AC 2010-806: TOWARDS A MODEL OF TEACHING EXPERTISE IN CAPSTONE DESIGN: DEVELOPMENT AND VALIDATION OF A PRELIMINARY SURVEY INSTRUMENT

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Towards a Model of Teaching Expertise in Capstone Design: Development and Validation of a Preliminary Survey Instrument

Abstract

Capstone design courses seek to create a transitional environment between school and work by engaging students in collaborative, open-ended projects. These environments present a challenge to capstone faculty because the pedagogies used in such courses may differ significantly from those used in more traditional courses focused on technical content. To date, however, little literature exists to help define these pedagogies or understand teaching expertise in the capstone classroom more broadly. To address this gap, this paper describes the development, validation, and results of a survey instrument to explore capstone teaching, using expertise constructs from the K-12 literature as a starting point. Results from this instrument, distributed as part of a national survey of capstone faculty, suggest that current capstone faculty exhibit expertise traits related to both experience and knowledge, but not those related to social recognition and teacher preparation. The next phase of this study will examine the degree to which these constructs correlate to both specific teaching practices and student learning in the design classroom.

Introduction

Cognitive approaches to expertise across domains demonstrate that experts think in ways that are qualitatively different from novices, and these differences allow experts to approach problems more efficiently and creatively.[1] Experts in any arena tend to recognize patterns and deep structures, conduct extended qualitative analysis of problems, effectively monitor situations, apply well-tuned decision-making practices, and adopt an opportunistic, flexible approach.[2] But while researchers have examined expertise across a variety of domains, including the arts, games, athletics, and design, few sustained studies of teacher expertise are currently available. Those that are available focus on K-12 [e.g., 3-9]; almost no studies examine teaching expertise among university faculty. Yet understanding such expertise is central to improving faculty preparation and professional development. Such understanding also provides an important complement to research that examines effective practices (e.g. active learning, outcomes based assessment models) by identifying how experts deploy those practices to maximum effect. The need to understand faculty expertise may be particularly sharp in design education, which often requires coaching and mentoring in ways that differ from the teaching approaches that have proven successful in traditional engineering classrooms.[10]

Prior researchers have examined design education from varying perspectives, including national surveys about course structure and management by Todd et al.[11] and Howe and Wilbarger[12, 13] and a national survey of assessment practices by McKenzie et al.[14] In addition, scholars have posited descriptions of both project criteria[15] and faculty practices[10] based on localized case studies. Design learning has also been examined from multiple perspectives, most notably by researchers at both the Center for Engineering Learning and Teaching [e.g., 16-22] and the Transferable Integrated Design Engineering Education project.[e.g., 23-29] While such studies contribute to design education, they do not yet provide models of teaching that can systematically support the preparation and development of design faculty.

Characterizing teaching expertise in design education first requires the identification of potential experts for study. Such identification is problematic, however, precisely because we have no clear definition of expert – the issue thus becomes an infinite loop. To break this loop, this paper posits one approach, based on expertise models derived from a related domain, and presents findings from the first phase of the study. In particular, we describe the development, validation, and results of an instrument to identify experts using criteria developed from studies of K-12 teachers. K-12 was selected as a starting point because it is the domain closest to university teaching where models of expertise exist. This preliminary model of expertise, when examined with the teacher beliefs and practices, will allow for identification and exploration of potential expert practices in capstone design education. Subsequent project phases will collect both qualitative and quantitative data to determine how these expertise criteria manifest themselves in the capstone classroom, the degree to which these measures of expertise correspond to success in student development, and what factors beyond the K-12 model also contribute to expertise in design teaching.

Importantly, we do not assume or even expect that the preliminary model, derived from K-12 research, fully represents capstone teaching expertise; instead, the model is used for two specific goals:

1. To determine the degree to which capstone faculty meet the criteria for expert teaching as defined by K-12 research.
2. To determine the degree to which this model, if applicable to the capstone environment, correlates with specific teaching practices in the capstone course.

The first goal provides a mechanism to understand the applicability of these criteria to the capstone domain; the second contributes to a robust understanding of capstone teaching that can inform professional development efforts for new and current faculty. This paper addresses the first goal by explaining the development and validation of an instrument based on the model and presenting the findings from a national study. In addition to these goals, the survey that included this instrument also provides a tool to identify potential faculty for further study to revise the model and more fully explore the nature of expert design teaching from both instructor and student perspectives.

