How early is too early to start teaching? Teaching portfolios as a training tool for undergraduate instructors

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Abstract
Undergraduate students, especially juniors and seniors in their programs, often have the necessary content knowledge to be able to assist effectively in teaching prerequisite courses in engineering and science. Because these undergraduates are 'near peers', undergraduate teaching assistants may seem more approachable than faculty instructors and serve as role models to students in classes that they teach. With some training, advanced undergraduate teaching assistants or instructors can potentially serve as a cost-effective way to provide additional instructional support. As part of an NSF funded teaching and learning center, the Engineering Teaching Portfolio Program (ETPP) has designed a four session teaching portfolio program that helps train undergraduate students to be more effective as instructors. During these 1 hour sessions, undergraduate instructors share and discuss teaching strategies with a forum of their peers while documenting their instructional activities through creating teaching portfolios. This paper describes the teaching portfolio program curriculum and discusses the curriculum design, the results of the initial curriculum usability testing with the undergraduate instructors who staff the Minority Science and Engineering Program (MSEP) study center, and the perspectives of these undergraduate instructors on teaching and learning. As a result of the success of this pilot offering, the MSEP study center is currently considering requiring the undergraduate ETPP as training for all MSEP student instructional support staff.

Introduction
Undergraduate students, especially juniors and seniors in their programs, often have the necessary content knowledge to be able to assist effectively in teaching prerequisite courses in engineering and science. Because undergraduate instructors and tutors are 'near peers', undergraduate teaching assistants may seem more approachable than faculty instructors and serve as role models to students in classes that they teach[1]. However, undergraduate students in science, technology, engineering and mathematics (STEM) fields have few opportunities to work as course instructors or teaching assistants, and even fewer opportunities to explore and develop scholarly approaches to teaching.

Although many undergraduates gain teaching experience through peer tutoring programs, these programs usually do not provide formal training for peer tutors about best practices for STEM instruction. Furthermore, undergraduates may not recognize that learning how to teach more effectively is a professional development skill that could be useful to them in non-teaching focused STEM fields. They also may not have a reason to archive or save work that they have done towards developing products of instruction such as worksheets, solved problem sets, lesson plans, and other documents related to their teaching. Unless a system exists to archive or save

these products, this lost work adds to personnel turnover costs when student teaching assistants move on.

The professional development benefits for undergraduates in STEM fields working as instructional staff include increasing their knowledge and core understanding of course material by learning through teaching. Other benefits include improving their communication skills, practicing their mentoring skills, and gaining more confidence in their leadership skills. Getting undergraduates in STEM fields to think about teaching at the college level early in their careers may make them more aware of the possibility of continuing their education in graduate school or faculty careers. In addition to these higher level professional outcomes, undergraduate teaching assistants and tutors are typically compensated for their work through hourly pay rather than teaching appointments. With some training, advanced undergraduate teaching assistants can potentially serve as a cost-effective way to provide additional instructional support.

This paper presents a pilot offering of a peer-focused teaching training program in which undergraduate instructors discuss, reflect, and share strategies about their teaching within the context of creating a teaching portfolio documenting their instructional activities. This pilot offering also included a preliminary research study that had two major goals: to gather some early stage user data about the initial curriculum design, and to gain insight about how undergraduate instructors think about teaching. The purpose of this research study was not to conduct an exhaustive, in-depth, generalizable investigation of these issues, but rather to take a snapshot that represented the experiences of a small number ($N < 6$) of undergraduates and graduate students within the context of this program.

In this paper, we will first describe the background for this project. Secondly, we will provide an overview of the undergraduate Engineering Teaching Portfolio Program (ETPP) which includes a description of the context in which we piloted this newly developed undergraduate version of the ETPP curriculum and the process we used to adapt the curriculum materials that we previously developed for an advanced graduate student audience to the undergraduate level. Third, we will present the design of the research study linked with this pilot offering and discuss the results and their implications of the formative evaluation of the curriculum redesign. We will then discuss what we learned about impact of creating teaching portfolios on these undergraduates, and what we learned about the attitudes these undergraduate instructors had about teaching and learning. Finally, we will talk about future work related to this pilot offering.

Background—portfolios in education

Portfolio construction represents a promising pedagogy for teacher training by helping undergraduate instructors learn more about teaching and make connections between teaching and professional development as they go through the process of archiving and presenting their teaching related work. This statement may feel odd to some readers since there is already much interest in portfolios from an assessment perspective[2]. However, there is also burgeoning interest in the learning that takes place when developing a portfolio. For example, Christy and Lima describe two uses of portfolios in engineering education, and report that at least 78% of the students who created these portfolios thought that "portfolios enhanced their learning"[3]. Moving beyond self-report data, Finlay and his colleagues found that certain oncology students who prepared a portfolio did better on a final exam than students who did not[4]. Even in some of the

assessment research, there are indicators that learning is taking place. For example, Scholes and her colleagues reported the need for nursing students to deconstruct and reconstruct their experiences when developing an assessment portfolio[5]. This deconstruction and reconstruction process strongly suggests that the portfolio creation would have resulted in learning.

We are developing a teacher training curriculum that leads undergraduate instructors through a series of facilitated discussions about teaching and learning as they create individual teaching portfolios documenting their instructional activities. As part of the Center for the Advancement of Engineering Education (CAEE), a National Science Foundation (NSF) funded center for engineering education research, the Engineering Teaching Portfolio Program (ETPP), was initially developed to help engineering graduate students discuss and reflect about their teaching in a group of their peers within the context of creating a teaching portfolio that could be used for faculty job searches[6]. The curriculum for this graduate level program is being modified and adapted into a pilot teaching portfolio program geared towards training undergraduate students to be more effective as instructors. This undergraduate version of the ETPP curriculum was piloted at the University of Washington with a group of undergraduate instructors and peer tutors working for the Minority Science and Engineering Program (MSEP)[7], an undergraduate diversity program housed within the College of Engineering that focuses on the recruitment and retention of underrepresented students in STEM fields.

