AC 2008-970: RESEARCH ON THE EVOLUTION OF COLLEGE INSTRUCTORS' PERSPECTIVES OF TEACHING AND LEARNING

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Research on the Evolution of College Instructors' Perspectives of Teaching and Learning

Abstract

This paper describes five recitation leaders' perspectives of teaching and learning and how they evolved over the course of a semester in which they taught an undergraduate, core curriculum, natural science course, particularly designed for non-engineering majors: ENGR 101, Energy: Resources, Utilization, and Importance to Society. Leaders' perspectives were captured through a series of three one-on-one interviews conducted over the course of an academic semester as they were team-teaching. Our participants, who were not all engineers, worked closely with engineering faculty —the content experts— and learning scientists — experts in pedagogy— over the course of a semester. Weekly group meetings were held to review the recitation activities, reflect on our team's teaching practices, discuss students' reactions, and consider strategies to enhance the effectiveness of our course deliverables. At these meetings, we cultivated a learning community in which we encouraged the recitation leaders to facilitate the learning process, instead of trying to be the main source of knowledge. Our recitation leaders have begun to employ strategies that are more student-centered. The interviews we conducted with them showed their evolving perspectives of teaching and learning. The interviews portray a collaboration that faculty with similar intentions to encourage instruction emphasizing student centered pedagogy may find helpful.

Introduction

Energy sustainability is an important concept for human societies and must address economic, environmental, and societal aspects. A long term goal to stimulate research and technology development toward transformational energy solutions is best addressed through the efforts of all educated citizens, and not only by engineers and scientists. For this reason, professors from petroleum and aerospace engineering departments developed a course (ENGR 101) for undergraduates in all majors, which focuses on the development of interest in and awareness of energy resources, utilization, sustainability and their impact on society. The ENGR 101 was approved as a core curriculum natural science elective. As such, it can fulfill a science requirement on the degree plans of non-science major students. This course is offered through the college of engineering to all undergraduates at a large Southern Research-I University.

Unlike more traditional engineering courses, which often emphasize mathematical calculations, ENGR 101 emphasizes critical thinking and effective communication skills as a mechanism to learn energy concepts, including energy resources, distribution, and management, and how energy may be effectively and sustainably consumed.

The focus of ENGR 101 on the development of critical thinking and effective communication skills required a shift in the pedagogy employed by more traditional engineering courses. In the following sections, we provide an overview of learner-centered pedagogies in order to shed light on our course design efforts, which resulted in this study's context, and influenced its design.

The design of the study we present in this paper was a collective case study[1,2,3]. We aimed at exploring the impact of the collaboration among engineering faculty members, graduate students, undergraduate peer teachers, and learning scientists on the recitation leaders' perspectives of teaching and learning as they attempted to enhance the student learning experiences and the teaching context of ENGR 101. We specifically describe the graduate teaching assistants' and the undergraduate peer teachers' perspectives of teaching and learning and how they evolved over an academic semester.

Theoretical Framework: Learner-centered Pedagogies

A review of literature suggests that learner-centered, student-focused instructional practices[4,5] promote learning goals of critical thinking and effective communication skills, which are a focus of the ENGR 101 course. In contrast to more traditional forms of instruction, which are typically knowledge-centered, teacher-focused, and where the taxonomy of the subject matter structures the activities, learner-centered forms of instruction typically explore students' pre-conceptions, interests and expectations as they participate in classroom activities[6,7]. A learner-centered instructor focuses on exploring and linking students' ideas, conceptual understandings, and interests to the topic of instruction. Student conceptions are constantly assessed and explored in order to develop, refine, or change their understandings in accordance with the learning goals of instruction. A learner-centered classroom often involves students' active participation in discussions. These discussions, which can be largely unstructured, are driven by student input, which creates a learning environment in which student ideas and understandings become central to the nature and completion of class activities. Students' interests, abilities, and limitations form the organization and the implementation of the class activities.