Defining Teacher Expertise

As noted above, cognitive science views expertise as a way of thinking. It goes beyond the collection and storage of knowledge. As people learn they create links between the new knowledge and knowledge formerly gained. Experts are capable of identifying many interrelationships, allowing them to retrieve information faster than novices and in more contexts.[1] Dreyfus and Dreyfus[30] have created a scale that examines five stages of expertise, from novice through expert. Using this scale, Berliner[3] has developed a heuristic model of how K-12 teachers develop into experts, shown in Figure 1.

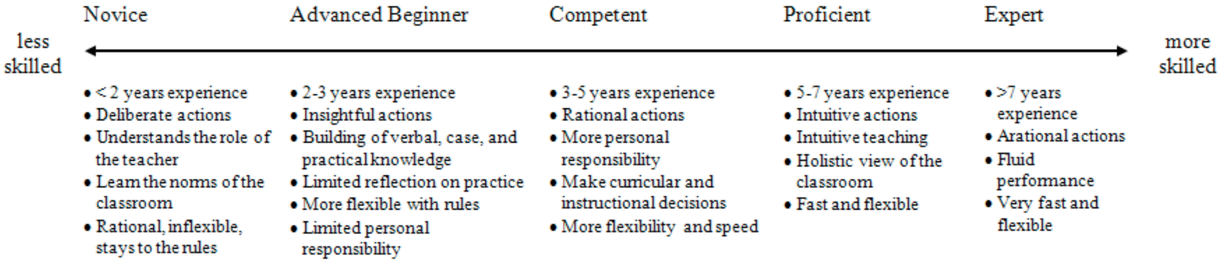

Figure 1: A construct map for the development of expertise.[3]

The first stage, novice, typically lasts through the first year of teaching. Novice teachers have a general understanding of the rules of the classroom, and are reluctant to alter those rules. According to Fennema,[31] when teachers do not have deep knowledge of a subject they focus their instruction on rules and ask questions that require students to recall rather than synthesize. During lectures the teachers discourage student questions and participation. Novice teachers often ignore or fail to recognize student misconceptions. Most of their actions are rationalized and they view this time in their development as means to gain real world experience.

The second phase, advanced beginner, is closely related to novice. It typically occurs during the 2nd to 3rd years. In this phase verbal, episodic, and case knowledge are added to the knowledge gained during the novice stage.[3] As a result, the use of reflection is important: teachers in this phase frequently reflect on their experiences and how those experiences contribute to their knowledge; based on these reflections, they then begin to make alterations to their teaching practices. Moreover, their experiences, particularly in powerful or memorable situations, help build episodic knowledge that they can then draw on to respond to non-standard situations (i.e. the places where real classrooms differ from textbook idealizations).[32] As novice teachers soon realize, the classroom is a "messy" and ill-defined environment. Nespor[32] notes that episodic knowledge allows teachers to make sense of these ill-defined environments. In an ill-defined situation teachers can quickly scan their episodic knowledge and provide a swift response to the situation. This episodic knowledge is so strong that any misconceptions embedded within it must be addressed prior to subsequent development along the expertise spectrum. It is difficult for experts to alter misconceptions once they have reached the proficient level.[1]

Competency, the third stage of expertise, is typically seen during years 3 to 5. Teachers spend this time making conscious decisions about what is important and how to properly execute it.[3] The routinization frequently seen by experts begins to develop during this phase, as teachers tend to stay on task during the class. They also become more personally responsible for their classes, deciding whether to move to a new subject or continue reinforcing the current lesson based on the context (e.g. evidence of students' grasp of the material) rather than a prescribed schedule. These actions show an increased flexibility in the teacher's rules and student engagement.

The last two stages are rarely seen among educators.[3] Berliner describes the fourth stage, proficient, as an increase in intuitive teaching. Teachers begin to see trends in student learning experience from one lesson to the next and are capable of altering their plans to accommodate a better learning environment. Expert teachers exceed this level by performing arationally, by acting effortlessly and fluidly without much analysis while things are going smoothly in the classroom.[3] Experts utilize routines effectively, while maintaining the ability to alter lesson plans based on the feedback from the students. Expertise is not normally reached until after year seven. According to Berliner, many teachers never progress past the competent stage.