Undergraduate ETPP

These undergraduate ETPP program sessions focused on giving the undergraduate instructors and tutors a forum to share their thoughts and strategies about teaching within the context of a discussion about instructional issues that they were facing in their teaching and tutoring. Specifically, the undergraduate instructors were asked to discuss and share successes and challenges that they were facing in classroom instruction and peer tutoring, and to create artifacts documenting the teaching work that they were doing. The instructors and tutors were encouraged to use the first 20-30 minutes of the meeting times to compare notes about student learning in the pre-engineering courses for which the instructors and tutors were all providing support, and to brainstorm solutions for how to help students learn difficult concepts. These discussions about teaching and learning took place with other instructors and tutors in their program, with light facilitation from an experienced teacher, and with occasional visits from full-time MSEP program staff.

This section will describe the context for the pilot offering of this curriculum in Autumn Quarter 2004. This section will also describe the user-centered design approach by which we are adapting a previously developed graduate level engineering teaching portfolio curriculum into a training tool for undergraduate instructors. Finally, we will discuss how our assumptions about the target audience of undergraduates influenced our initial design decisions for the undergraduate ETPP curriculum and describe the pilot version of the curriculum.

Context for pilot offering

The undergraduate teaching portfolio curriculum that we adapted from the graduate level Engineering Teaching Portfolio Program was piloted with a group that consisted of 1 undergraduate instructor, 1 graduate student instructor, and 4 tutors working for the Minority Science and Engineering Program. In MSEP, student instructors teach 1 credit problem solving

workshops linked with science, mathematics and engineering prerequisite classes. The MSEP program would prefer to hire graduate student instructors, but recruiting graduate students for this work has been difficult because funding is not available for graduate teaching appointments, and most graduate students in STEM fields prefer teaching appointments over hourly wages. In addition to the instructor positions, undergraduates also provide tutoring services through the MSEP study center, which offers tutoring in STEM prerequisite courses 7 days a week. The tutors typically are at an earlier stage in their program than the instructors, and many of the undergraduate instructors started their instructional activities at MSEP as peer tutors.

Curriculum design process

This undergraduate ETPP curriculum was significantly modified from the graduate level ETPP curriculum described previously by Linse *et al*[6]. The teaching portfolio curriculum is being developed through a user centered design approach to engineering education. User centered design within a specific educational context is characterized by an early focus on users such as students or teachers, with studies of their needs, capabilities, and prior understanding taking place early in the design process. Data about the users is collected with empirical measurements that often involve qualitative studies of user processes as they experience an initial curriculum design. The analysis of this user data generates ideas for design improvements, and the curriculum design is iterated to reflect what was learned from the users. This iteration cycle repeats when the revised curriculum is user tested again[8].

The purpose of this pilot offering was twofold: to obtain some initial usability testing data by seeing how a small group of instructors and tutors experienced the first version of this undergraduate teaching portfolio curriculum, and to provide some initial data about this training project so that the MSEP full-time staff could make a more informed decision about whether to require their instructors and tutors to create teaching portfolios. The instructors and tutors volunteered to participate in the pilot and the associated research study. Attendance was strongly encouraged but was not required, and 2-4 of the instructors and tutors typically attended each session.

The design of the research and usability study will be described in later sections. The next section discusses how we adapted the curriculum design of the graduate ETPP curriculum based on our initial assumptions about the target audience of undergraduate instructors.

Design adaptations and target audience

We developed the first version of the undergraduate ETPP curriculum by adapting a user tested version of the graduate ETPP curriculum. This section will explain how the differences in the target audience for the undergraduate teaching portfolio program influenced our curriculum design decisions.

The original ETPP curriculum for graduate students consisted of 8 peer-led, peer-facilitated sessions in which engineering graduate students and post-docs met for 1½ hours each week to get and give peer feedback about their portfolio elements while discussing their teaching. Participants in the graduate student program were asked to write a teaching philosophy statement, diversity statement, and to provide 2-5 annotated artifacts of their teaching that supported their teaching philosophy and diversity statements. The graduate students in the pilot offering of the

ETPP voluntarily participated in the program. The majority of the graduate students and post-docs were strongly motivated to continue participating in the program because they were interested in applying for engineering faculty positions within the next 2-24 months and they wanted to create as strong an application package as possible.

The motivations for the undergraduates participating in the ETPP program were very different from those of the graduate students. Unlike the graduate students, the undergraduates typically were not interested in teaching as a career and primarily thought of their instructional activities as an above minimum wage student job that offered them the opportunity to give back to the community—in this case a recruitment and retention program that provided support to them when they were pre-engineering students[9]. The undergraduate instructors and peer tutors for the MSEP program were in general at a much earlier stage of their academic careers than the graduate students and post-docs who participated in ETPP; they have typically been accepted into engineering or science majors and are planning careers in engineering and science after they graduate. Some of the undergraduates are thinking in terms of graduate school, but it is unknown what knowledge or awareness they have of being a graduate teaching assistant beyond what they have experienced as a student in classes taught by teaching assistants.

The structure for the undergraduate version of the ETPP curriculum was similar to the graduate student version in that the undergraduates were asked to create portfolio elements about their teaching, and discuss and receive feedback about their drafts from their peers. However, the time spent in program sessions and the time expected to prepare portfolio elements for the undergraduate version of the program was far less than the corresponding graduate student program. The portfolio elements that the undergraduates were asked to create were also intended to be products useful to the instructional programs that MSEP offers. As an additional incentive to participate, the time that the undergraduates spent attending program sessions and creating their portfolio elements was considered to count towards their work. Therefore, they were compensated for the time they spent creating their teaching portfolios at the instructor or tutor hourly rate.

