International Journal of Engineering Education Vol. 29, No. 1, pp. 99–106, 2013
Printed in Great Britain

0949-149X/91 $3.00+0.00

Engineering Students' Perceptions of and Reflections on Portfolio Practice in Leadership Development*

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Engineering education has been striving to find good ways to improve students' learning of engineering. However, non-technical professional skills such as communication and interpersonal skills, teamwork, and creative and intuitive thinking skills are also seen as essential for engineers, and especially for leaders. The portfolio practice has proved to be effective in supporting students' learning, as it allows them to document evidence of their learning and to reflect on personal growth. This paper reports a case study on implementation of the portfolio practice in an engineering leadership block curriculum and assessment of students' perceptions of this practice. It also provides implications for advancing engineering education with this approach.

Keywords: block curriculum; engineering education; engineering leadership development; portfolio assessment; student learning and reflection

1. Introduction

To prepare engineering students better with interpersonal skills, a North American research university created a leadership block curriculum with three core courses that address specific topics such as leadership principles, leadership in an organizational context, technology-based entrepreneurship, creativity, innovation, and change. Students who choose this Engineering Leadership minor are required to take all three courses in this block and two elective courses. This block curriculum is designed to provide integrated knowledge and a cohort learning experience for holistic understanding of leadership in a real-life, global context. It is expected that students will learn good communication and interpersonal skills, develop sound teamwork, and acquire creative and intuitive thinking skills that will help them perform well in their future careers as engineers.

Clearly, leadership is application oriented and experientially based. As a result, the method of instruction for the core block curriculum is a departure from the approach that is traditionally employed in engineering education. While being rooted in the perspectives of constructivism in general, the core courses of this curriculum are specifically based upon the concepts of discovery and disclosure. Students are not presented with the material to be learned. Rather, they are presented with opportunities to discover the desired content and, having discovered it, must demonstrate the knowledge by applying it in their course work or through reflective writing in the portfolio. A brief summary of the key perspectives adopted with the integrated methodology of this approach is provided in Table 1.

Students can successfully meet the objectives of the leadership core block curriculum through performing three characteristic roles of successful inquiry learning: a self-directed learner, a problem-solver, and a group learner in an authentic learning environment. The core courses of this block curriculum employ a number of active and collaborative learning techniques in order to create opportunities for the students to perform characteristic roles in each of these to enhance the learning process. Integral to the design of the leadership block curriculum is the use of the personal leadership portfolio. The portfolio practice, as the key integrated methodology employed in all of the core courses, is intended to be used by students as a learning tool to integrate their learning throughout the entire leadership development process. It is also to be used by teachers as an assessment tool to review students' learning of engineering leadership through not only the final products that they produce but also by their individual progress and personal learning processes. Figure 1 presents the conceptual framework of the block course design and portfolio practice in leadership development.

2. Portfolio practice

Portfolio practice has been extensively applied or adopted in education at all levels and in various professions for the last two decades. A portfolio is a collection of a student's work that demonstrates his or her learning and development of skills over time

* Accepted 27 June 2012.

Table 1. Key perspectives of the leadership block curriculum

Dimensions	Key perspectives	Integrated methodology
Instructional paradigm	Constructivism	Personal leadership portfolios
Teaching format	Dynamic/Responsive process	
Knowledge and information	Situation/Application dependent	
Learning	Reflection-in-action, Inquiry	
Evaluation	Portfolio, Projects, Group work	
Focus	Application, Integration	
Instructor	Learning facilitator	
Learners	Active participants, Knowledge constructors	

Fig. 1. Conceptual framework of portfolio practice and leadership development curriculum.

[1–2]. Portfolio practice can be used for many purposes, and it can be categorized into different types [3]. In engineering education, many cases have adopted portfolio practices with different implementation purposes as well as key abilities and competencies to develop, such as to help engineering students develop an integrated understanding of engineering design [4–5], knowledge management [6], and personal reflection and career planning [7–8], and to improve the first year engineering curriculum [9–11]. Those portfolio practices are all intended to give engineering students both good engineering skills and good interpersonal skills by self-constructing learning portfolios.