When learner-centered, student-focused instruction[4] is emphasized in a classroom, the role of an instructor becomes that of a leader as they engage students in discussions pertaining to the subject matter of the course. When the overarching course learning goals include the cultivation of life-long learners and informed citizens who are effective communicators, the crucial aspect of the classroom context needs to be concerned with the extent to which students participate in the recitation discussions. In ENGR 101 students are encouraged to not only understand core energy concepts but also think critically and reflectively about those concepts and their potential impacts on society. These abilities include understanding the validity and reliability of information, its political and economical agenda, and its role in sustaining or changing the dynamics of the society. Through this focus, it is hoped that students will learn how to respond

critically and function effectively as citizens in a technologically advanced democratic society.

Energy and its sustainability are the key concepts of the ENGR 101 course. It is apparent that in a democratic society all citizens should be informed and responsible for making decisions that may directly influence their daily lives. Energy is one of the most predominant elements of modern human societies and their survival in a healthy political, economic, and social environment. Hence, the main teaching goal of ENGR 101 is to promote student participation in every aspect of the course activities, ranging from the in-class discussions to the design of the course projects. With this goal in mind, peer teachers, graduate students, engineering faculty, and learning scientists systematically worked together over the academic semester which was the focus of this research to emphasize a learner-centered instructional design in teaching the ENGR 101 course. This collaboration is supported by the National Science Foundation.

Course Context

The ENGR 101 *Energy: Resources, Utilization, and Importance to Society* was not designed like a traditional engineering course. Unique elements in the course design included the non-engineering student population it targeted, the skills and knowledge it emphasized, and the varied learner centered approach to instruction it employed.

Specifically, ENGR 101 employed a variety of learning strategies, including

- weekly quizzes on assigned reading,
- interactive lectures provided to all students as a group,
- weekly recitation sections of no more than 20 students designed to engage students in discussions of current energy news and how it impacts energy sustainability,
- weekly essay assignments requiring students to summarize, analyze, synthesize, and evaluate the material they were initially provided, and later encouraged to find for themselves, and
- a semester-long project with open-ended guidelines

Among the topics ENGR 101 included are major energy resources (e.g., oil, natural gas, nuclear, hydro, wind, etc.); their geographical distribution, production, management, and use, key energy technologies; their historical development, economic and political impacts, challenges we face in using the energy resources; natural versus anthropogenic global warming and emerging initiatives for the efforts to sustain energy consumption across nations (e.g., Kyoto Protocol).

ENGR 101 met for 3 hours per week of lecture for the collection of recitation sections. In addition, each recitation section meets for two hours once a week. Two petroleum engineering professors provide the lectures along with invited lectures from other faculty and industry representatives on various energy topics. While the honors recitation section

is taught by an aerospace professor, the remaining recitation sections are led by undergraduate peer teachers (UPTs) and graduate teaching assistants (GTAs). Employing students to lead in-class discussions and guide the class activities is rare in any course and almost unthinkable in an engineering course. As a result, persuading student teachers to exercise learning centered pedagogies is challenging. However, their own prior experience as students in the ENGR 101 course is very helpful, and this is why UPTs who have taken the course are favored over GTAs. Support from learning scientists has provided a mechanism for nurturing dialogical pedagogies and learner-centered instructional strategies that are proving effective in the recitation portion of the ENGR 101 course.

In addition to what is being done in our ENGR 101 course, peer-teaching strategies have been found very effective in motivating students to engage in science[8] and engineering fields[9,10]. Among the reasons peer-teachers are effective are their close ages and freshness of their learning experience with the concepts students are about to learn. Particularly when the expert-blind spot hypothesis[11] is considered, peer teachers can generate more effective strategies and tangible alternatives to scaffold meaningful student learning.