Early user feedback from a professional portfolio study in which seniors in technical communication peer-facilitated program meetings that led them through the process of creating professional portfolios, showed that the undergraduates wanted an authority figure to reinforce their thoughts and opinions about technical communication and what they should include in their portfolio elements. In the absence of the authority figure, the undergraduate students in technical communication were less likely to perceive the thoughts and opinions expressed by fellow students as valid[10]. Based on the results of this previous study, we felt that undergraduate students require non-peer facilitators to make sure the program sessions run smoothly. The role of the facilitator during these sessions was to make sure the curriculum in each section was covered within the allotted time, to validate the thoughts and opinions participants expressed about teaching and learning, to encourage attendance, to encourage compliance in completing portfolio elements, to provide feedback and advice from the perspective of an experienced teacher, and to be an external authority figure.

Curriculum description

We used the preliminary user information described in the previous section to adapt the graduate ETPP curriculum into a version tailored towards undergraduates that also addressed the program needs of MSEP. The undergraduate version of the program consisted of 4 program sessions that met for 1 hour, and was lightly facilitated by the author, who is an experienced teacher. The portfolio elements for the undergraduate version of the ETPP curriculum were also correspondingly scaled down, and consisted of an 'Ideas about Teaching' statement, and two annotated artifacts.

All of the 60 minute sessions began with an approximately 20-30 minute 'teaching assistant meeting', during which the undergraduate instructors and tutors had an opportunity to discuss and share strategies for dealing with any instructional issues that emerged during their teaching and tutoring. The session handouts introduced a new topic related to their teaching in each session and the activities on the session handout then facilitated 5-10 minutes of discussion around the new topic. At the end of each session the instructors and tutors were asked to create a portfolio element about the new topic as 'homework' and bring two copies of a draft of this portfolio element for peer review during the next session. The facilitator made sure that the sessions did not take more than the allotted 60 minutes.

In the subsequent session, the instructors and tutors peer-reviewed each other's portfolio elements and discussed each others ideas about the topic for 10-20 minutes within the context of providing constructive feedback. The instructors and tutors were encouraged to use this peer feedback to revise their portfolio elements. Towards the end of the session, the next portfolio element was introduced and discussed, and the task of creating the new portfolio element was assigned as 'homework' to be peer-reviewed in the next session. This cycle was repeated for all of the sessions except the first session which had a program introduction in place of a peer-review activity. The topics and activities were all designed to target the discussion towards instructional issues that the tutors and instructors were facing.

In the first session, participants were asked to discuss their ideas about teaching and how they personally went about teaching in their job. They were then asked to write a 100-300 word 'Ideas about Teaching' statement as their first portfolio element and bring it to the next session. As the new topic for the second session, participants were asked to share successes and challenges they had faced in their teaching. For the second portfolio element they were then asked to bring an artifact of their teaching that described a challenge they faced, a success that they had, or anything else they thought was professionally relevant, and to write a 25-50 word annotation that provided an explanation of what the artifact demonstrated.

The new topic introduced in the third session was making connections between their instructional activities and their professional development through artifacts. As their third portfolio element, participants were asked to find an artifact that showed some aspect of their teaching in terms of a professional development activity and write a 100-300 word annotation that explained the connection between the artifact, their teaching, and their professional development. As the 'homework' for the last session, the instructors and tutors were encouraged

to assemble their teaching portfolios from their revised portfolio elements and to make their teaching portfolios available to MSEP.

Research Design

The research questions surrounding this undergraduate teaching portfolio curriculum included a formative evaluation of the curriculum design in addition to specific research questions about the impacts related to the use of teaching portfolios as a learning intervention and the beliefs about teaching and learning held by undergraduates. Because this was essentially an initial usability study of the curriculum, the group of students participating in this study was very small, with 5 undergraduate student tutors and instructors and 1 graduate student instructor. Therefore the intention of this study was to get some fast initial user feedback to see if the curriculum was workable, meaningful, and enjoyable for the undergraduates, and to gather some initial impressions about the perspectives that these undergraduates had about teaching and learning. The specific research questions for this study were:

- What are the implications for the curriculum redesign based on the user data from this pilot study?
- What cognitive and affective impacts does the action of constructing teaching portfolios have on undergraduate instructors?
- What attitudes, conceptions, and opinions do very early career engineering educators have about teaching and learning?

In order to answer these research questions, we used ethnographic methods to collect the data from the 6 participants. This section will discuss the research goals and design, the data collection, and the methods we used to analyze the data.

Research goals and design

The interview and survey data that we collected were intended to provide some insight to each of the research questions. Specifically, we constructed the interview protocol and survey instrument to gather information about whether the students found the program activities to be enjoyable and useful, to find out if having a forum to discuss teaching issues was filling an unmet need for the undergraduate tutors and facilitators, to make some initial assessments of what impact portfolio construction had on the students, and to learn more about the thoughts and opinions these undergraduates had about teaching and learning. We also hoped that if a usability issue in the adapted curriculum were major it would emerge in the sessions and be documented through the field notes, and that the students would also identify it in their survey and interview responses.

The first research question is specific to applying user centered design principles in an engineering education context. In user centered design, incorporating the results of early feedback from test users is critical to the design cycle. Therefore, the primary purpose of running a small scale usability study involving 2-6 undergraduate instructors and tutors was to check for usability issues in the adapted curriculum in order to address them in the next design iteration. The MSEP staff was also interested the findings from this pilot study so that they could make a more informed decision about the feasibility of offering this teaching portfolio program as a required training exercise for all of their undergraduate instructors and tutors.

The second goal of this research was to gain some more information about the impact of constructing teaching portfolios as a learning intervention. Given the small sample size, and the types of data that we were allowed to collect under a Institutional Review Board certificate of exemption, this was a difficult question to answer definitively. However, some participants did provide some self-reported information related to how the action of creating the portfolio elements helped them to reflect about their teaching and that the discussions around teaching issues helped them to learn more about teaching.

