing a new curriculum and revised their capstone to better align with the needs and outcomes of the curriculum. Another school changed their research-focused capstone from a requirement to an elective course when they implemented their new curriculum. As illustrated by one author, "We plan to offer the capstone for one more year. We will be eliminating this course because we have made a major curricular revision and enhancement that allows us to include two new courses called advanced therapeutics, which should serve the purpose of the current capstone course in addition to other advantages."

Other authors described minor changes made to their school's capstone experience over the years, acknowledging that the topics had changed but that the core

Table 2. Characteristics of Pharmacy Education Capstone Courses/Experiences Described in the Literature, 2007-2017 (N=15)

Institution Type	Purpose of Capstone	Year of Publication	Placement of Capstone	Types of Assessment	Status ^a	Design Changes ^a	Outcomes ^a
Public	Pharmacotherapy education	2017	Before APPEs	Clinical case discussion	Ongoing	Updated and incorporated capstone into new curriculum. Added a cumulative knowledge exam.	Clinical rotation readiness; Inform curriculum development
Public	Pharmacotherapy education	2017	PY3 spring	Exam/Quiz; Student self-assessment	N/A	N/A	N/A
Public	Research-focused	2015	Throughout all 4 years	Project-based assessment	Discontinued	Used material to create self-paced modules. Started to embed parts of capstone in other courses.	Detect areas of student weakness; Inform curriculum development
Private	Reflection	2015	Before graduation	Student self-assessment	Ongoing	No major changes.	Detect areas of student weakness
Private	APPE Preparedness	2015	PY3 fall	Project-based assessment	N/A	N/A	N/A
Private	APPE preparedness	2014	PY3 before spring semester	Clinical case discussion; Verbal/OSCE	Discontinued	Replaced by an advanced therapeutics course. Changed to a review course to help prepare students for APPEs.	Detect areas of student weakness for targeted remediation
Public	APPE preparedness	2014	PY3 pre-APPE	Clinical case discussion; Verbal/OSCE	Ongoing	Changed logistical aspects of OSCEs	Clinical rotation readiness
Public	APPE preparedness	2014	PY3 pre-APPE	Project-based assessment; Verbal/OSCE	Ongoing	Removed items that did not directly link to performance-based tasks. Added labs in PY1 and PY2	Inform curriculum development; Clinical rotation readiness
Public	Pharmacotherapy education	2014	PY3 pre-APPE	Clinical case discussions	N/A	N/A	N/A
Private	Research-focused	2013	PY3 spring	Project-based assessment	Discontinued		
Public	Reflection	2013	During APPEs	Student self-assessment	N/A	N/A	N/A
Public	Pharmacotherapy education	2012	PY3 pre-APPE	Exam/Quiz; Clinical case discussion; Verbal/OSCE	Ongoing	Added assessments (PCOA, OSCE)	Clinical rotation readiness
Public	Research-focused	2010	During APPEs	Project-based assessment	Ongoing	Started as introduction to APPEs, transitioned to research capstone	Inform curriculum development
Public	Research-focused	2009	Fall PY1 to Winter PY2	Project-based assessment	Ongoing	New assignments, capstone now takes less time	Clinical rotation readiness
Private	Immersive learning-external organization	2007	During APPEs	Student self-assessment; Exam/Quiz; APPE rubric	Ongoing	No major changes	Clinical rotation readiness

Abbreviations: APPE=advanced pharmacy practice experience, PY=pharmacy year, OSCE=objective structured clinical examination, N/A=nonapplicable (data missing because authors responded by email rather than participating in an interview about their study regarding a capstone course)

^a Information collected during interviews in January-February 2019 with authors of published capstone studies

elements of the course were still the same. Changes to capstone experiences varied and included focusing more on professional practice skills (eg, medical writing), updating course topics, and revising the capstone course's schedule, activities, and goals to better prepare students for APPEs.

Feasibility

Capstone management, time invested to design and maintain a capstone experience, and the cost of implementing a capstone, were subthemes that emerged from the interviews. When asked about capstone oversight, authors reported one of two structures: a single course director or a small executive committee. The two discontinued capstone experiences had a single course director, while the ongoing capstone courses on research, APPE preparedness, and pharmacotherapy used both forms of oversight.

