Andragogical Practices in Capstone Design Courses

James J. Pembridge[1] and Marie Paretti[1]
[1]Virginia Tech

Faculty knowledge and beliefs structures impact the practices that teachers use in their courses in a wide variety of ways. In this paper, we focus on beliefs about student identity and the impact of those beliefs on teaching in the capstone course. Specifically, prior research suggests that faculty who view students as children will use pedagogical practices that are teacher centered, whereas faculty who view students as adults will generally prescribe to andragogical practices that are student centered. To examine pedagogy versus andragogy at the capstone level, this study utilizes data from a recent national survey of capstone faculty to compare the practices of those who believe students are essentially still children to those who believe they are adults. The findings indicate that faculty with high andragogical perspectives promote the self-directed learning and professional development of their students more than faculty that tend to have a pedagogical perspective of their students.

Introduction

Recent trends in engineering education have called for reforms in teaching that more closely align faculty practices with current learning science research and that more effectively develop engineers prepared to work in the twenty-first century workplace[1]. In part, in any field the ability to develop students who can function as successful practitioners depends on the degree to which their education experience occurs in a realistic environment comparable to the workplace[2]. For engineering students, one of the closest examples of a realistic environment is the capstone design course, which is required of all ABET accredited engineering programs. The capstone experience is an opportunity to immerse students in a realistic context so that they can apply what they have learned throughout their undergraduate education. Although the project themselves vary significantly across engineering fields, many have ties to industry and outside-of-academia connections that require a professional attitude by the students.

Students in these courses, however, occupy a unique place in the curriculum. Capstone courses are liminal spaces in which the students are at once still undergraduates in a course working for a grade, and practicing engineers addressing pressing, open-ended design challenges in their field. And the degree to which faculty beliefs position the students as one or the other (or both) significantly effects teaching and learning.

To examine this impact, we draw on the concept of "andragogy." Knowles[3] coined the term andragogy, meaning the art and science of helping adults learn, whereas the traditional term of pedagogy is the "art and science of teaching children"[4]. Thus although "pedagogy" is often used more generally to refer to all teaching practices, in this paper we use it specifically to refer to practices associated with perceiving students as children. Knowles approaches the concept of andragogy and pedagogy as a theory of practices that lies on a continuum, where pedagogy is at one extreme and andragogy at the other with defining assumptions for each (Table 1). This continuum also reflects a continuum between teacher centered (pedagogy) and student centered (andragogy) teaching.

Teacher Knowledge and Beliefs

This study of andragogy versus pedagogy in the capstone course draws broad prior research regarding teacher knowledge and beliefs. Shulman, for example, has identified several types of teacher knowledge that greatly contribute to the skill of teaching: subject matter knowledge, general pedagogical knowledge, pedagogical content knowledge, curricular knowledge, knowledge of the learners, knowledge of educational

Table 1: A comparison of pedagogical and andragogical assumptions based on a continuum[3, 5]

Pedagogy		Andragogy
• Learner is dependent on the decision of the teacher	—	• Self directed learner
• Few life experiences	—	• Large amount of life experiences
• Learning needs are dictated by the teacher	—	• Learning needs are closely related to social roles
• Subject/content-centered	—	• Problem-centered
• Extrinsically motivated	—	• Intrinsically motivated

contexts, and knowledge of educational ends, purposes, and values[6]. Of interest to this study is teachers' knowledge of and beliefs about the learner.

Beliefs are particularly important in capstone courses because of the ill-defined nature of the environment. The open-ended nature of the projects means that each project is different, with different needs and expectations. The highly variable nature of capstone projects means that faculty must often rely on personal judgment and experiences to make decision about how best to guide student learning. Moreover, ill-defined environments frequently require educators to process information quickly and make decisions at intuitive levels. In these situations, underlying beliefs are critical determinants of practice [7]. Since belief structures are unbounded and are less dynamic and flexible than knowledge systems, they add stable contextual characteristics to an ill defined setting [7]. Moreover, beliefs are predominately stored in the episodic memory; as a result, they contain the background coloration that allows educators to quickly scan their memory files and address the situation [7].