The third goal of this study was to find out more about what opinions and attitudes these undergraduate instructors had about teaching and learning. In contrast to K-12 educators, typically faculty in science, mathematics, engineering, and technology fields have few opportunities for formal training about teaching and learning. A survey of 13 previous studies regarding faculty attitudes towards teaching and learning by Kember suggested that many faculty in higher education lean towards transmission of knowledge based methods such as lecture because their attitudes about teaching were initially formed through their experiences as students in traditional lecture classes[11]. However, little research has been done that documents at what stage in their student career these instructors form their opinions about teaching. Therefore, this study provided an opportunity to take a snapshot of the attitudes that this small group of undergraduates working as instructional staff have formed about teaching and learning.

Data collection

We used ethnographic methods to collect data in order to address the three research questions outlined above. Because this educational research required collecting data about human subjects, the study required approval through the Institutional Review Board at the University of Washington. We opted to design the data collection activities such that this study was eligible for a certificate of exemption in order to streamline the Institutional Review Board's review and approval process. Data collection activities that qualified as exempt from review within an educational context were field observations and interviews documented through anonymized handwritten or typed field notes, and confidential surveys. Audio recording and transcribing the program sessions and exit interviews, and collecting the teaching portfolios required a greater level of review and a more involved application for approval. For this preliminary, small-scale study we chose to collect only the forms of data that qualified as exempt for review: handwritten or typed field notes from the sessions and interviews, and anonymous written surveys.

The raw data included personally identifiable information about the student participants. This data was anonymized by creating a random subject code for each participant in the study. The link between the subject code and the participant name was destroyed after the data was processed. All analysis was done using this anonymized data rather than the raw data.

For the field observations, an undergraduate research assistant attended all the program sessions and concurrently recorded field observations via handwritten and typed notes. The research assistant captured the gist of the conversations that took place during the sessions by transcribing them in real time on a laptop computer. We also asked participants in the program to fill out an exit survey in which they rated 23 aspects of the program on a Likert scale and responded to two free response questions. The survey questions with data from two respondents may be found in Appendix A.

Two participants also consented to be interviewed about their experiences in the program two weeks after the last session. These semi-structured interviews asked questions regarding the process participants used to create their portfolio elements, what types of support they had for doing this, the impact on them of participating in the program, and the overall impressions that participants had about the program. The interview questions and field notes from the two exit interviews may be found in Appendices B and C.

Description of data analysis

The data set for this study was modest, and included field observation notes from each of the 4 one hour weekly program sessions, 2 completed participant surveys, and 2 individual exit interviews. The 4 sets of field observation notes provided a record of how the sessions actually transpired. We are in the process of redesigning some parts of the curriculum based on these field observation notes, and the survey and interview results. Because the sample size for the participant surveys and interviews was so small (N=2), we did not perform any statistical analysis of these results. Instead, we looked for general impressions about the program and implications for the curriculum redesign from the surveys and interviews. Participants seemed to either choose to be interviewed or submit a written survey; none of the undergraduates in the study participated in both an exit survey and an in-person exit interview.

We were also interested in any insights about the impact of portfolio construction on the person constructing the portfolio. Data specifically related to measuring impact was extremely limited. However, participants did report some information about impact in their exit interviews and surveys.

The field notes were coded for themes related to undergraduate attitudes about teaching and learning using the constant comparison method. These themes, along with examples from the field notes, surveys, and interviews, may be found in the last part of the Results and Discussion section.

Results and Discussion

This section will present the findings regarding the formative assessment of the curriculum design and discuss the implications for the curriculum redesign and possible future expansion of this program. Initial findings concerning how the action of creating teaching portfolio elements may have contributed to learning more about teaching will also be presented. This section will conclude by summarizing some of our findings regarding the thoughts, opinions and beliefs that the 5 undergraduates and 1 graduate student participating in this program held about teaching and learning engineering.

Formative evaluation of curriculum design

Overall, the participants in the pilot study seemed to enjoy the program activities and find them valuable. Participants seemed eager to talk with each other about how to help their students understand the material and prepare them for their midterms and finals in pre-engineering and science prerequisite courses. In exit interviews and exit surveys, participant comments were very positive about the teaching portfolio program and most participants agreed with statements that

they would participate in this program again and that the MSEP program should offer this workshop or ones like it in the future.

Each program session began with a 20-30 minute 'TA meeting' in which any participant could bring up any issue related to teaching or learning that they wished and get feedback about it from the group. The issues that emerged from the TA meeting portion of the session time were often highly related to the topic planned for the portfolio element discussion. Therefore, we regarded this as an indication that the portfolio element assignments were successful and very relevant to their teaching because the undergraduate instructors and tutors brought up the topics independently before they were introduced in the session handouts. MSEP full time staff observed 1 of the sessions and thought that these unstructured 'TA meeting' discussions about teaching were extremely valuable. Based on these early usability results from the pilot offering, the MSEP full time staff are exploring the possibility of expanding this program into a 1 credit seminar course and making it a requirement for all of their undergraduate instructors and tutors.

In response to survey questions related to enjoyment, data from the two participants indicated neutral to agreement, with most responses corresponding to an agreement value of 1 = agree on a Likert scale. The Likert scale values ranged from -2, which corresponded to strongly disagree, to +2, which corresponded to strongly agree. Participants agreed with statements that the workshop was helpful in getting them to share strategies about teaching with their peers and getting them to talk more clearly about their teaching and document examples of their teaching, and they also strongly agreed that teaching and tutoring was valuable for their professional development, and agreed to a lesser degree that teaching and tutoring was important to potential employers and valuable in preparing them to work in STEM fields.

Participants responded in the survey that they had not constructed teaching portfolios, although one participant said in his exit interview that he planned to put a portfolio together but he had not had time to do it yet. The one participant who created first drafts of all portfolio elements was actually a doctoral student who stated during one of the sessions that she was working as an instructor for hourly pay because she wanted to get some teaching experience prior to a faculty career. She also stated that her motivation for creating drafts of the portfolio elements was to help her prepare for a faculty job search. Based on this pilot study, the undergraduates seemed to be less motivated to create portfolio elements for this program. Therefore, undergraduate students may need the structure of a course requirement or job requirement to actually complete a portfolio, or to provide an incentive for them to polish and share their portfolio elements. Some participants also wished for more structure in the meetings.