Berliner's contention that many teachers never reach the expert level indicates that identifying expert teachers requires more than simply using years of experience since a great many teachers have decades of experience and thousands of hours in the classroom. Instead, researchers have used a variety of criteria. In one meta-analysis, Palmer et al.[6] examined 27 studies that used various means to identify expert teachers; common factors included years of experience in conjunction with teacher preparation, social recognition, and teacher knowledge. For example, a study by Leinhardt[33] identified experts as those teachers with 20+ years experience who had received social recognition for their teaching and who had a passion for their subject matter. Palmer's study also highlights the use of normative performances for teacher evaluation – that is, approaches that linked teacher expertise to measures of student learning; we note that subsequent phases of this study of capstone teaching expertise will include such measures.

Drawing from this research, we developed a preliminary model built on the integration of experience, teacher preparation, social recognition, and knowledge base (with the knowledge base subdivided), as illustrated in Figure 2. As noted above, this model is based on factors associated with expertise that were identified primarily in research on K-12 teachers, and it accords each factor equal weight; the resulting instrument is the first step in testing the applicability of these criteria to the capstone environment. Each construct is explained in detail in the following sections.

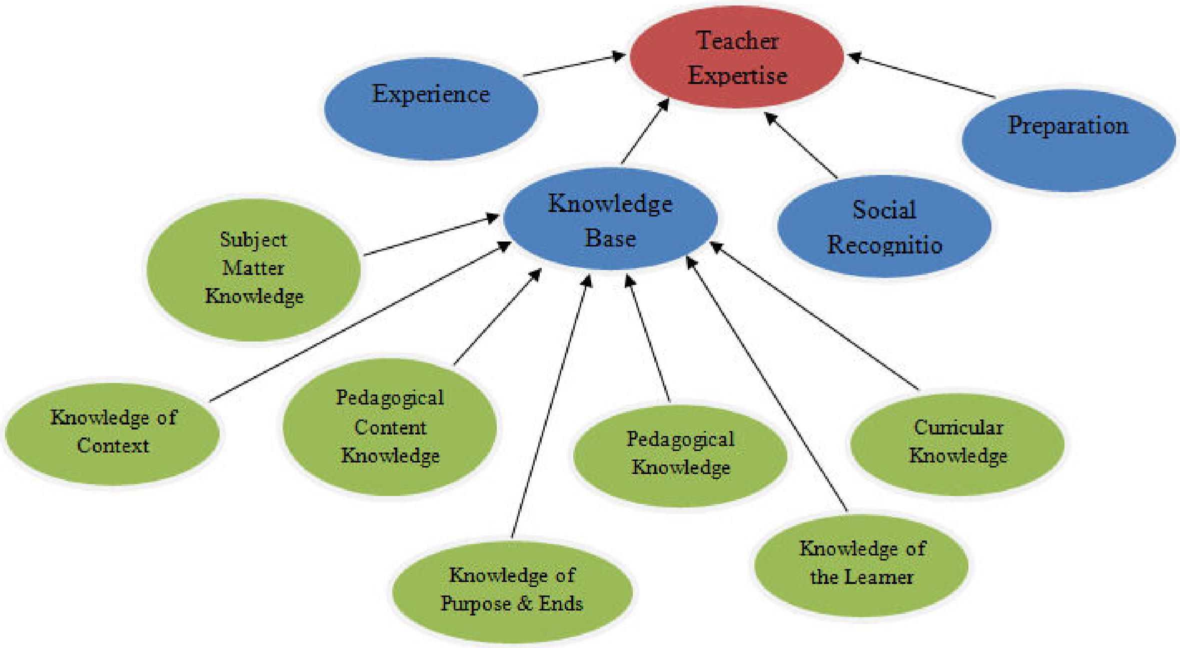

Figure 2: An Internal Model of Teacher Expertise.

Experience

While experience alone is not sufficient to account for expertise, it is a significant factor. Studies suggest that it requires 7,000 – 10,000 hours of practice at an activity, along with useful, constructive feedback on performance, to develop such expertise.[3, 6] Studies of expert teachers typically examine those with 5- 10 years of experience.[6] A typical K-12 teacher with 7 years experience has spent more than 7,000 hours in the classroom, in addition to more than 1000 hours in student-teaching settings.[3] Berliner reports that teachers feel it takes 3 to 5 years of experience within a specific classroom before they are not surprised by the ill-defined nature of the classroom.[3] Confirming this "feeling," a study by Huberman[34] identified 18 problems that novice teachers faced when they began to teach, all related to classroom management. During their 3rd year of teaching, they had only solved 5 of these problems.