Eight of 11 authors (73%) acknowledged the large time commitment required from them and their school's faculty and staff to implement the capstone experience effectively. Many of the authors indicated that the workload varied throughout the academic year. For instance, one author stated, "pretty much the months of April and May are dedicated to the capstone," while another shared, "the course coordinator spends many hours enhancing the course" each year. An author who was the director for a research capstone said, "my full-time job was the capstone . . . I maybe had a couple of lectures here and there, but the capstone was my whole responsibility." When this author was asked about faculty commitment they stated, "faculty spent probably 10 hours a month on it. . . they had to mentor the students."

Among the ongoing capstone experiences, financial requirements varied. For some, the capstone experience was ingrained in the school's curriculum and additional resources were only needed to cover the cost of poster printing. For others, specifically those with OSCE components, the capstone required more substantial funding. The main costs associated with pharmacotherapy capstone courses were teaching assistant and resident wages, simulation center rental fees, and payment for OSCE actors. Authors of papers on research-focused capstone experiences reported that little to no funding was provided. Specifically, one author shared that "zero" was spent, while another stated, "about \$1000 per semester at the most."

Desirability

Authors discussed the desirability of their capstone experiences in terms of two student outcomes: determining student preparedness for APPEs and developing

students' research skills. The goal of ensuring students were prepared for APPEs was discussed by authors who had directed pharmacotherapy and APPE preparedness capstone courses. One author noted, "I can tell you what I define as success. . . if students go on rotations and they can interview patients well [and] they can do the pharmacy patient care process." Others believed that "students doing well on APPE rotations and the NAPLEX" and having satisfactory practice skills were markers of capstone success. In the same vein, research-focused capstone courses aimed to develop students' clinical research skills. Authors indicated they wanted the capstone experience to develop students' "research skills, time management skills, [and help them] achieve deadlines" and "go through the process of creating a research proposal or IRB."

Challenges

Three themes emerged regarding the challenges the authors experienced while implementing capstone experiences: faculty and student engagement; providing students with effective feedback; and logistics. Nearly all authors (n=10, 90.9%) identified faculty engagement as a challenge, specifically struggling to secure the number of faculty members and amount of time needed to implement the capstone experience. For instance, authors had trouble dealing with the "sheer manpower it takes to deliver a capstone course." It was a struggle to get faculty members to participate in research capstone experiences because of the "teaching faculty not having any research experience" and faculty's research projects starting to "dry up" or they "were getting worn out with all of the projects." Finally, authors whose capstones included OSCE-like components acknowledged the challenge of obtaining enough faculty members to implement the capstone course.

In addition, authors identified student engagement and motivation as challenges. Several noted that some students stopped putting forth effort once they accumulated enough points to pass the course: "they just stopped trying . . . we didn't know if they were doing poorly on something because they didn't try or because they actually were struggling with it." Not knowing if students were struggling led to other challenges, such as ensuring that students were prepared for APPEs. Authors of a discontinued capstone course discussed how students frequently lacked the time management skills needed to successfully complete their projects, resulting in delayed student graduation or presentation of incomplete work. For instance, one disclosed, "one challenge was keeping the students on track. It's like a mini master's thesis and students have to comply with deadlines."

Another challenge that emerged was providing consistent and timely feedback to students. Authors reported grading inconsistencies by course directors, trained faculty members, and residents. As one author stated, “. . . sometimes residents are pretty tough because they forget where they were the year before.” Research-focused capstone experiences also reported grading challenges, with one author acknowledging that they “just couldn’t review 115 research protocols and give meaningful feedback.”

Finally, logistics was described as a challenge by all authors, from obtaining space and coordinating schedules to conducting OSCEs and research presentations. Scheduling was described as a constant struggle, particularly if authors shared a simulation center with other health professions schools. This was particularly difficult for the authors involved in administering a pharmacotherapy capstone course. Others described difficulty obtaining physical space to hold their culminating events because of competing end of the year activities.

DISCUSSION

Capstone experiences can play an important role in assessing student progress and preparedness in pharmacy education. By conducting a mapping review¹⁵ and follow-up interviews with study authors, this study revealed variability in the design, purpose, and outcomes of capstone experiences in pharmacy education. Despite these differences, authors identified similar goals (eg, student skill development), faced similar challenges (eg, faculty buy-in, time, cost), and emphasized the importance of capstone experiences within their school’s curricula.