All of the participants indicated that they thought the discussions in which they shared strategies and approaches for teaching and got advice from others about instructional issues was valuable. Although some participants said that creating their portfolio elements was helpful, with one exception, they did not complete their portfolios. If a program wishes to document products of instruction as a resource, having undergraduate instructors create teaching portfolios is an effective approach; however unless creating these artifacts and statements is required, it is likely that the undergraduate instructors and tutors will not actually do them. In this pilot offering, we did not require the undergraduates to turn in their portfolios or make them available on a website.

Although all but one of the undergraduates did some work towards their portfolio elements, they did not finish their drafts or make them available for sharing.

In addition, participants indicated that they would like to have more input from an experienced teacher. In this pilot offering, the facilitator was an experienced teacher who deliberately tried to keep the focus of the discussions on the students. However, having the sessions be more teacher-centered is possible, and may only require the facilitator to spend more time validating issues that the undergraduates raise during the discussion along with talking more about approaches and techniques for dealing with instructional issues. If MSEP chooses to run this undergraduate teaching portfolio program as a required seminar class for all of their student instructional support staff, then creating a teaching portfolio and posting it to an MSEP website could be easily added as a course requirement. The facilitated discussion could then be led by the experienced teachers on the MSEP full-time staff, with more emphasis on the facilitator validating the issues about teaching and learning raised by the undergraduate instructors and tutors.

Impact of portfolio construction

Some participant comments had implications about the impacts of portfolio construction on the person constructing the portfolio. Only one of the participants completed a draft of their entire portfolio, however all but one of the participants completed a draft of at least one portfolio element. Although the participants seemed to be resistant to creating a complete portfolio, two participants stated that they found the activity of creating the portfolio elements to be helpful to their learning about teaching.

The participants seemed to find creating drafts of the portfolio elements to be valuable towards learning about teaching. In response to a survey question asking about the best parts of the workshop, one participant commented that "I found the exercise of putting some of my experiences into words to be useful… more helpful than I expected." Another participant commented in an interview that "doing the portfolio was a good idea", and that it helped him look at teaching in a different way, to analyze and organize it more, it made it clearer for him. He also commented that the action of typing the activities and putting them in the portfolio was helpful, and further commented about the act of reflection, saying "looking back in retrospect, seeing what you're doing, is helpful." All of the activities that these two participants described are strongly suggestive that learning is taking place as they reflect about their teaching and create their portfolio elements.

Attitudes about teaching and learning

Student beliefs, conceptions, and attitudes about teaching and learning have been studied by others including Hativa[12], who surveyed students in engineering and education at an Israeli university on their preferred teaching styles, and Kember[13], who conducted research studies with beginning and advanced undergraduate students at a Hong Kong university about attitudes and approaches to study and how they related to student success. Other studies in the United States include work by Seymour and Hewitt[14] regarding retention of students in STEM disciplines, and ongoing studies about learning engineering by Sheppard *et. al*[15].

However, few studies exist about the attitudes towards teaching of undergraduate instructors. Teaching is generally new for this group, and they often shared their struggles without prompting and seemed to want to hear from others experiencing similar issues and get advice. They also shared with the group approaches that they felt were effective. The four meetings became a forum in which the undergraduate instructors and tutors discussed how their work was going, explained their challenges and concerns, gave advice to each other, and shared their opinions and thoughts about the best way to help students understand the material and be successful. Although the facilitator introduced some specific topics to the group, the participants without prompting discussed several key topics about teaching independently during the unstructured 'TA meeting' portion of the program sessions.

This section will present some of the key themes about teaching and learning that surfaced multiple times in the field observation notes. The extracts of conversation captured in these field notes show the ways that participants talked about issues such as sharing their practices and techniques, difficulties shared through their experience, suggestions for improvement, teaching with consideration of different learning styles, the struggle between solving problems vs. understanding the concept, and sharing specific experiences about the prerequisite courses.

Sharing practices and techniques: Participants shared what each did and why they felt their approach was effective. One of the 2 instructors, a senior in chemical engineering, described how he structured his class around a 20-30 minute lecture about key concepts, with the remainder of the time working problems in small groups and on the board.

> *M3: based on what they covered in class that day or before, I'll go over each section, summarize the main points and if we have time I ask them if they have any homework problems.*

This instructor also talked about getting confused students to participate in working problems on the board. In his class, he did not want to call on students who were raising their hands saying 'Me! Me!' in response to a problem he wrote on the board because he knew those students could work the problem. Instead, he would choose a student who had a confused look on their face to work the problem on the board. He encouraged the student by saying that if they got stuck he and the other students would help them learn how to do the problem. He said that he wanted to create a "friendly, no-ridicule learning environment" in his classes where fellow students were willing "to help you if you get stuck".

The other instructor, who was a doctoral student in a department committed to inquiry-based teaching, created worksheets that led the students through discovering concepts related to the subject material. However, she reported that the worksheets took a lot of preparation time to create, and she was not sure how effective the students were at trying to figure out the concepts for themselves.

> *M1: I usually have a written worksheet and we discuss a problem on the board. The one thing I don't know, I guess it's starting to smooth out a little bit, I think I want to do the unfinished problems from the last section… [students have not been able to complete her worksheets during the class meeting]*

Near the end she sounded uncertain about her approach, letting the rest of the participants know that she was unsure of its effectiveness.

The 4 tutors also shared strategies and methods they use to help students. The participants had many conversations like this about how active they should be when tutoring:

> *Facilitator: Should you work or let the student do the writing. Sometimes I won't pick up a pencil when I tutor, because I want them to get involved.*
> *M1: It depends on how lost the student is.*
> *M6: I try not to write, if they do it then they retain it.*
> *M2: Sometimes you find yourself asking "So… what comes next?" Then when they get stuck you start to tell them; so it's annoying.*

This showed that participants were looking at the role of the tutor from the perspective of the teacher and the student. Ideally it would be nice for the tutor to step aside and guide the student through the problem, but the participants understood that was not always realistic.

