AC 2011-1091: ENGINEERING EDUCATION RESEARCH TO PRACTICE (E2R2P)

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Dr. Plumlee is certified as a Professional Engineer in the state of Idaho. He has spent the last ten years establishing the Ceramic MEMS laboratory at Boise State University. Dr. Plumlee is involved in numerous projects developing micro-electro-mechanical devices in LTCC including an Ion Mobility Spectrometer and microfluidic/chemical micro-propulsion devices funded by NASA. Prior to arriving at Boise State University, Dr. Plumlee worked for Lockheed Martin Astronautics as a Mechanical Designer on structural airframe components for several aerospace vehicles. He developed and improved manufacturing processes for the Atlas/Centaur rocket program, managed the production implementation of the J-2 rocket program, and created the designs for structural/propulsion/electrical systems in both the Atlas/Centaur and J-2 programs. Dr. Plumlee also worked at NASA's Marshall Space Flight Center as an engineer in the Propulsion Laboratory. In practicing the engineering profession as a conduit for preparing future generations of engineers, he wants to provide students with both a technical competency and the ability to understand and respect the trust that is invested in us by society. As an educator, he guides future engineers through a learning process that develops a strong technical foundation and the ability to independently cultivate further technical competencies. He is particularly interested in advocating for project-oriented engineering education. He and a research team at Boise State University is currently participating in a project focused on encouraging the adoption of project-based techniques.

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ENGINEERING EDUCATION RESEARCH TO PRACTICE (E^2R2P): NSF GRANT 1037808

Abstract

The E^2R2P team employs a unique interdisciplinary approach to facilitate faculty adoption of research-based educational strategies across the engineering curriculum. As part of a "Sounding Board" of potential adopters, faculty will provide guidance, review components of redesigned courses, and participate in a series of workshops highlighting a variety of problem- and project-based instructional strategies[1, 2].

A "Test Bed" will act as a venue for the visible redesign of existing courses in ways that employ authentic learning and assessment activities--where students do real-world engineering in the classroom. The redesigned courses will also help students inbound into their community of professional practice [3, 4]. Project mentors drawn from a local professional engineering organization will help students to complete projects, and online webinars/live lectures will bring practicing engineers and other experts into the classroom. These instructional approaches should increase the number of activities and beliefs that support student entry into their community of engineering practice. This poster session provides in-progress results of a literature review identifying factors and potential measures facilitating entry into this community of practice.

As courses are redesigned in the Test Bed, the Sounding Board will provide guidance and feedback on deliverables arising from the course redesigns, such as job-focused objectives, active learning strategies, authentic assessments, rubrics, and prototypes illustrating key instructional components. The Sounding Board will also provide a venue to deliver skill training associated problem- and project-based instructional skills. In addition, the Sounding Board will enable the team to employ change management approaches [5, 6] that decrease resistance to change by facilitating the adoption process and building characteristics into educational strategies that will encourage their use. To create a demand ("pull") for these strategies and redesigned courses while mitigating project risk, the team will use a software engineering approach called Rapid Application Development [7, 8]. To measure rates of faculty adoption, the team will create a Sounding Board Survey collecting both quantitative and qualitative data. This poster session provides an in-progress version of this survey and an analysis of collected data.