The findings of this study suggest that pharmacy capstone experiences are primarily used to either assess and promote students’ preparedness for APPEs or develop students’ research skills. This aligns with ACPE Standards 2016, which requires schools of pharmacy to assess outcomes demonstrating student readiness to: enter advanced pharmacy practice experiences (APPE-ready); provide direct patient care in a variety of health care settings (practice-ready); and contribute as a member of an interprofessional collaborative patient care team (team-ready).¹⁹

In addition, ACPE Standards 2016 and the 2013 CAPE statement of educational outcomes identify and encourage the inclusion of research skill-building activities in the PharmD curriculum.^{1,19} The role of the pharmacist has become increasingly complex, thus dictating the need for pharmacists to be both creators and critical consumers of research.^{20,22} Currently, for most pharmacists to obtain formal research experience, they must

complete a residency, fellowship, or advanced degree.^{22,23} While obtaining research experience at the postgraduate level is critical, all PharmD graduates must be equipped with the skills needed to understand and conduct inquiry-based activities. Capstone courses, like some of the ones described here, can provide a mechanism for pharmacy students to engage in structured research experiences under the supervision of faculty members.

The majority of the capstone experiences included in this study are ongoing, with most undergoing minor modifications over the years in response to curriculum changes. Curriculum reform is prevalent among schools of pharmacy as they work to align their programs with health care needs and changes in pharmacy practice.²⁴ Outcomes from capstone experiences can provide schools with valuable information regarding their curriculum’s ability to prepare future pharmacists. Saseen and colleagues were able to use their capstone course as a form of curriculum assessment for course directors.²⁵ This allowed for the modification of courses and changes to pedagogical strategies, which led to the inclusion of more active-learning and student-centered approaches across the curriculum.²⁵ Thus, capstone courses can have the additional purpose of supporting curriculum assessment, which demonstrates the importance of creating a capstone experience that is not only adaptable to advances in pharmacy practice, but also leads to improvements in educational programs.

When thinking about the sustainability of capstone courses, schools of pharmacy should consider the resources needed to ensure success. Schools must be cognizant of the time requirement that capstone experiences place upon the faculty, the resources, and ultimately the cost required to implement a capstone course.^{20,21,25,26} In addition, changes to the curriculum may be needed to accommodate a capstone course within a school’s overall curricular structure. For instance, research-focused capstone courses need purposeful alignment and structure to support students for the duration of their research experience.^{20,26} In addition, advanced practice-readiness capstone experiences should incorporate a wide range of comprehensive topics and skills to ensure students are ready for experiential placements.^{25,27}

More broadly, capstone designers must be thoughtful about viability, feasibility, desirability, and potential challenges.^{13,14} *Design thinking* (also called *human-centered-design*) is a time-tested, widely recognized, and evidence-based approach to problem-solving that brings together what is desirable, feasible, and viable to design processes and aligns them with user needs.^{13,14,28} Design thinking is also increasingly used within health professions education and health services research.^{29,30} By

focusing on end users, processes can be developed in a way that aligns key objectives with user needs, thereby optimizing outcomes more efficiently and effectively. In the context of capstone experiences, consideration should be given to who the key stakeholders and end users are, what problem the capstone experience should be designed to address, and which possible solutions most closely map to the design criteria described above.

This review and series of interviews provides insight into the current landscape of capstone experiences in pharmacy education. However, there are some limitations to this work. First, this study included only capstone experiences that have been described in published research, which means only a small portion of the capstone experiences currently provided in US pharmacy schools were included. Second, the current study used only a single database, PubMed, to identify and obtain the articles included. While this review purposefully focused on pharmacy capstone experiences, capstone experiences from other health sciences professions may provide additional insight into capstone design and sustainability. Further, some authors only responded to our inquiry via email, thus limiting the opportunity to ask clarifying questions.

Despite these limitations, this study provides critical insight into capstone experiences within pharmacy education, specifically as it relates to their purpose and sustainability. Given the resources and time required of faculty members and students to engage in capstone experiences, more research is needed to fully understand the return on investment for capstone experiences. More specifically, for whom and at what point are various types of capstone experiences effective for assessment and promoting student learning? Future research could also explore the feasibility of capstone experiences as a threshold for student progression, and as a potential approach to standardizing the definition and assessment of APPE readiness.

CONCLUSION

A variety of capstone designs are used within pharmacy education for various purposes. This study suggests that capstone success relies largely on faculty buy-in and effort and that schools must commit time, money, and personnel resources to enable capstone success. Given the lack of capstone guidelines, this study can help pharmacy educators better understand and account for these issues in the capstone design process. Additional research is needed to elevate capstone practices and equip faculty members with the tools needed to optimize student learning, enable accurate assessment, and inform curricular design through the use of capstone experiences.

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