The portfolio, as applied in the leadership block curriculum of this study, focuses on several key facets of the students' learning: knowledge and skills, self-directed learning, communication, application of the knowledge gained and skills developed, collaboration, and creativity. In an effort to facilitate the portfolio process, students are provided with general guidelines for how the portfolio can be constructed and suggestions on the number of items to be included. Although some previous studies have suggested specific items to be included (i.e., [4, 10]), this study intentionally did not provide students with a model or specific requirements. The ambiguity resulting from this omission was intended to serve as a catalyst for the learning process, in which students could self-direct their learning [12] and use their creativity. Therefore, they were expected to demonstrate their learning processes and the outcomes from being autonomous, self-motivated learners who have their own problem-solving strategies, as well as their leadership knowledge, experience, and the skills that they had acquired.

Despite existing research on the role that the portfolio plays in enhancing the learning experiences of students in K-12 and higher education, few contemporary researchers have actually conducted empirical studies to assess the effectiveness of the portfolio as an integrated tool for learning and assessment. Even fewer researchers have explored engineering students' perceptions of and reflections on the portfolio constructing process in depth and its impact on learning. In particular, one recent study [13] even pointed out that while many research articles on portfolios have focused on teacher education, medical education, and nursing education, research in the field of engineering is relatively limited. The present study aimed to understand how engineering students would perceive the portfolio practice and how students would develop their learning of engineering leadership through constructing personal leadership portfolios.

3. Method

This study employed the case study approach [14] with the implementation of portfolio practice, a quantitative survey design, and document content analysis to explore the portfolio practice in detail and to determine to what extent, if any, this practice contributed to the students' learning and development of engineering leadership in these block curriculum courses. In an effort to determine the effectiveness of the leadership learning portfolio from the student perspective, a student perception and attitude survey study was conducted throughout the semester during which this portfolio practice

was implemented, and student portfolios were collected for review and analysis.

The instrument adopted in this study was a portfolio attitude questionnaire developed by the researcher, which consisted of eleven six-point, Likert-type scale items that were intended to measure students' perceptions and attitudes concerning the portfolio as an integrated learning and assessment tool used in the block curriculum. In addition, the questionnaire also contained four open-ended questions soliciting students' opinions about the advantages and disadvantages of the portfolio process, and their preferences regarding performance assessment. Furthermore, student portfolios were collected and reviewed three times by the instructor: twice during the semester and again at the end of the semester for final evaluation. The researcher, who was also the facilitator of these courses, reviewed and analyzed these portfolios to determine the students' performances and progress, as well as their reflections on their leadership learning and development.

The primary data analysis techniques used in this study included a quantitative method of descriptive statistics analysis of the final attitudinal survey, and qualitative methods of document analysis of the course syllabus; content analysis of individual portfolios; a perception survey and interview data; categorizing themes using an analysis matrix developed by the researcher; cross-case analysis; and triangulation to cross-check the accuracy of the data collected.

The main threat to the validity of this study was researcher bias, as the researcher also assisted in the instruction of the courses. To mitigate this threat and to enhance the accuracy of this study, an independent third party was invited to evaluate the research and findings. To ensure the credibility of this study, methods triangulation, source triangulation, and analyst triangulation were used. Throughout the analysis process, care was taken in the organization and interpretation of the data to ensure the transferability, dependability, and conformability of this study [15].

4. Results of the student perception survey

4.1 Sample

Participants in this study included the forty-eight students enrolled in the three core courses in the leadership block curriculum of the same semester. The students in each of these courses were provided with a course syllabus and were required to do the following: attend weekly, three-hour seminars for 15 weeks; work on group and individual projects as assigned for each of the different courses; and create a personal leadership portfolio. In addition, the students enrolled in one of the courses were individually and personally interviewed by the researcher at the end of the semester.

4.2 Students' perception analysis

All items that evaluated students' perceptions toward the application of the portfolio in both learning and assessment reflected a central tendency to support the portfolio as an effective learning tool (Cronbach's Alpha = 0.994; Means range: 3.95–4.55; SD range: 1.11–1.48). The students' perceptions of the portfolios supported the effectiveness of the portfolio as a learning tool in general. Most of the students (71.5%) considered the experience of creating a portfolio to be rewarding, and these students agreed that the portfolio was a good learning tool. Most students (81.0%) appreciated the multidimensional perspectives of learning that the portfolio demonstrated and, specifically, they thought that the portfolio was effective in demonstrating students' personal growth, both at the present time and in the long term. Most important of all, the learning experience with the portfolio was recognized by nearly all respondents (90.5%) to significantly improve the interaction between the students and instructors. About 80% of the students believed that the portfolio process helped them to communicate their learning process and outcomes to their peers and instructors.