Difficulties shared through their experience: Teaching was generally new for this group. They were able to share their struggles and they heard from others experiencing similar issues. Here an instructor discussed a common problem among educators; he was having trouble dividing his attention evenly among the class.

> *M3: Here's one problem I'm having. There is one or two people in class that ask a lot of questions…what happens is that one person has a problem and she always asks the questions. The other people think that I will always help her and not anyone else.*

Many of the other participants were able to relate. Although no definite solution was reached, discussing the issue seemed to be helpful for the instructor.

Suggestions for improvement: They were always looking for ways to better themselves, they came to the meetings with their own suggestions for each other, or with advice they had received from others. They also shared interesting approaches and different activities that each could experiment with in their own teaching. Here the participant noticed that some teachers do not make the distinction between answering questions and listening to what students are really asking.

> *M1: I uh notice that from the perspective of students it sometimes helps if they explain something that isn't directly related … Try to listen to the student and see where they are stuck and what they need to do instead of just answering their question.*

This participant was explaining that in cases where a student is "stuck" they do not know what question they should ask, what they really need is an understanding of what is going on. She suggested that instead of just answering the question the educator should try to find what the student does not understand.

Teaching with consideration of different learning styles: The instructors and tutors noticed both among themselves and within the students they teach, that not everyone learns the same way. They were not only aware of this, but wanted to teach in a way that cultivates students according to how they learn. One of the program handouts had a link to Felder's Index of Learning Styles[16] and the facilitator introduced this link and also talked about Myers-Briggs[17] testing. In the subsequent discussion, one instructor said that he understands his teaching may have been more effective if he considered that his students learn in different ways. He goes on to suggest that he would have tailored his teaching to fit the needs of the class if he would have had an idea how his students learned.

M3: looking back I would have had them take a test like that [referring to a test that categorizes people into different types of learners], to see how I'd teach, I've been just shooting in the dark.

The struggle between students simply solving problems vs. understanding the concept:
Participants frequently ran into the problem of teaching a procedure for solving a problem vs. helping students develop a conceptual understanding of the material. They constantly had to choose whether teaching the students what to do or teaching them how to think about the problem was more helpful. Many of their students wanted a 'turn the crank' procedure for solving problems, and were less interested in trying to understand concepts. As students the participants appreciated the simplicity of plugging in numbers, but as tutors and instructors they understood the importance of teaching students to develop a basic understanding of the concepts behind the methods.

M2: I wanted to teach more conceptually, but most people just want the answer
M8: Well the physics faculty agrees with you, people who do research in physics are trying to teach at a conceptual level.

In this example, this tutor wanted not only to teach students how to do the problems, but he also wanted them to understand the concepts behind the formulas and reasoning they use.

Participants sharing personal experiences about prerequisite courses:
Since these participants all were advanced students in STEM fields, they had in many cases taken the same courses that their students were currently taking and could relate to them on different levels: that of an undergraduate, a student in a major, or as a teacher.
One of the tutors gave advice to the group based on her experience with a freshman physics class, saying:

M4: physics 121 midterms are designed not to be finished… make sure you know how to do what you're doing quickly.

The instructor who was teaching the problem-solving workshop associated with this course was eager to use this tutor's experience to help teach her class. The instructors and tutors discussed more of the particular challenges that came with this physics class:

M2: seems like in 121 no one takes force diagrams seriously. They should know how to work with them.
M1: I haven't seen anyone try to skip it… I think they're struggling …

The instructors and tutors also noticed that many students, especially the faster ones, tended to resist someone telling them how to structure their work. Many of the instructors and tutors had taken this course recently, so they understood the temptation to solve problems without setting anything up. They also recognized the importance of taking time out and planning ahead and struggled with how to convey the importance of this to their students:

M8: they don't want to do the algebra and the work, they want to do it mentally. But later on when it comes to doing harder problems they freak out and don't know how to get started.

The themes that emerged from the unstructured conversations that took place during the program sessions showed that the undergraduate instructors and tutors had an awareness of many pedagogical issues that they incorporated into their own teaching even though they were not able to articulate them in the jargon. For example, M3 was an instructor who is working towards a

B.S. in chemical engineering with a minor in applied mathematics and computing science. He did not have much formal training in pedagogy, but he was extremely comfortable in discussing his classroom in these terms, and specifically used the term 'learning environment' more than once during conversations about his teaching.

Through their discussions it is clear the instructors and tutors, who are mostly undergraduate students, take their roles as educators seriously. Many of the undergraduate instructors and tutors have taken the prerequisite courses that they are now supporting, and have dealt with the same struggles as the students they now teach. These instructors have the capability to teach and mentor students, and because they are 'near peers' they may be able to reach the students they serve more effectively in some ways than faculty, graduate students, or full-time instructional staff.

Conclusions and Future Work

Undergraduate students in science, technology, engineering and mathematics (STEM) fields have traditionally had few opportunities to work as course instructors or teaching assistants, and even fewer opportunities to explore and develop scholarly approaches to teaching. However, undergraduate students do have the ability to think critically about their approaches to teaching and have the untapped potential to be a cost-effective resource for providing additional instructional support. Furthermore, teaching and tutoring jobs can also provide undergraduates in STEM fields with valuable professional development experience related to leadership and communication skills.

This paper described an initial usability study for an undergraduate teaching portfolio curriculum in which undergraduate instructors and tutors were able to reflect, discuss, and learn more about their teaching within the context of creating teaching portfolios that documented their teaching. This usability study was done in order to obtain initial user data about the first version of this curriculum, which was designed using a user-centered approach to engineering education. A group of 2 instructors and 4 tutors worked through the program materials and gave us feedback about the curriculum. The data collected about the participants in the program provided insight into the learning about teaching that took place as a result of creating teaching portfolios within a forum of their peers. The data also gave us a snapshot of the thoughts, attitudes, and beliefs that this group of undergraduate instructors had about teaching and learning.