Engineering faculty team taught the course lecture while graduate students and undergraduate peer teachers led the course recitations in pairs. Lectures were delivered collectively to the entire class. Over the semester more than a dozen guest lecturers provided expertise over a wide range of energy topics. Recitations were delivered as facilitated discussions in three sections. Each section during the semester we collected data contained less than 15 students. The honors recitation section was lead by a professor and one GTA, two UPTs lead one recitation section, and two GTAs led the third recitation section. These recitations were intended to provide students with the opportunities to discuss the topics of the lectures, course readings, and connections to current events.

Students were encouraged to engage in discussions concerning the quiz questions, current events, course readings, and lecture topics. Peer-teachers employed evolving strategies to better engage students in current events. For example, it was not until the mid of the semester that our peer teachers began using the Internet during the recitation time to ask students locate current events and discuss them with their peers in class. Another activity that evolved by the end of the semester was the final course project. Peer-teachers helped students in groups of four to five to design and present final course projects on energy sustainability that modeled a similar project designed as a K-12 outreach activity. Students in the various project groups developed posters, short movies, and presentations. Some conducted interviews with people on campus.

The delivery of the ENGR 101 course at our research campus differed from traditional engineering course offerings in two ways: (a) peer teachers led the recitation activities and (b) weekly homework assignments were essays rather than problem solving assignments. It is not uncommon that many students view engineering practice as simply constructing artifacts such as building a bridge or designing an engine. Partly because many undergraduate engineering courses are heavily involved with concepts of

mathematics and physics, students do not develop a well-informed understanding of engineering practice. Discussing and writing about engineering science offers a means to develop critical thinking and communication skills that many engineers struggle with.

As mentioned earlier, a review of literature suggests that peer-teachers can effectively motivate students to engage in science[8] and engineering fields[9,10], partly because of their close ages with the students, and partly because of the freshness of their learning experience with the same concepts students are about to learn. In this case, the unusual way the concepts are conveyed through discussion and writing makes UPTs the optimal choice for leading the recitation part of the course.

The pairs of peer teachers also attended discussion-based weekly meetings aimed at developing effective methods by which students could be engaged in discussions during the recitations. These weekly meetings were often highly engaging as the learning scientists, peer teachers, and engineering faculty discussed their differing views on instructional practices.

Partly because this course has a unique design and partly because the recitation leaders are peer teachers, and engineering faculty, learning scientists provided guidance to the recitation leaders over the course of the semester during these weekly meetings. Two engineering faculty and two learning scientists systematically worked together with the recitation team-teachers to design and implement learner-centered instructional strategies. Recitation leaders also participated in workshops and seminars on best practices of teaching.

A typical weekly meeting was broken into two halves. The first half was spent discussing the activities of the previous weeks' recitations and the effectiveness of the strategies used to engage students in discussion. The learning scientists and other team members discussed the past week's recitations with the leaders to better understand how their recitations had played out. For example, we discussed the different outcomes of didactically presenting the subject matter to students versus encourage students think critically and reflectively about issues. The second half of a typical weekly meeting was spent discussing the strategies which could be used for the upcoming week's recitation. Depending upon the group's discussion, proposed activities were abandoned, modified, or enhanced. Overall, the weekly meetings provided an opportunity for the recitation leaders, to be immersed in discussing differences in pedagogical approaches to the recitations.

This study was designed to evaluate the impact participating in the design and teaching of ENGR 101 had on the recitation leaders' ideas about teaching and learning. We hoped that as a result of participating in the weekly meeting discussions and teaching the recitations the ideas of the peer teachers and the strategies they employed to better engage students in discussion would evolve over the course of the semester and become more knowledgeable and accepting of learner-centered, student-focused approaches.

Research Questions

Specifically, we investigated two questions: (a) what was the impact of the recitation leaders' participation in team collaboration on their perspectives of teaching and learning, and (b) how did the recitation leaders' perspectives of teaching and learning evolve over the course of the semester as they participated in weekly meetings and other pedagogical activities.