Importantly, because expertise is domain and context specific,[6] experience needs to be related to both the subject matter and the classroom context (i.e. level of learners and type of classroom). That is, teaching general chemistry to first-year students in a 500-seat lecture does not necessarily build expertise that would transfer to teaching thermodynamics to juniors in chemical engineering in a 40-seat class. Moreover, for experience to be effective in promoting expertise, teachers must engage in tasks that are difficult and require them to pursue more complex issues. These tasks must also be repeated and practiced, followed by reflection.

Teacher Preparation

Expert teachers also usually experience several levels of preparation, including an initial training period (e.g. a degree or formal coursework in education) and ongoing professional development (e.g. additional courses, workshops, reading in the current literature), as well as time spent individually preparing for classes and courses. Formal coursework in education often provides a basic foundation for understanding teaching and learning. Professional development frequently introduces teachers to new uses of technological learning aids or class management techniques under the guidance of experts who can support learning and development, much the way athletes learn from coaches.[3]

In addition to "being prepared" by others, expert teachers also value time they themselves spend preparing for lessons. When questioned, expert teachers noted that they rarely taught a class where they had not sufficiently planned the lesson.[3] Prior to entering the classroom, expert teachers devoted enough time to planning so that they understood the context of the classroom and could successfully carry out several activities. When asked, participants of Berliner's study said that they would need anywhere from 3 hours to 3 weeks preparing for a class, depending on the nature of the class and their specific domain of knowledge.[3]

Knowledge Base

Expertise as a teacher requires considerable knowledge. Although teacher preparation and experience represent one means of accumulating such knowledge, the knowledge itself represents a separate criterion with several subcategories. Shulman,[35] for example, has identified the seven categories of teacher knowledge that represent the minimum needed for expertise: subject matter knowledge, general pedagogical knowledge, pedagogical content knowledge, curricular knowledge, knowledge of the learners, knowledge of educational contexts, and knowledge of educational ends, purposes, and values. Each category impacts the others and influences a teacher's level of expertise.

Subject matter knowledge is, obviously, critical. Fennema[31] indicates that when teachers had a deep understanding of the subject matter, they structure class activities so that students deal with the conceptual nature of subjects, giving teachers the opportunity to actively encourage student questions. They rely less on drill activities and focus class lessons around problem-solving activities where they are comfortable asking questions that involve transfer and draw on the relationships between concepts. These teachers are also more efficient and have different paths for solving problems, making them more willing and able to deal with students' misconceptions.

General pedagogical knowledge pertains to basic principles of class management and organization of materials, often learned through propositions and case knowledge.[36] Experts with general pedagogical knowledge carry out their classes according to a structured, scripted routine. For example, teachers with pedagogical knowledge can clearly identify the different segments of a lesson.[37]

Pedagogical content knowledge combines both specific domain knowledge and pedagogical practices, and reflects what experts know about how this particular subject can be taught effectively, what misconceptions are likely to arise, and how to help students achieve the specific learning goals of the domain.[36] Such knowledge allows expert teachers to craft lessons so that they can be adapted to varying students and abilities. Experts display high levels of metacognition and are capable of identifying patterns quickly and accurately, allowing them to confront and alter student misconceptions.[37]

Knowledge of the educational context and knowledge of the learner define the teacher's understanding of the environment in which they teach. As noted earlier, both subject matter and context are domain-specific. A teacher who is expert at lecturing to a large class may not be an expert individual tutor.[38] Berliner found that expert teachers clearly recognized the importance of this contextual knowledge.[3, 37] The expert teachers, for example, when placed in an unfamiliar classroom, asked to be able to negotiate their own relationship with their students rather than be briefed on the students by others. They wanted to develop their own knowledge of students' cognitive capabilities because such knowledge was critical to the design of their lessons and the management of the classroom. When placed in an environment where such knowledge was not readily available, even experts had difficulty teaching the lesson.

Knowledge of educational ends, purposes, and values refers to the degree to which teachers comprehend the educational purposes of their course and the outcomes that they intended for their students to achieve at the end of the course. [35] This aspect of knowledge is critical to the development of the course curriculum and the focus that teachers give to specific topics covered throughout the course.