The usability study and formative evaluation of the curriculum showed that for the most part, the participants enjoyed the program activities and found them valuable. The undergraduate instructors and tutors that participated in this pilot study were very conscientious about their teaching and were aware of teaching related issues such as accommodating different student learning styles and motivating students to understand concepts rather than plug in numbers. However, the undergraduates wished for more structure in the sessions and also seemed to require more incentive to actually complete their portfolios. This user feedback will be incorporated into the redesigned curriculum when this program is offered again.

Based on this pilot study, the MSEP program is considering the possibility of requiring all of their undergraduate instructors and tutors to participate in a teaching portfolio program in order to provide some additional teacher training, to develop a file of worksheets and other products of

teaching that could be used from year to year, and to provide an opportunity for the undergraduate instructors to showcase their teaching as a professional development activity. Depending on the needs of the course or program, the session structure could also take place as a series of 1 hour long bi-monthly meetings over a quarter or semester, facilitated by a lead teaching assistant or faculty member, with undergraduate or graduate student teaching assistants archiving and annotating additional artifacts to add to their portfolios and the course resources.

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Appendix A: Exit Survey Data

Please note the following about the survey results from participants M1 and M2. Questions 1-23 were rated on a five point Likert scale, with responses ranging from "strongly disagree" to "strongly agree". One participant split the Likert scale further. For example, a mark between neutral and agree was given a value of 0.5. The participant responses correspond to the following numerical values in Table 1:

-2 = strongly disagree
-1 = agree
0 = neutral
1 = agree
2 = strongly agree

Participants were also asked to comment about the course in three free response questions. The questions and the verbatim participant responses to these questions may be found in Table 2.

Table 1: Exit survey—Likert scale responses

As a result of participating in this workshop…	M2	M1
1. I constructed a teaching portfolio.	-1	0
2. I had conversations with other facilitators and tutors about teaching.	1	1
3. I was able to identify teaching techniques and strategies.	1	1
4. I was able to share teaching artifacts and discuss their significance with other facilitators and tutors.	1	1

Please indicate whether you agree or disagree with the following statements:	M2	M1
15. Facilitating and tutoring helps me to learn.	1	2
16. Working as a facilitator or tutor helps me give back to the community.	0	0
17. This workshop was a good use of my time.	1	0
18. I would participate in this workshop again.	1	1

5. I was able to document examples of my teaching by creating artifacts.	1	1
6. I was able to add electronic or paper copies of my teaching artifacts to the MSEP archive.	0	
7. I learned new ways to teach.	1	-1
8. I was able to find solutions for teaching problems that I was facing.	1	-1
9. I got advice or help from other facilitators and tutors about teaching and tutoring.	1	1
10. I feel that I became a better facilitator or tutor.	1	0
11. I feel that I can talk about my teaching more clearly.	1	1
12. I feel that facilitating and tutoring is valuable in preparing me to work in science, technology, engineering or mathematics fields.	1	1
13. I think my teaching is important to potential employers.	0	1
14. I feel that learning how to teach well is important to my professional development.	2	2

19. I would recommend this workshop to a friend.	1	0
20. MSEP should offer this workshop or ones like it in the future.	1	1
21. This workshop was fun.	1	0
22. I liked this workshop.	1	0.5
23. This workshop helped me learn more about teaching.	1	1

Table 2: Exit survey—written comments

	M2	M1
Free response: What were the best parts of this workshop?	Simply talking about how we teach	Getting a chance to discuss teaching with other tutors/facilitators; + also w/more experienced teachers. Also, the worksheets asked good questions-- I found the exercise of putting some of my experiences into words to be useful. [more helpful than I expected :)]
Free response: What things about the workshop need improvement?	More talking	At times, I thought the discussion was a bit too vague or repetitive - maybe a somewhat more structured discussion would help. Also, it might be nice to talk more with people already experienced at teaching.
Free response: If you have any additional comments about this workshop, please write them here.		I found it a little hard to talk about some of the difficulties I was having with teaching, both because I felt many of my problems were unique to facilitating (as opposed to tutoring), and because the people at the workshop changed quite a bit from week to week (which makes it harder to have a good, in depth discussion).

Appendix B: Exit Interview with Participant M3 – Field Observation Notes

I. Questions related to process and supports for participants:

How did you go about creating your teaching portfolio?

[He hasn't actually put it together yet, but this is what he plans to do.]
He'll include:
1) Notes from all the chapters for Math 126
His notes: Notes from the book on the left half of the page, uses the right half of the page for questions to ask the class, certain "snags" or areas of trouble he expects the student to have, marks good examples from the book to explain complicated concepts. He uses these notes as a "teaching tool" – he looks over them before class, and uses them in his teaching.
2) Practice exams that he made, and some off the web
3) Reflections from big review sessions before exams, common "snags" that the students had.
4) Write-ups of different teaching techniques that he used, with examples, what worked and why.

How much time did you spend outside of the program sessions on your portfolio?
The note taking part is done. That was infused with prep for the class. That took longer than expected: for the four sections, it took about an hour extra.
Additional stuff (like making up the practice exams) – all part of class prep time. About 70% of the prep is what he already does [i.e., what he would do anyway for class prep even if not involved in this project]. The extra work, like articulating what worked and what didn't, comes out to a page or two, so about an hour.

Did you work together on portfolio elements?
He talked to the tutors for Math 126 a lot. Talked to them about the "snags" that they hear about from the students. Sometimes they're the same snags he hears about, sometimes they're different, so it's good to know what the tutors hear. He has done some collaborating with the tutors, which was helpful.

Did you get help from others?
The interviews throughout the quarter were helpful. He got a lot of ideas from the facilitators.