Study Methods

This study employed a three phase qualitative design within the context of a multiple case study[1,2,3]. The overall design of this study was sequential, with data collection and interpretation from each phase occurring before data collection for the next began. The exploratory nature of the study as well as the researchers' integral roles in the teaching team's activities suggested a qualitative design would be appropriate. Researchers attended and often guided the direction of teaching team meetings, as well as met and planned extensively with course instructors. The research presented in this paper was intended to provide a basis for the design of the ENGR 101 course as well as systematically understand team teacher's perceptions and their evolution.

The term case study implies that a single or small set of cases form the basis of the research strategy and the methods used stem from this focus[1]. Studies involving several cases related to one another in some way can take the form of a multiple case study, which narrows the study of the cases to a particular objective, phenomenon, or condition rather than each case as a whole. The focus of this research was the specific phenomenon of how recitation leaders' participation in the ENGR 101 collaboration impacted their perspectives of teaching and learning and how those perspectives evolved as a result. Data were examined, analyzed, and evaluated in relation to research focus. This focus allowed for a more thorough understanding of the perspectives of the teachers in the study as they pertained to their participation in the teaching of ENGR 101.

The recitation leaders whose perceptions formed the basis for this study were five students who led the recitation activities of the ENGR 101 course. These students were specifically selected to be recitation leaders for individual reasons, including their knowledge about energy sustainability, their experience teaching, and their personal interest.

In order to understand the evolution of the perspectives of the teaching-team members it is imperative that one understands the evolution of context in which they taught and learned. The context of the ENGR 101 course was unique in the elements included in its design, the student population it targeted, the skills and knowledge it emphasized, and the varied delivery of the class meetings. Because of this, the section that follows provides an in-depth description of the ENGR 101 course and how its design evolved over the course of the three semesters leading up to the semester in which this research was conducted.

Participants

In this study we collected data from five recitation leaders; Andrew, Jack, and Ken, who were graduate students, and Mandy and Brian, who were undergraduate students at the time they participated.

Andrew was one of the three graduate students who was part of the ENGR 101 teaching team during the fall 2007 semester. Andrew was unique to this project in several ways. He was the only teaching assistant whose graduate funding was dedicated to the ENGR 101 course. Before the fall 2007 semester, Andrew had observed and aided one of the engineers in the teaching of a recitation section. Partially because of his funding and partially because of his personal interest, Andrew had taken a leadership role in the design and delivery aspects of the ENGR 101 student assignments and recitation activities. He crafted the student essay prompts in consultation with the teaching team's guidance. Andrew also designed the PowerPoint slides that the other recitation leaders used in their recitations, especially early in the semester. Andrew had completed his undergraduate education in France, a country that has a different higher education system from the US. Andrew might have different ideas about teaching from the other recitation leaders because of his learning experiences in a country other than the US. Andrew was pursing a graduate degree in Aerospace engineering. He was assigned to lead recitations for honors students in the ENGR 101 course.

Jack and Ken were both Physics doctoral students. They team-taught one of the two recitation sections for non-honors students. Jack and Ken had previous teaching experience in the department of Physics as lab TAs as well as in summer programs for middle school students.

Mandy and Brian were undergraduate peer teachers (UPTs) who team-taught the second recitation section for the non-honors students. Brian was a second year economics major while Mandy was a fourth year political science major. They had both taken the course during the Fall 2006 semester. The fall 2007 semester of ENGR 101 was their first teaching opportunity.

Interview Structure

We designed a semi-structured interview protocol[12] to explore our participants' perspectives of teaching and learning. The semi-structured interview questions sought to uncover participants' (a) conceptualizations of teaching and learning, (b) views on the responsibilities of a teacher and a learner, (c) evolved perspectives of teaching and learning, and (e) the ways in which they perceived their teaching practices had changed over the course of the semester.

Data collection

All five recitation-leaders were invited to participate in this study voluntarily. They were all asked to review and sign consent forms, which had been approved by the Institutional Review Board. All agreed to participate and signed the forms before we began collecting data.