Social Recognition

Finally, social recognition has historically played an important part in identifying expert teachers for study.[6] For example, awards are often given to teachers that have been recognized by the community as successful. Recognition can also take the form of grants or monetary funds or publication of writings. Publications, in particular, represent a form of teaching scholarship where teachers are recognized as experts when reports of their teaching practices are submitted to sources that are peer reviewed. This type of scholarship indicates that the teacher is aware of their practice and is contributing to the body of knowledge in a specific area.[38] Membership in professional organizations can also be a marker of social recognition, though such memberships have been considered less significant because they are socially constructed and can be initiated by the teacher.[6]

Summary

As noted earlier, these four constructs (experience, preparation, knowledge, and social recognition) were derived primarily from studies of expert teachers at the K-12, and they are used here as a starting point to model teaching expertise in capstone design. They are not, however, intended to fully capture that expertise, and we expect that future phases of this project will demonstrate that some criteria appropriate for K-12 may not apply or carry equal weight at the university level and that additional criteria not included in K-12 studies are salient for the capstone domain.

Instrument Development: Test Specifications

Development, validation, and distribution of the survey were conducted with approval from the university's Institutional Review Board (IRB #08-465).

Operationalization of Constructs

The theoretical framework for the instrument identified four primary variables of teacher expertise: experience, social recognition, preparation, and knowledge base. Knowledge base was further subdivided into subject matter knowledge, pedagogical knowledge, pedagogical content knowledge, curricular knowledge, knowledge of the context, knowledge of the learner, and knowledge of ends and purposes. For the purposes of the survey, these constructs were operationalized as shown in Table 1. These characteristics were then converted into survey questions.

Table 1: Operationalization of characteristics of teacher expertise.

Experience	• overall # of years teaching • # of years teaching design courses • # of years teaching current capstone course • # of years work experience in subject of capstone course
Preparation	• time spent preparing for the year, semester, or class • # of additional courses taken (not towards a degree) focused on design or subject matter related to capstone course • # of courses taken to aid with class management (technological tools, teaching approaches, etc.)
Knowledge *Subject Matter (SMK)*	• education related to design or capstone subject area • # of years work experience in subject of capstone course
Knowledge *Pedagogical (PK)*:	• education related to teaching • overall # of years teaching • classroom management (routines & flexibility)
Knowledge *Pedagogical Content (PCK)*	• # of years teaching design courses • # of years teaching current capstone course
Knowledge *Curricular (CK)*	• familiarity with other capstone course • conferences attended related to capstone courses
Knowledge *Context (K of C)*	• familiarity with the teaching institution • familiarity with available tools and resources
Knowledge *Learner (K of L)*	• familiarity with students • effort to know students
Knowledge *Purposes and Ends (K of P&E)*	• purposes of the course • intended student outcomes
Social Recognition:	• involvement in organizations related to subject of capstone course or design (how many?) • # of published articles related to subject of capstone course or design (peer reviewed?) • # of awards received (local, state, national, international) • # of grants received related to subject of capstone course or design (how much was it worth?)

Pilot Testing

Following the procedure for test construction outlined by Crocker and Algina,[39] after operationalizing the constructs (Table 1), we created an item pool and conducted pilot testing. The pilot version of the instrument included all four criteria (experience, preparation, knowledge, and social recognition), along with demographic information. The instrument consisted of 42 items and included both categorical, multiple choice, and Likert scale items.

Pilot testing took place in three phases: review by content experts, review and testing by participants, and an analysis of test items. The first phase included a review of the instrument by three content experts in the fields of design, capstone design education, and pedagogy. This review took place prior to sending out the instrument. Several phrases and terminology were modified to properly address the questions.

Once the items and overall test had been revised, the instrument was distributed to 102 faculty members involved in engineering capstone design courses in 10 engineering departments at a large land grant university in the southeast United States. Their involvement included roles as course coordinators and project advisors. The test was distributed to the sample through email. Five days after the first distribution there was a 16% response rate. A second notice was sent out on the 5th day. This resulted in a total response rate of 38% after 12 days. As part of the survey, all participants had the opportunity to provide written feedback about each question and the instrument as a whole.

A reliability analysis was conducted on all items. The total reliability of the test had a Cronbach's alpha of 0.702. The minimum alpha "if item deleted" was 0.643. The maximum was 0.734. Examining the results of the point-biserial analysis shows that there were 3 items that had low values (<0.1). Removing these items increased Cronbach's alpha to 0.773 (Table 2).

Table 2: Total Cronbach's alpha for pilot test and items removed

Test Reliability	0.702
Test Reliability – Items removed	0.773

The results of the item analysis and participant feedback provided significant information for the refinement of the instrument. Overall, each item had an independent alpha greater than 0.6, which is acceptable for item analysis. In order to improve alpha, an additional review of the items was conducted to identify poorly written questions.[40] Written feedback from the participants identified such questions, suggested improvements, and helped identify items that needed to be added or removed.