Further measurement of how the students perceived the portfolio as an educational assessment tool also suggested favorable attitudes and positive outcomes. About two-thirds of the students found the portfolio to be a good assessment tool for evaluating performance, and 83.3% of them believed that the portfolio provided a multidimensional perspective of the assessment. About three-quarters of the respondents (76.2%) stated that they would apply the portfolio process in the future. Table 2 summarizes the results of the descriptive analysis.

4.3 Student feedback on the portfolio practice

Many of the students suggested that the portfolio practice could enhance their learning because it allowed them to self-pace, monitor, direct, and assess their individual learning. In addition, many believed that the portfolio improved their thinking because the assignment forced them to keep track of, reflect on, and organize their thoughts. Moreover, the survey results suggested that the personal leadership portfolio helped the students to connect what they were learning to their real-life experience and helped to improve their creativity, both which are very important in engineering education.

The primary drawbacks of the leadership portfo-

Table 2. Analysis of final portfolio perception and attitude survey

Items	SD (n)	MD (n)	D (n)	A (n)	MA (n)	SA (n)	Means	SD
1. I consider the experience of creating my portfolio in this course to be successful.	5	2	5	13	12	5	3.95	1.48
2. The portfolio is a good learning tool to help students learn.	4	2	4	13	14	5	4.12	1.40
3. The portfolio is a good tool to demonstrate my personal growth.	4	0	3	13	16	6	4.31	1.35
4. The portfolio is a good tool to demonstrate my learning progress over time.	4	0	3	13	14	8	4.36	1.39
5. The portfolio process provides a multidimensional perspective of learning.	4	0	4	14	11	9	4.31	1.42
6. The portfolio process can improve the interaction of students and instructors.	1	2	1	14	17	7	4.55	1.11
7. The portfolio process can help me communicate my learning with others.	2	1	5	12	16	6	4.36	1.23
8. I consider the use of portfolios in this course to be successful.	3	1	5	10	12	11	4.43	1.43
9. The portfolio is a good assessment tool to evaluate students' performance.	2	6	5	7	15	7	4.14	1.47
10. The portfolio process provides a multidimensional perspective of assessment.	3	1	3	16	12	7	4.29	1.31
11. I will apply my experience of the portfolio process to other subject matter in the future.	3	1	6	17	8	7	4.12	1.33

lio were as follows. First, many of the students claimed that the ambiguity of this assignment, though intentionally designed to provoke students' creativity, caused problems, especially at the beginning of the semester. Engineering students tend to expect concise guidelines to refer to while doing assignments. Additionally, the portfolio process, much like the learning process, can be very time consuming. Understandably, the time required was cited as a disadvantage. Moreover, the greater subjectivity of the grading system than that of conventional tests or examinations was considered a potential disadvantage, since students were used to evaluation systems with absolute criteria.

Clearly, however, the participants in this study considered alternative assessment to be more appropriate for assessing student performance in this new approach to leadership development courses. A summary of responses to the open-ended questions is provided in Table 3.

Table 3. Results of issues in portfolio practice

Facets	Frequency (*n*)
Advantages	
Enhancing learning	20
Enhancing thinking	20
Connecting to real-life experience	5
Improving creativity	3
Disadvantages	
Ambiguity	15
Time consuming	19
Subjectivity of grading system	3
Preference of assessment format	
Alternative assessment (e.g., Portfolio assessment)	36
Standardized tests and examinations	5
Combine both	2

5. Students' reflections on learning with leadership portfolio experiences

To further explore how this portfolio practice acted as a tool to develop students' learning of leadership, students' portfolios were analyzed with a particular focus on their learning and performance on content knowledge and skill acquisition, self-directed learning, communication with readers, real-life application, collaboration in groups, and creativity, as represented by the portfolios. Each of the following sections addresses one of the key facets of student learning based on documentation of their personal leadership portfolios. Important excerpts are included.