The role of beliefs in ill-defined teaching situations makes it particularly important to understand both what beliefs capstone faculty hold about students and how those beliefs correlate to teaching practices. As noted earlier, the ill-defined nature of the capstone course is complicated by the transitional nature of the students as they participate in the course. These students operate in a space between undergraduate and professional, and the students themselves may be uncertain of their identity in this context, or even conscious of the ways in which both identities exist in tension[8,9] To address this issue, we examine the following research:

RQ1. In terms of pedagogical and andragogical preference, how do capstone design teachers view the students?

RQ2. What differences in teaching practices emerge between pedagogically and andragogically focused faculty in capstone design courses?

Methods

This study is part of a larger nationwide study to examine a variety of factors associated with teaching capstone design. Related work includes comparison of current trends in course structure to previous studies[10] and the development of a robust understanding of teaching expertise in this environment[11].

Sample

The population of interest for this study is all faculty involved in ABET-accredited capstone design courses. Participants include course coordinators, project advisors, and lecturers. During the summer of 2009, a recruitment effort began to obtain a list of participants willing to participate in the Capstone Design Pedagogy study. The recruitment returned a list of 1258 interested participants. These participants were emailed the survey in the fall and were given a total of 6 weeks to complete it. Throughout the 6 week process, reminders were sent to the list of participants; one at the beginning of week 2 and one at the beginning of week 4. At the end of 6 weeks, there was a 39% response rate.

Measure

The instrument to differentiate pedagogical and andragogical beliefs was incorporated into a larger Capstone Design Pedagogy survey that included questions about faculty background, teacher beliefs, teaching practices, course management, and institutional and department demographics. Built into these sections was a measure of andragogical perspective.

The Andragogical Perspective Measure (APM) consisted of 5 Likert style questions with answers ranging from strongly disagree to strongly agree that were based on the 5 assumptions proposed by Knowles[3]:

1. My students have an independent self-concept and can direct their own learning
2. My students recognize that their learning needs are changing as they develop professionally
3. My students have accumulated a reservoir of life experiences that offers a rich resource for learning
4. My students are problem-centered and interested in immediate application of knowledge
5. My students are motivated to learn by internal rather than external factors

A reliability analysis revealed that the Cronbach alpha for the entire measure was .729. When examined individually the items had a minimum Cronbach alpha of .652. A principal component analysis revealed that 48.3% of the variation in the results were explained by the measure, indicating that the APM is unidimensional; validating that the instrument is most likely solely measuring the faculty's andragogical perspective.

Instrument Design and Analysis

This study was constructed as a non-experimental design as there was no randomization of the participant, use of a control group, or multiple measures[11]. As a result the research design was centered on a descriptive design for the research question 1 and a relation design for question 2.

The APM's Likert item format allows for an addition of the score for each item forming an Andragogical Perspective Score (APS). The score ranges from a minimum of 5 to a maximum of 25. In an effort to determine the different views of those with low andragogical perspective and those with high andragogical perspective, the APS was broken into two

groups based on standard deviations. Participants with an APS of more than one standard deviation below the mean are considered to have a low andragogical perspective and those with an APS of more than one standard deviation above the mean are considered to have a high andragogical perspective.

The descriptive research design addressing RQ1 provides descriptive statics for the overall measure. To address RQ 2, we present statistical analyses that will compare the medians of the low-APS and high-APS groups for survey questions with Likert item responses through the non-parametric Mann-Whitney U test. The U test is frequently used when the data is ordinal. It compares the difference in distribution of ranked scores between two groups in a population.
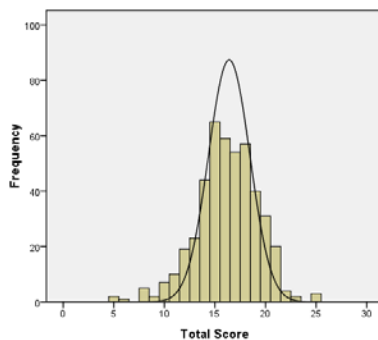
Findings