Once issues raised by the analysis and feedback were addressed, the number of items was reduced to 28 and the measure was included in a larger survey about capstone design. This survey incorporated items from two earlier national surveys[11-13] and added not only the expertise criteria but also questions about teaching practices, faculty beliefs, course structure, and related areas. Prior to distribution, the full survey was evaluated by content experts in both capstone design and survey development; no statistical analysis was conducted on the expert review of the full survey because of the small sample size (n=7) of this evaluation. After modifications based on this expert feedback, the survey was distributed nationally, as described below.

National Survey Validation

During the Fall of 2009, the survey was administered to 1258 participants, all of whom had been identified as capstone design faculty in ABET-accredited programs. The study pool was developed by sending contact emails to every ABET-accredited engineering program in the country; these emails requested contact information for the program's capstone course. Capstone instructors were sent individual emails containing a link to the survey. After three reminders sent over the span of 6 weeks, 491 participants had responded to at least part of the survey (an overall response rate of 39%); however, the survey allowed individuals to skip any question at their discretion. For the expertise measure, 396 respondents answered all questions included in the measure. A reliability analysis indicated that the expertise measure had a Cronbach alpha of .635 overall and .677 on standardized items. Further analysis of individual items indicated that items had a minimum alpha of .611 and a maximum alpha of .657, which is acceptable for attitudinal and demographic questions.[41] An examination of the point-biserial of the items indicated that 5 items had values less than 0.1. Questions 6 and 7, related to subject matter knowledge, had low scores due to an overwhelming population of participants having extensive technical knowledge in the field of their capstone design course. A question that addressed social recognition by inquiring into the number of grants received by the respondent received a low score due to a bimodal distribution of responses at the extremes of the answer responses. The last two items that had low scores, 6a and 6b, addressed the pedagogical knowledge of the faculty. These low scores may have been due to poor wording of the questions.

Table 3: Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.635	.677	28

With 396 participants completing the expertise measure questions, the requirements for principal component analysis (PCA) were satisfied (a minimum of 5 to 10 times the number of items is needed for survey respondents, with a minimum of 100 responses[42]). The results of the PCA indicated that 11 primary components made up 67.9% of the variance in the instrument. This result aligns with the number of components in the subgrouping in the internal model, with items loading on their respective categories, indicating that the instrument was valid and that the results can be used to probe expertise in capstone teaching in relation to the model used for K-12 environments.

Survey Results

The expertise score is a normalized summation of all items included in the expertise measure. The results of the expertise measure indicated that out of a possible score of 131, the mean score was 78 with a standard deviation of 9.2. A distribution of the scores (Figure 3), while not statistically normal, shows that the majority of scores ranged from 68 to 87.

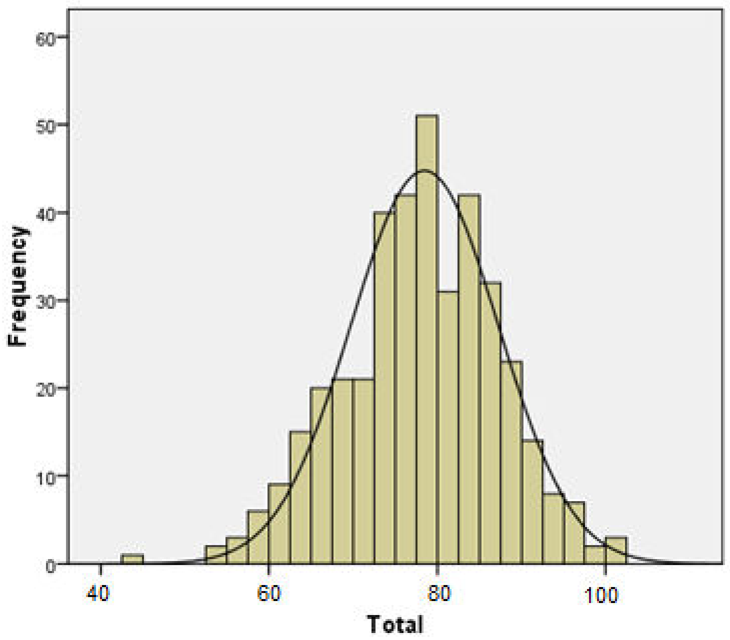

Figure 3: Distribution of teacher expertise scores among capstone faculty

The following sections describe the results for each component of expertise in the model.