5.1 Content knowledge and skills acquisition

The portfolio approach is not as structured as the traditional testing approach, and it is not designed to evaluate absolute right and wrong answers from students' responses. Instead, students have a better chance to demonstrate the knowledge gained and skills developed in more authentic ways throughout the learning process. Students need not memorize facts, concepts and rules in the traditional way in order to recall them in a test environment. Rather, students are expected to demonstrate their development through a purposeful collection of their work with self-reflection that exhibits their learning processes and outcomes [1]. As a result, students must show what they have learned through the synthesis of ideas and concepts. This can be as straightforwardly stated as:

> This section shows where I have seen leadership during the semester. It shows what I think a good leader is, based upon what has happened this semester. These are by no means the only good characteristics of a leader, but only the ones I have mentioned in my working portfolio. (P-S01)

Or, it can be inherently stated in a reflective statement such as:

> *The Engineer as a Leader* More and more I have come to realize that industry is moving their technical people into management positions. Not just team leader or supervisor but director and vice president positions [sic]. Why is this? In my opinion, I think it is because the engineers have a good grasp of what is going on within

> the company. This is because they have had to work with the company at its bottom level and can identify its strengths and weaknesses. They also have worked with the products and interacted with the customers to find out exactly what it is that makes them happy. And most engineers imitate some sort of a leadership role just from working with teams. I think that a great deal of people working in the business units may miss out on some of these experiences and could be less qualified for these leadership positions. (P-S02)

5.2 *Self-directed learning*

As previously noted, while the requirement of a portfolio is not particularly ground-breaking, the use of the portfolio as a self-directed learning tool and for the purpose of course and performance assessment in the leadership core block curriculum is both unique and innovative. Although guidelines and self-evaluation check sheets for the portfolio assignment were provided in the course syllabi, students were expected to develop and use the portfolio as their personalized tool to help direct and pace their own learning process. According to [12], "Self-direction in learning is a process in which the learner makes a decision to learn in order to achieve a goal, formulates a plan to reach the goal, and takes action toward the goal." Therefore, self-directed learners need to be able to establish specific individual learning objectives and to develop their own strategies for learning the course content. The portfolio must reflect these objectives and strategies and must be created accordingly. Students in this leadership core block curriculum are expected to concurrently search for resources, monitor and regulate their learning processes, and continually evaluate their progress in attaining their learning outcomes.

While such expectations may seem too lofty for undergraduate engineering students, evidence from student portfolio entries indicated that the students in these classes were able to self-direct their learning. First, students demonstrated an understanding of the process despite the intentional lack of clear direction.

> The final key ingredient to understanding self is setting goals and effectively structuring and implementing a strategy to achieve those goals. (P-S03)

Second, students demonstrated the ability to meet the expectations of the portfolio. This ability was apparent not only in their portfolio entries and reflections but also in the changes and revisions of their portfolio entries, as well as in their self-constructed learning goals and objectives. This is illustrated by the following excerpts from the portfolios, both explicitly:

> *My learning goals* 1. To develop a clear understanding of how the entrepreneurial process works in the United States. 2. Learn the key elements of the marketing field. 3. Learn what is involved in and participate in making a business plan. 4. Find out what people out in the workplace are doing, how they got there, and why they were successful. 5. Develop some good relationships with classmates and faculty. (P-S04)

and implicitly:

> . . . I am using this as a tool to help me express my thoughts and ideas as they related to my learning. I hope to better able to conceptualize my thoughts to allow me to understand myself better by the end of this course. (P-S05)
>
> I have done my best to convey the thought processes I went through to learn and apply the given material. (P-S06)
>
> This portfolio consists of five submissions. They range from terrible to very good. I am including all of them unedited because bad work is as much a learning tool as good work. I have analyzed the comments in the bad submissions and tried to make next submissions better. (P-S07)

5.3 *Communication with readers*

One of the significant benefits of the use of portfolio practice for learning and assessment is that the portfolio itself can be used as a communication tool that can better communicate student learning to a reader than is possible with traditional standardized tests [12]. In the personal leadership portfolio requirement, students are expected to demonstrate, and if necessary to develop, the communication skills requisite to effectively communicate their learning to the readers of their portfolios. A number of students effectively communicated learning through the appropriate selection of entries, as expressed in the following excerpt:

> Taking the time to write down my thoughts from class provides a good forum for me to understand myself and my ideas better. It enables me to be able to communicate better with people (which is key in business). I can do this better by assessing my weaknesses and working to improve upon myself. (P-S08)