Over the course of the semester, we conducted three interviews with each recitation instructor. The first interviews were conducted in the first week of the semester, the second interviews were conducted in the mid of the semester and the last ones were completed within the last two weeks of the semester. These interviews are referred to as first, second, and last throughout this paper. All interviews were tape-recorded. Interviews lasted between 15 and 60 minutes.

Analysis

Interviews were transcribed and two of the researchers analyzed the transcriptions using the constant-comparative method[13,14]. The third researcher did not read the transcriptions because she had been the manager of the teaching team and her review of the interview data was not allowed by the Institutional Review Board due to a possible conflict of interest.

In our analysis, we used open-coding, axial-coding, and selective-coding strategies as described by Glaser and Strauss (1967). We employed open-coding when we first read the transcriptions. The codes we generated in this first coding stage emerged from our reading of the incidents our participants portrayed. The categories also began to appear in this first stage; however they needed refinement and delimitation for a more coherent description. In the axial-coding stage, which was our second time reading the transcriptions, we build connections among the codes we had generated and as necessary we renamed the codes to signal their interconnections among them. This second axial-coding stage strengthened the linkages among the categories and the sub-categories, which informed the individual codes pertaining to individual incidents participants had portrayed. In the final selective-coding stage, we developed the structure of the categories by integrating and delimiting the codes and sub-categories. This stage was conducted to systematically validate the relations among the codes, categories, and sub-categories.

Glaser and Strauss (1967) noted that the coding process is not always linear and the steps researchers follow are not always distinct from one another. In our analysis we experienced this nonlinearity in two ways. One was because of the nature of human memory and the other was because of the number of interviews we conducted with each participant. We interviewed each participant three times. The codes we generated from reading the first interviews informed our readings of the second and the third interviews. Therefore, the second and the third interview analysis we conducted were not entirely open-ended. The coding stages, in that regard, were not entirely linear.

Some of the codes we generated were *in-vivo* codes and some were sociologically constructed. Examples of in-vivo codes were "PowerPoint Slides" and "feeling comfortable with the content," that are participants' direct words. Examples of sociologically constructed codes are "didactic teaching methods" and "reflective thinking," that are researcher constructed words. The codes we generated were grouped under some main categories, for example, "participants' discarded teaching practices" and "perspectives of teaching and learning."

Because this study is a collective case study with five participants, we performed within-case and across-case analyses. In with-in case analyses, we focused on each case separately, that is, we analyzed one participant's three interviews separate from those of the other participants. In the cross-case analysis, we compared our findings from each case (participant) and discussed the similar and different themes among them.

Findings

In this section, we present the main themes, which emerged from our across-case analysis. These themes are illustrated with excerpts from the participants' interview transcriptions.

Discarded teaching practices

At the beginning of the semester, participants reported that they were accustomed to relying on PowerPoint (PP) slides for the basic information students need to know when they taught their recitation. Closer to the middle of the semester, our recitation leaders began to emphasize the use of PP slides less. The reasons they provided us on why and how they thought PP slides were assisting or hindering their class discussions varied.

At the beginning of the semester, Andrew told us that he was accustomed to using PP slides. During the second interview, he discussed teaching one of his recitations without any PP slides for the first time. In this second interview, he stated:

> [The class] went fast. I did not see the time pass. I did not want to have slides today so I think it went well since I am used to having backups. But this time I chose just to talk to [the students] kind of like Jack or Ken does.

Andrew had been using the PP slides because he thought PP slides had provided necessary information to students. Without any information, Andrew seemed to believe that students would have nothing to discuss. Andrew believed in this notion so strongly that when he did not use the PP slides, he was sending students to the Internet so that they could access the information they needed to learn. Andrew discussed this as he stated "… because it is hard to discuss when you know nothing about the question."

Brian, one of the UPTs, had different thoughts than Andrew's. During his second interview, Brian stated that it was "easier to talk fluidly when there are no PP slides." Brian also noted that "not having the PP slides is challenging" because sometimes he did

not feel confident enough to comment on the students' questions especially if they were engineering content related.