Experience

Survey respondents reported considerable experience both in teaching and in engineering work outside academia, as shown in Table 4. Seventy-seven percent have 8 or more years of teaching in general, and 60% have 8 or more years of experience teaching non-senior level design courses. Fifty-one percent have been teaching a capstone design course for 8 or more years and the median years of experience were 6 to 7 years.

Similarly, almost half of the respondents have 8 or more years experience working outside of academia in engineering (47.4%) or in the discipline that they are teaching (42.8%). The median level of work experience is between 6 and 7 years.

Table 4: Experience of capstone design faculty

	Median	**Mode**
Overall teaching	≥ 8 years	≥ 8 years (77.4%)
Teaching non-capstone design courses	≥ 8 years	≥ 8 years (59.6%)
Teaching senior design	≥ 8 years	≥ 8 years (50.9%)
Professional work outside academia	6 - 7 years	6 - 7 years (47.4%)
Professional work in the same discipline as their capstone design course	6 - 7 years	6 - 7 years (42.8%)

Preparation

Despite high levels of experience, survey respondents report only low to moderate levels of preparation with respect to professional development, a finding not unexpected among university faculty. A majority of the sample does not attend short courses or conference sessions related to design or capstone education. Fewer than half of the sample (47.8%) attends 1 to 3 short courses a year that focuses on general pedagogy, while an almost equal number (48.8%) do not attend any. Similarly, fewer than half of the respondents (48.1%) read 1 to 3 articles or books related to design education or their capstone course and a majority (59.5%) report that they do not attend conference sessions related to design education or capstone courses.

Table 7: Annual professional development activities of capstone faculty

	Median	**Mode**
Short course on design education	Zero	Zero (73.4%)
Short courses on general pedagogy	1-3	Zero (48.8%); 1-3 (47.8%)
Conference sessions on design education/capstone courses	Zero	Zero (59.5%)
Read material about design education or capstone courses	1-3	1-3 (48.1%)

Knowledge

As noted earlier, knowledge includes subject matter knowledge, general pedagogical knowledge, pedagogical content knowledge, curricular knowledge, knowledge of the learners, knowledge of educational contexts, and knowledge of educational ends, purposes, and values.[36]

In several subareas, survey respondents reported high scores. Not surprisingly, with respect to subject matter knowledge 86.5% of the faculty have a doctoral degree and 83.4% have their highest degree in the same discipline as the capstone course that they teach. Knowledge of the educational ends, purposes, and values show similarly high numbers, with more than 70% reporting a strong understanding of the purpose of the capstone course and 85% strongly agreeing that it is important to the development of their students.

With respect to knowledge of learners and context, the results are still strong, though slightly lower, with most faculty selecting “agree” rather than “strongly agree” that they know their students and know what is happening in their classrooms. Faculty typically know their students personally, and they know how the students are progressing with their work and how their teams are working. Importantly, they report that this knowledge affects the way they teach their course.

Scores are lower with respect to pedagogical content knowledge and pedagogical knowledge, with median responses to these questions at “neutral” (3) rather than agree (4 or 5). Typically, faculty that have a strong pedagogical knowledge base have a set routine that they follow each day and their students are aware of this. [35] Faculty that have strong pedagogical content knowledge have a flexible timeline in their classes, allowing time to answer questions that are important to students and deal with misconceptions as they arise, rather than pushing the class along. The median score among respondents in both of these areas is lower than scores for other knowledge subareas.

Table 5: Capstone design faculty perceptions of knowledge base (Likert Scale Responses where 1 = Strongly Disagree and 5 = Strongly Agree)

	Type of Knowledge	**Median**	**Mode**
Highest degree in discipline	SMK	Doctoral	Doctoral (86.5%)
Have a flexible time line for their classes	PCK	3	4 (29.3%)
Have a specific routine for each class they teach	PK	3	3 (31.0%)
Am familiar with different engineering programs	CK	4	4 (37.6%)
Keep up with their student's progress	KoC	4	5 (43.9%)
Know how well the teams are functioning	KoC	4	4 (43.0%)
Know students personally	KoL	4	4 (34.1%)
Teaching is affected by the knowledge of their students	KoL	4	4 (37.5%)
Understand the purpose of the capstone course	KoP&E	5	5 (70.7%)
Feel the capstone course is important	KoP&E	5	5 (85.4%)