Of course, the striking example of one student's understanding of the portfolio as a communication tool is provided in the following quote:

> By including this in my portfolio, I hope it gives the reader the opportunity to realize why I react to some things some ways, while I react to other things in a different manner. Maybe this will give the reader some additional insight into my personality, and my leadership style. (P-S09)

5.4 *Real-life application*

The engineering leadership block curriculum in this study encourages students to develop life-long learning skills. Topics discussed and activities implemented in the classes are always real-world issues and examples. The intent is both to create an authentic learning environment and to help students anchor what they learn in a real-world appli-

cation. Portfolio assessment provides a complex and comprehensive view of student performance in an authentic context [1, 16–19]. Students are expected to relate what they have learned to the context of the real world. Again, evidence from the leadership portfolios shows that most students demonstrate the ability to apply the knowledge gained and skills developed in their daily life experiences.

> It is currently being used as a quick-reference tool for myself. As I have questions, problems or critical situations develop, I often turn to this portfolio for answers [sic]. Not that it gives me the magic 8-ball answer, but rather I can find a similar situation described previously and see how I handled it and then make my decision. Documenting and then reflecting on mistakes/failures is a key element of the human learning process, and I am no different. (P-S10)

> It was also important for me to learn about myself in addition to learning about leadership. This is where the portfolio helped in the learning process. It made me think about leadership on a consistent basis, most of the time pertaining to material covered in class. It also made me think about the leadership situations I have been in the past and am in, in the present [sic]. And with all these situations that I thought about and wrote down in this portfolio, I will have a history of my mental growth throughout the course. (P-S11)

Of course, it is important to remember that for most undergraduate students, there is often little frame of reference to the context of the real world. For many, school or future school-related activities are their real-world context. However, these too can prove to be a powerful context, as shown in the following portfolio entries:

> The other day I was sitting in one of my classes (CSE465—Data Structures and Algorithms) and it suddenly dawned on me that the 'flow network' the teacher was attempting to teach us about are [sic] very similar to PERT charts. We were told to write a program to compute the 'maximum flow' of the network. This would be analogous to finding the critical path on a PERT chart . . . This time, I'm applying what I have been learning to another class, and what I learned in that class to this class. (P-S12)

> Next summer I am going to be running an engineering camp for high school age kids. Hopefully, I can gain some insight into dealing with all the people here at the university, with local business, and with parents that I need to make the program successful. I know a lot of the leadership techniques that I have learned and will learn should come in handy in many situations. (P-S13)

5.5 Collaboration in groups

One important characteristic of the engineering leadership block curriculum is that students in all of the core courses are required to form small groups to collaboratively work on course projects. Students are expected to experience group dynamics and to learn from those experiences. Additionally, they have to reflect upon those experiences and to communicate their insights in their portfolios. As is clear from the following quotes from portfolios, the students in the core courses clearly indicated what they had learned while working in the group by showing their task distribution, the effectiveness of working on group projects, and the general group process, including the communication and interpersonal skills:

> In this class practically every assignment involved working in groups. Although this is the perfect testing grounds for leadership, I often found some problems within the group. In most cases, one person within the group would come up with the most information or devote a large portion of their time to the assignment and then share that information with the rest of the group. This resulted in some people doing most of the work while others accomplished nothing. I found this characteristic of group dynamics very frustrating. On the other hand, if we didn't work in groups on some of the projects, they never would have been accomplished. (P-S14)

> A good leader would have been able to make the other group members feel like they had done their part. . . . A group working together as a team will almost certainly accomplish more than a single person. This is something that I have kept reminding myself. I have a problem with trying to do everything myself, kind of like if it's not done my way, it's not right so I better do it myself [sic]. Many times the other person can do the job, and do it right, however I have trouble if it's not done my way. (P-S15)

It is important to note that even the instructors of the course were surprised at the apparent resourcefulness of the students to find learning opportunities.