Jack reported during his first interview that he used the PP slides because they were a part of the teaching process all the recitation leaders were implementing. He added however, that he would personally prefer not using them. He did not make any comment on the use of PP slides as the semester progressed.

In addition to their comments on the PP slides, our participants also commented on some other aspects of the course. For example, Jack raised concerns that the calibrated peer review (CPR) system, a system used to grade student essays more efficiently, was not an effective tool for helping students enhance their written communication skills. Jack suggested that students would rather provide constructive feedback directly to one another instead of completing an anonymous calibration process, which graded them on their abilities as raters.

Even though it was not explicitly asked in any of the interviews, most of our participants commented on the exams and conveyed their position on their use. For example, during the last interview Mandy stated:

> I think [getting rid of the exams] would be perfectly fine. I think that taking the tests away wouldn't do much. The tests aren't teaching much as it is and I think they would learn much more from writing a more thorough essay and more completely doing a project than just doing the test. I mean you don't retain much from studying for a test, has been my experience anyway, you learn a lot more when you write an essay and do projects and that sort of thing.

Mandy viewed the tests she had taken in the past as learning experiences. She pointed out that the tests our teaching-team administered in the fall 2007 were for assessment purposes only, that is, students were not learning anything new as they were completing them.

Perspectives of teaching

Our participants' perspectives of teaching evolved over the course of the semester. Each participant added at least one new component to their definition of teaching, which resulted in their views of teaching seeming more complex. Our participants' awareness of various methods of teaching and ways to think about student learning increased.

Brian defined teaching as "sharing knowledge" or the "exchange of information" in the first interview. During the second interview, he defined teaching as an act to make people interested in the information. In the last interview, he defined it as "presenting information and motivating students." It seems Brian added a new dimension (i.e., enhancing student motivation) to his definition of teaching in the second interview and

then merged this dimension into his first definition in the last interview (i.e., presenting information and motivating the learner).

Andrew defined teaching differently in each of his three interviews. In the first interview, he defined teaching as "making the content fun and valuable for the students." In the second interview, he defined it as "making sure students gain knowledge" and making sure "they are not asleep." In the last interview, he stated: "teaching is to present some information and ideas to other people so that they can use it as their own." Similar to his definition of learning, Andrew added to his definition of teaching the notion that using the knowledge as your own is important.

During her first interview, Mandy defined teaching as "ensuring that your students thoroughly understand instead of merely recalling facts and definitions." In the definition of teaching given in her second interview, Mandy defined teaching as "imparting what knowledge you have but also encouraging the students to seek out their own answers." In this definition, it was apparent that Mandy valued the act of guiding students to find the information they needed on their own. In the final interview, Mandy enhanced her definition of teaching as follows:

> I think teaching is articulating or leading the student to discover the information on their own and really, I guess that's more of a goal of teaching, teaching is not only I guess providing information but it is also giving the students a framework to fit it into so they understand how everything stands in the course and not just giving them the information and leading them to apply that information and use it in other ways and also helping them to bring what they already know to the table and incorporate the new information with their previous knowledge and, um, providing them, I guess, a higher level of overall understanding.

During his first interview Ken defined teaching as "conveying the structure, or the context, of scattered facts and information, it is more an act of making the connections visible." In his last interview, Ken expanded this definition as he stated:

> It would be to convey knowledge and relationships and also do it in a way that the students would most efficiently learn. That would include fostering a safe environment, safe in the sense of, comfortable; creating an environment that would allow students to learn most efficiently.

During his first interview, Jack defined teaching as the "communication of information with the intent of processing by the students." Jack did not dramatically revise his conception of teaching over the semester but he did place more emphasis on the role of the teacher in his last interview. He said:

> Teaching is transformation. To take information or knowledge or ability and transfer it to someone else or multiple someone else's.

As illustrated, our participants' definitions of teaching increased in complexity as the semester progressed.

Perspectives of learning

Much like ways in which the participant enhanced their views on teaching over the course of the semester, our participants added new dimensions to their explanations of learning and enriched their definitions of learning.