RQ1: Andragogical Perspective Score: Descriptive Statistics

Of the 448 completed andragogical perspective scores obtained, the mean score was 16.23 with a standard deviation of 3.034. The median score was 16, with a minimum value of 5 and a maximum value of 25. Despite a non-normal distribution (Figure 1), 71% of the respondents had an APS within one standard deviation of the mean. The limits of high andragogical and low andragogical perspective were determined as those participants that are outside the range of the first standard deviation. An APS above 19 is considered high, while an APS below 13 is considered low.

The results of this analysis indicate that a large percentage of the faculty believe their students are more suited to andragogical practices than pedagogical, but that they also believe students exist in a transition between the two categories.

Figure 1: Distribution of andragogical perspective score among capstone design faculty

RQ2: Comparative Andragogical Beliefs and Practices

Background: When comparing high-APS and low-APS responders, both groups have similar years experience teaching capstone design and working outside of academia. They also have similar levels of involvement in professional societies and professional development. Where the two groups differ is in their level of education (Table 2). Those that have a high andragogical perspective have less formal education (i.e. their highest degree is a Masters) than those with low andragogical perspectives.

Table 2: Difference in andragogical perspective score and level of education

	M rank	U
Low APS	96.22	3170.5 *
High APS	83.34	

* p < .05

Feedback and Evaluation Practices: Both the mechanisms for feedback (e.g. written comments on papers) and the frequency of interaction with students are common across APS groups. Differences occur, however, in how the groups evaluate performance. Low APS faculty tend to rely on course instructors more frequently, while high-APS faculty tend to use the input of students and advisory boards. Faculty with higher APS also use evaluations that focused more on the individual student, including consistent progress throughout the course, self reflection papers, focus groups, and individual interviews. Despite these differences, both groups use final written reports, the technical quality of the final product and completeness of deliverables as major components in their evaluation of student performance (Table 3).

Table 3: Evaluations used by capstone design faculty

	Low APS M rank	High APS M rank	U
Final written report	70.82	73.84	2333.0
Technical quality of final product	70.33	74.60	2290.5
Completeness of deliverables	67.65	78.76	2057.5
Consistent progress	65.24	81.40	1848.0*
Quality of teamwork	66.14	81.10	1926.5*
Self reflection papers	61.67	82.73	1610.0*
Peer feedback	66.75	77.46	2018.5
Logbooks	70.58	70.38	2345.5
Focus groups	65.88	77.44	1963.5*

Individual Interviews	61.28	83.32	1577.5*

* p < .05

Course Purpose: The largest difference between the two groups surrounds their beliefs about the purposes of capstone design, important learning outcomes, and their role in the capstone course. High-APS faculty tend to define the purpose of capstone design courses as preparing students for their careers after they graduate. They place more emphasis on providing students with opportunities to network with industry, publish their work, and become involved with professional societies than low APS faculty.

Student Learning: When it comes to student learning outcomes, high APS faculty place more emphasis on students being and becoming more self directed and independent learners. They see having the skills of asking important questions taking responsibility for deadlines and thinking creatively more important than faculty with low APS.

Student Engagement: High-APS faculty also take more interest in learning who their students are and how the design teams are functioning. They view their role in the course as a mentor and managerial position, where they provide guidance on the organization and planning of the project, as well as providing general content knowledge and troubleshooting assistance, but at the same time allowing their students to make mistakes.

Conclusion

The findings of this study support the application of the andragogical theory proposed by Knowles in capstone design courses. Faculty with a high andragogical perspective, hold beliefs and implement practices in their capstone design courses that align with andragogical practices. These faculty put more emphasis on the professional development of their students, giving them the tools needed to work effectively in their future careers. These findings have significant implications in the development of ways to train new design faculty and enhance the teaching practices of current faculty. They suggest, for example, that faculty development efforts may need to begin with teacher beliefs, rather than addressing only classroom practices.

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