> During all my group meetings I have been trying to sit back and let others sort of lead. I think it is important to be on other side of leadership, experiencing someone else's leading is different from what I am used to because I usually try to take charge even if I probably shouldn't [sic]. I think that seeing the things that bug me about what others do as leaders and relating that to what I do as a leader that probably bugs other people is a good tool for improving my own leadership style. (P-S16)

5.6 Creativity

Another important characteristic of the engineering leadership block curriculum is that students are expected to explore and expand their individual creativity. To accomplish this, each of the instructional strategies and classroom activities are designed to be innovative and to spark the students' creativity. The personal leadership portfolio is fully aligned with this purpose. Innovative ideas are welcomed and students are encouraged to be as creative as they can in all facets of the portfolio. This component of the curriculum is perhaps the most demanding for the students. Although many students created written and reflective portfolio entries, several students enclosed articles, photo-

graphs, quotations, and even cartoons from outside sources that they considered relevant to their learning. Others related stories about their personal real-life experiences. Some students arranged their portfolio entries by using very creative topics to organize their thoughts and learning. Some of the thoughts expressed by students in their portfolios include:

> Creativity and innovation is a never ending process that should be incorporated into everyday living. Being a student of such [an] enormous institution, I find that there are high levels of competition. Being a black student living in a predominantly white environment can be very uncomfortable. These are just two of the reasons why creativity has to be stressed in everyday life. Everybody has a need for creativity in dealing with the situations of life. (P-S17)

> . . . I think this is a fantastic change from [the] traditional teaching style, which helps to unlock the creativity in our own brains. This approach to learning virtually eliminates thought walls mentally constructed because of fear of failure. In fact, the instructors encourage us to fail because it is a valuable learning technique. (P-S18)

According to the analysis of students' personal leadership portfolios, results such as those discussed above are encouraging in terms of what students developed, and what is reflected in the portfolios actually accords with the purposes of the portfolio practice implemented in this leadership block curriculum. Through the documentation and development of personal leadership portfolios, students could integrate their learning in the three core courses as well as connect what they had learned to real-world experiences. They demonstrated growth in their communication, interpersonal, teamwork, creative, and intuitive thinking skills, the skills that they were expected to develop as part of a core competency that would help them to become good engineers and leaders in the future.

6. Conclusions

In sum, the results suggested a number of potentially significant implications for engineering educators interested in the use of portfolios as an alternative method of learning and assessment, confirming that the effective use of portfolios can enhance engineering students' scholastic experiences and, especially, their leadership development. The results of this study echoed that the portfolio can be an effective integrated learning and assessment tool, especially in courses that involve a great deal of complexity and authenticity such as leadership, management, and interpersonal skills. Additionally, while the portfolio approach can entail a high degree of complexity, students exposed to this type of learning and assessment experience may be more likely to develop life-long learning skills. The portfolio process, as applied in the leadership block curriculum, motivated students to take responsibility for their own learning by setting their own learning goals, determining and applying their learning strategies, identifying related resources that support their learning objectives, and assessing their learning progress. Furthermore, students who have experienced the portfolio process may develop the tools to apply self-directed learning strategies in other contexts and other subject areas. Such a transfer would most likely be reflected in their way of thinking and strategies associated with learning, rather than in content knowledge. While the majority of students initially resisted any new approach to teaching and learning, the more effort they devoted to the self-directed learning philosophy of the portfolio, the more clearly they saw what and how they were learning, and the effect and ultimate success of their learning strategies.

Perhaps the most significant finding of this study concerns the potential implication that the use of portfolio practice such as that employed in the leadership development curriculum could meet the guidelines of Engineering Criteria 2010 [20] or similar criteria for accreditation in higher education in general. Most of these criteria require engineering schools or institutions of higher education to create educational objectives, a curriculum, and an assessment process that clearly demonstrates that graduates of their engineering programs have skills that include, among others, an ability to work on multidisciplinary teams, an ability to communicate effectively, and a recognition of the need for and an ability to engage in life-long learning. The results of this study indicate that a portfolio practice, such as that employed in the engineering leadership block curriculum, is in keeping with the intent of those guidelines mentioned above and is a potential means of demonstrating program compliance with the three criteria identified.

Finally, one critical finding of this study is to witness a magnificent change of students' attitudes toward the portfolio practices, students acted with resistance in the beginning, then gradually they reluctantly participated, and finally became actively engaged. From the perspective of an engineering education researcher, however, there is no more powerful statement that can be made concerning the effectiveness and value of the engineering leadership portfolio than that contained in the following student's entry:

> Overall, I am very pleased with my work. The thing that I think that I am happiest about is that, when I read over some of the literature I have gathered over the course of the semester, it says many of the things that my portfolio says. Only I discovered them for myself through the use of my portfolio. (P-S19)

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