During the first interview, Brian stated: "Learning is participating or being engaged in a topic." During the second interview, he modified this definition slightly and defined learning as "a process of understanding and application of concepts." During the last interview, Brian stated: "Learning is being motivated enough to actively synthesize information into concepts that can be applied to different things."

During the first interview, Andrew defined learning as "gaining knowledge." During the second interview, he defined it in the same manner as "acquiring knowledge." During the last interview, Andrew changed his definition slightly as he defined learning as "acquiring information to being able to use it as your own." He went on to state that in addition to being able to use the knowledge as her own, the knowledge one gains should help "challenge" their opinion or "make it stronger."

During the beginning of the semester, Mandy defined learning as "Building on not only your knowledge base but also your skills and tools you have to apply that knowledge to everyday life."

During her second interview Mandy stated:

> Learning is taking the information that is provided and really trying to understand it and think about it on your own time outside of lecture and applying what you know from other sources and previous experiences and coming out of that with a different perspective and a different concept of the material. So that's what learning is I think. Its not just accumulating knowledge but using that and your prior experience to come to a new kind of place I guess. It's not a linear path. I guess is what I am trying to say.

It was apparent that Mandy's definition of learning had increased in complexity during this second interview. When asked again during the final interview, Mandy stated:

> Learning is active participation, not necessarily verbal but active listening to what the teacher has to say and then also on their own further thinking, further investigation into the topics. Just thinking about the stuff on their own, I think is a big part of learning.

During the first interview, Ken defined learning as "making the relationships or seeing the connections." During the second interview, he commented on the importance of making the connections rigid. He stated:

> Generally speaking the structure, as far as I guess in my opinion, the structure does not stay intact, a lot of stuff is destroyed in the process so it's a matter of making sure we can rebuild the structure is [learning].

During the final interview Ken defined learning as "the other part of teaching so that is the taking of certain distinct ideas or concepts or things like that and then organizing them in such a way so that they make sense in a larger content."

During his first interview, Jack defined learning as "the ability to process information, not just gather it". During the second interview, he simplified this definition as he stated "learning is getting information." During the last interview, he defined learning as "reception of the information being taught, or something that you can read it in a book." Jack's definitions of learning did not change in any significant way over the course of the semester.

Role of discussions

The recitation leaders were aware that the primary intent of the recitations was to encourage student participation and discussion on energy and its sustainability. A common view most of the recitation leaders held was that they needed to have information at hand in order to facilitate discussion in their recitations.

For example, Andrew saw the PP slides as containing the information he saw as necessary for student discussion. Moreover, when Andrew did not use the PP slides, he felt that students needed to have access to some information on the topic of discussion. Because of this belief, Andrew sent his students to the internet to look for information. According to Andrew, information was an essential precursor to class discussion.

During his second interview, Andrew commented that it was often necessary to provide some information to students for a lively discussion. He stated:

> I think the best is to have a discussion topic that they know a little about and then give them some information that they don't know about so that triggers some thinking of what they have thought had been going on and that's the best way to trigger discussion.

Jack expressed slightly different views from those of Andrew. During his first interview, Jack mentioned that he would prefer not to use the PP slides, because he felt they hindered potential discussion.

Role of expertise in the content and in pedagogy

Mandy and Brian, the two recitation leaders who were undergraduates, did not have an engineering background or any prior teaching experience. Because of these characteristics, it was not a surprise to us that there were commonalities among the patterns that emerged from the analysis of their interviews.

Brian stated that he felt more comfortable when he knew the content knowledge his students were discussing. During the times students were asking questions about the engineering concepts, Brian did not know the answers and so he would send the students to the Internet to search for answers and, as needed, he would search the Internet himself.

Also during the second interview, Brian stated, "I am not sure how to get people more involved in the discussions." This statement indicated that he sometimes felt that he lacked the pedagogical knowledge to keep students on track.