II. Questions related to the impact this teaching portfolio program had:
What are you taking away from this program?
Things he learned:
- Now he has a better grasp of Math 126 than the first time around (when he took it as a student).
- "Students are *really* demanding. They want to do the least amount of work to understand the concepts, and want you to just give it to them."
- Students want more and more review sessions, to fit their lives and schedules.
- They seem to think that this is all he does, like he has tons of time to do review sessions for them. It's like they don't realize he's taking his own classes too. "There's only so much you can do."
- He didn't expect the students to be so "active," asking for so many review sessions.
- Students started skipping their actual class and just went to his sessions, because he "made more sense." So he explained to them why it's important to go to class, to make

sure they get all the material that the professor covers and not just what they go over in the review session. He thinks they started going to class again after that.
- He learned a lot about note taking. This was a new system for him [see above, the strategy with notes on the left side and questions on the right side]. Actually, he learned about it in high school, but it "clicked better as a teacher" than as a high school student. "That's the best thing I've taken back from this."
- Now he'll use this note taking strategy for his own chemical engineering classes as a student. While he takes his notes he'll be thinking about how he would teach the material, which will make his notes better.

Were you able to create a teaching portfolio?
No. But he's working on it. He just hasn't had time yet.

Were you able to create teaching documents/artifacts to add to the MSEP files?
Yes. Like the practice exams he made.

Did participating in this program change how you think about teaching?
Did participating in this program change how you teach?
[His answers to these questions sort of morphed together as he talked.]
- He refined his teaching techniques.
- Before, he had done tutoring. "Tutoring is just helping, not thinking critically about the curriculum." That's what he did the first week [tutoring], and it didn't work. He learned that you have to look at the demographic of the class, who they are, what different learning styles they have, and be prepared for the questions they'll ask.
- After two or three weeks he figured out the different learning styles of the students and started doing different activities to fit. For example, since most of the class liked listening to lectures, he spent a good chunk of time doing that, but he also had the students who liked to get up and do things come up and do things at the board.
- Meetings with facilitators helped him change his teaching. Interacting with the facilitators helped him be aware of things like different learning styles and what to do about them.
- At the start, he thought of teaching as just lectures. Then he was more aware of learning styles, and how to invest planning time to come up with new activities.
- It was more work, more analysis than the thought it would be. "You're engineering your curriculum." "You want to get a successful product or solution," and that product is your students' learning the concepts. So you engineer your curriculum and teaching to get to that product.

III. Questions related to the participant's overall impressions:

What were your overall impressions about the program?
- "Good. Lots of good ideas."
- One concern: "We talked about a lot of stuff, but didn't follow up on a lot of it."
- Meeting weekly, or every two weeks worked well. But the same themes came up a lot, so it was kind of repetitive.

- Doing the portfolio was a good idea. It helped him look at teaching in a different way, analyze and organize it more. It made it clearer for him. By typing activities up and putting them in the portfolio, it helped.
- Looking back in retrospect, seeing what you're doing, is helpful.

What could be improved?
- Maybe the repetitiveness. The same problems come up, and the facilitators provide solutions, which is good. But the solutions just take a while to fix the problem.
- Can't think of any other improvements or suggestions for next time. It was good.

Appendix C: Exit Interview with Participant M4 – Field Observation Notes

I. Questions related to process and supports for participants:

How did you go about creating your teaching portfolio?
Did you use the program materials?
She got a sheet every week. They had homework assignments that she completed

Did you work together on portfolio elements?
They'd bring in the homework each week and go over it as a group.

How much time did you spend outside of the program sessions on your portfolio?
She spent some time on the first assignment –maybe a half hour. She didn't complete a portfolio in this workshop because she could only make it to the first two sessions. (She already has a FIG portfolio)

Did you get help from others? If yes, what types of help did you get?
She didn't create a portfolio so there wasn't any help to get. As mentioned above she talked about homework in class. *Background information added by interviewer: She made the FIG (Freshman Interest Group) portfolio in her general studies class last year. She got a worksheet that laid out how to make a portfolio in Catalyst. The GS class instructor helped her w/ questions. She didn't actually create the portfolio originally: the instructor created it, then sent an invite to the students. The students then added to the portfolio.*

II. Questions related to the impact this teaching portfolio program had:

What are you taking away from this program?
Were there particular things you learned?
It was nice to talk; talked with other tutors and facilitators. They all had different knowledge. She could give her chemical engineering perspective; she got the physics perspective.

Were you able to create a teaching portfolio?
She only did the first assignment about teaching. She was given the assignment to create an artifact but since she couldn't come to the 3rd session (due to a schedule conflict) she didn't complete it.

Were you able to create teaching documents/artifacts to add to the MSEP files?
She thought that this question didn't make sense and that it might be for facilitators, so she didn't have an answer.

Did participating in this program change how you think about teaching?
What things changed?
Not sure that it changed anything. She's sure that teaching at a different level helped (tutoring in elementary schools). She already had this experience with teaching/tutoring. She was nervous about college level teaching since she's in college (tutoring peers now) and since her experience was only elementary level. But she realized that there are similarities between the elementary teaching experience and the collegiate teaching experience. That realization helped her.

What caused you to change how you think about teaching?
The first assignment, then talking about it as a group. She used her experience as an elementary school tutor to write her teaching statement. The people in the workshop thought it was really good, then she explained it was about elementary school.

Did participating in this program change how you teach?
What things changed?
"I'm not sure it changed how I tutor." She was just starting tutoring college chemistry & math. This was the first quarter tutoring at MSEP. (She's done a lot of private tutoring and tutoring at Rainer Beach elementary and high school -- all last year.) She wasn't already established in her tutoring (in HOW she tutors) at MSEP; already had a lot of experience

What part of this program caused you to change how you teach?
It didn't really change how she teaches.

Do you feel that these changes improved your teaching?
Not applicable—it didn't change how she teaches.

III. Questions related to participant's overall impressions:

What were your overall impressions about the program?
What went well?
"I was happy with them. I liked going to them."

What could be improved?
Maybe try to get more people there. Only had a few people show up. Schedule it at a time that more people could show up. Friday at 4:30 is tough for some people.

Comments for future directions of the program:
Encourage more people to come. (the first time there were 5; 2nd session – 3 other people—not that many people).