Social Recognition

In contrast to knowledge and experience, social recognition measures suggest that capstone design instructors place less emphasis on this component - again, perhaps, not surprising among university faculty (although opportunities for both teaching awards and publication of engineering education scholarship are growing, making this an area worth following in the coming years). On a 5 point scale (5=strongly agree), faculty rate the importance of having their work recognized a 3 (median and modal, 33.6%). This lack of concern for social recognition is also reflected in the number of grants received and papers accepted. While most faculty are involved in at least one professional organization related to their discipline (77%) and to engineering education (65%), a substantial minority report no grants or published papers. With respect to the number of grants received related to the discipline of their capstone design course, the median number was between 1 and 3 grants per year, but a modal analysis reveals that about a third of the sample receives no grants and another third receives 8 or more per year. Less emphasis is placed on publishing papers in design education; the median number of papers published per year is between 1 and 3, with almost half of the sample publishing none.

Table 6: Aspects of social recognition of expertise achieved by capstone design faculty

	Median	**Mode**
Involved in professional organizations in capstone design discipline	1-3	1-3 (76.9%)
Involved in professional organization in engineering education	1-3	1-3 (64.9%)
Grants received related to capstone design discipline	1-3	None (30.1%); ≥ 8 (29.5%)
Papers published related to design education or capstone courses	1-3	None (46.6%)

Conclusions

Understanding teaching expertise in capstone design courses is an important step in developing strategies for preparing design educators and enhancing design learning. To date, however, no robust models of expertise in this domain exist, though research on K-12 teachers does present potential criteria. The instrument presented here applies a model based in K-12 pedagogy to identify the potential transferability of these criteria to the capstone setting. The results of a national survey suggest that the criteria have at least some applicability and merit further exploration. The items associated with each criteria (experience, preparation, knowledge, and social recognition) have sufficient internal validity to demonstrate that the instrument is measuring these constructs effectively. Moreover, the faculty responding to this survey do exhibit many of the characteristics of teaching expertise at a level comparable to teachers in K-12, the domain from which the model was derived. A majority of respondents fall into the "competent" category defined by Berliner's development scheme, which corresponds to Berliner's findings for K-12 teachers.[3] That is, capstone faculty responding to this survey exhibit characteristics comparable to K-12 teachers.

In particular, capstone faculty report high levels of *experience* in both teaching and working outside of academia. In addition, they report high levels of *content knowledge* in the discipline of their capstone design courses. However, they report only moderate levels of *pedagogical knowledge* and *pedagogical content knowledge*, perhaps due to a lack of professional *preparation* in these areas to advance the pedagogical practices used in their courses. In addition, while respondents report strong knowledge about the educational goals and outcomes, and place a high value on the place of the course within the curriculum, *social recognition* does not appear to play a strong role.

These findings, however, represent only the first step in exploring capstone teaching expertise. Subsequent analysis of the survey data will explore correlations between the expertise measure as a whole, as well as the individual criteria, and classroom teaching practices. Beyond this analysis, additional qualitative and quantitative data collection will be used to explore the degree to which these criteria correlate to student development in the classroom. The results of such work will ultimately be used to enhance both faculty preparation and ongoing professional development in support of design education.

Acknowledgements

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Appendix A: Item analysis for nationally distributed instrument

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
6	84.00	83.264	-.037	.223	.639
7	86.00	82.685	.051	.119	.635
8a	82.26	78.815	.226	.515	.624
8b	82.88	75.375	.223	.360	.624
8c	83.01	75.541	.262	.388	.619
8d	83.27	74.997	.215	.822	.625
8e	83.48	73.717	.243	.810	.622
9	85.08	80.552	.221	.326	.627
10a	84.72	80.893	.213	.302	.628
10b	85.09	79.536	.317	.369	.622
10c	83.98	80.412	.003	.285	.657
10d	84.80	74.519	.299	.256	.614
11a	85.55	80.495	.269	.338	.626
11b	85.24	80.713	.167	.312	.629
11c	85.40	81.066	.161	.342	.630
11d	84.17	74.718	.280	.241	.616
12a	80.86	74.557	.179	.264	.633
12b	84.11	80.040	.143	.213	.631
6a	83.64	80.432	.053	.108	.642
6b	83.73	80.744	.046	.196	.642
6c	83.09	76.060	.375	.189	.611
6d	83.86	76.508	.243	.229	.621
6e	82.65	77.874	.292	.539	.619
6f	82.77	77.836	.306	.536	.618
6g	83.19	76.593	.291	.391	.617
6h	83.43	76.969	.234	.333	.622
6i	82.20	78.871	.353	.370	.619
6j	82.03	80.733	.244	.330	.627