During her second interview Mandy also reported that she often felt that she did not know the content in enough detail. However, she was becoming more comfortable with the fact that she was not a content expert and felt that she could still engage students in discussions effectively. During the second interview, when asked how her teaching had changed since the beginning of the semester she responded:

> I am not as unsure. I guess, in the beginning I was very nervous about not knowing all of the material by heart and now I am a little bit more comfortable with not knowing everything and I'm much more comfortable with admitting that I don't know something and asking them to look it up. I don't know if it comes across as a co-learning environment but that's definitely how I feel it is. I'm much more comfortable with that so I think my ideas are different [than the beginning of the semester].

Discussion

As mentioned earlier, all participants added new dimensions to their perspectives of teaching and learning. Often, these dimensions seemed more aligned with the principles of a learner-centered pedagogical approach and discussion-based teaching practices.

Our weekly meeting discussions might have influenced our recitation leaders' perspectives of teaching and learning. For example, the definition of learning Andrew offered during the last interview discussed a pedagogical approach in which a learner should use newly learned information to either "challenge" their previous conceptions or "strengthen" them. This definition of learning is closely aligned with the conceptual change approach[10].

Our recitation instructors strongly believed that students needed to know information about a topic in order to engage in a discussion. For a discussion to be triggered, they felt students needed to access information such as through a PowerPoint slide or through the

Internet. This belief could be connected to our recitation leaders' epistemological beliefs, such as the belief they expressed that students were learning about the information but they did not generate it.

The notion of "I" in the teaching act

Our participants tended to describe their teaching practices with a notion of "I." In most of the interview conversations, our team leaders focused on what they wanted their students to learn. This focus demonstrated the belief that information was more important than how students made sense of that information or the pre-conceptions they might have about it.

For example, during the first and the second interviews, Andrew described his teaching strategies as trying to "show" students the important aspects of the course content. In his description of his classroom activities, he often used phrases such as "I want to show them," and "I want them to realize."

Andrew's use of terms like "showing" and "helping students realize" also appeared in his definition of teaching. During the first interview, Andrew defined a goal of teaching as "making sure students gain knowledge." When asked what he thought the major jobs or responsibilities of a teacher were he responded "Well, make sure [the students] listen and that they are not asleep." Similarly, Andrew defined learning as "acquiring some knowledge" during the first interview.

Concluding Remarks

In this study, we explored the ENGR 101 recitation leaders' perspectives of teaching and learning. We interviewed them three times over the course of the fall 2007 semester as they were engaged teaching the recitations of ENGR 101. We described the evolution of their perspectives of teaching and learning as part of an ongoing discussion. We did not intend to capture changes in their perspectives, even though we presented the differences we had seen among our participants' definitions of teaching and learning.

Describing the recitation leaders' perspectives provided valuable data that have been used to improve our design of the ENGR 101 course. We expect the course to grow in size over the next few semesters and to eventually have several hundred students enrolled. As the course size continues to increase, we are interning and hiring larger numbers of UPTs who will lead the recitation activities. In such a case, our understanding of their views and how the weekly meetings help them succeed as recitation leaders will play an ever more important role in shaping the overall delivery of the recitations. Growing numbers of peer-teachers bring asked to engage in discussions about their teaching practices will make our work more challenging. We are preparing to effectively respond to the needs of increasing numbers of peer teachers. Our ongoing efforts to describe what peer-teachers' approaches of teaching and learning are and how they evolve in response to their participation in this project will help us manage and sustain the learning community we aim to cultivate: a lively and dynamic team collaboration.

The findings of this project are not limited to this paper, and we will be reporting the lessons learned as we progress in our course design efforts, grow in numbers of team participants, and generate new instructional strategies and pedagogies. We do not expect that there will be an end point of our iterative design of our team teaching collaboration, but there will be improvements in the ways we serve the needs of our peer-teachers and students, as well as, in the ways our students empower themselves to critically and effectively search, communicate, and reflect upon the concepts of energy and its sustainability.

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