Index Terms

Engineering education, Learning, Project engineering, Engineering profession

I. Introduction

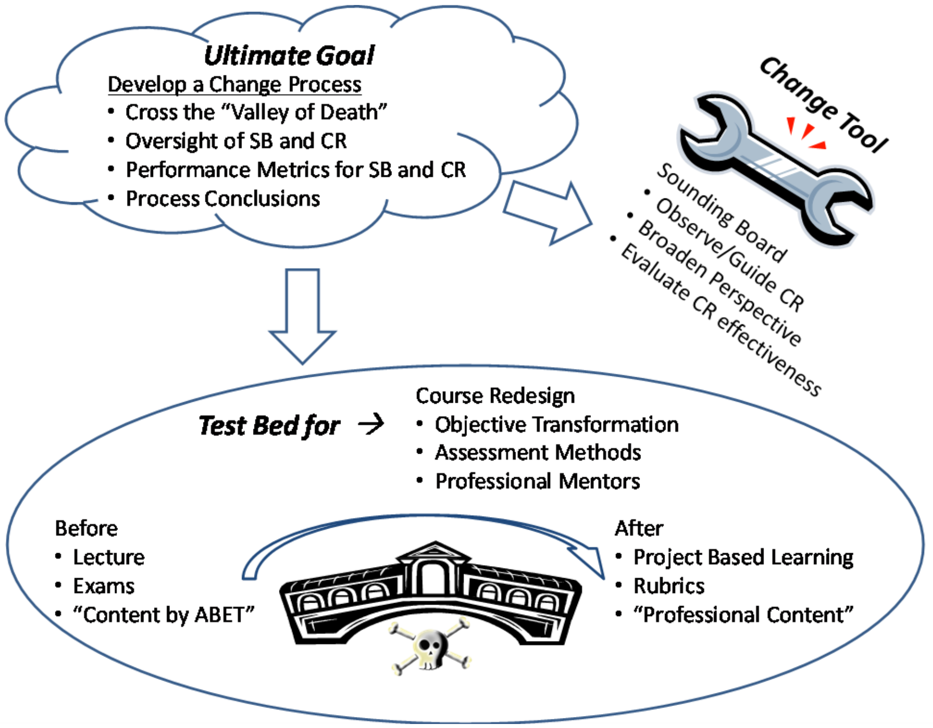

Figure 1: E2R2P Concept. To cross a valley of death promoting transfer of learned engineering skills to later courses and the workplace, the E2R2P effort will employ course redesigns in a visible test bed and a sounding board.

Engineering education has typically been delivered via the transformation of information and theory through lecture in isolation of the active use of the acquired knowledge. While classroom taught engineering fundamentals are certainly important, of equal value and importance is the integration of hands-on practical learning to enhance the transfer of fundamentals to later courses and, ultimately, real-world contexts. To address this issue the E²R2P project aims to redesign engineering courses at an urban university. This paper will provide an overview of the E²R2P project and the efforts of this project to date, which include a survey measuring students' inbounding activities related to their professional community of practice (see appendix) and a survey that measures faculty adoption (see appendix) of the problem- and project-based learning techniques used in the redesigned courses. This paper will also present a synopsis of the data collected to date, which includes a first run of the faculty adoption survey.

As depicted in Figure 1, the E^{2}R2P effort will develop a change process to span the "valley of death" separating engineering education and the engineering workplace. Courses before this effort could be characterized by their reliance on lecture, exams, and content mandated by ABET. Future courses should be characterized by their use of project- and problem-based learning, rubrics measuring complex problem solving and decision making, and professional content associated with real-world engineering deliverables.

II. Course Redesign in the Test Bed

To facilitate this change, the E^{2}R2P team will redesign courses in a test bed, using the guidance, feedback, and collaboration of university faculty comprising a sounding board. In the test bed, engineering faculty will collaborate with instructional designers and workplace performance improvement specialists to redesign selected courses. As depicted in Figure 2, the redesigns will include increased reliance on instructional strategies such as active learning, problem-based learning, and project-based learning. Use of these strategies will transform objectives and assessment methods, leading to improved learning outcomes that facilitate skill to subsequent courses and the engineering workplace. Drawing on aspects of a cognitive apprenticeship, the redesigned courses will also incorporate modeling by practicing engineers who will act as project mentors and other visiting experts who will deliver lectures and facilitate webinars on topics relating to engineering and what engineers typically do in the workplace.

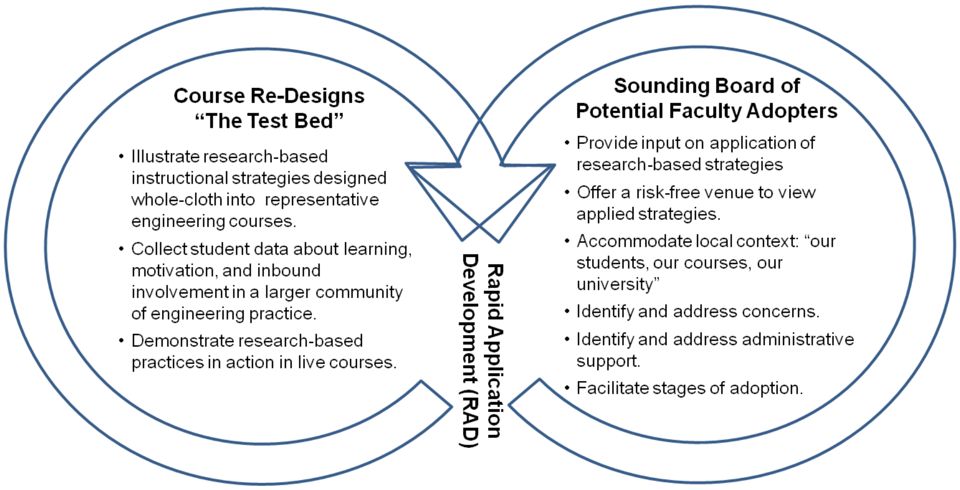

Figure 2: E2R2P Components. The E^2R2P effort seeks to facilitate engineering faculty adoption of research-based instructional strategies that will improve student learning, retention, and transfer of learned skills to subsequent courses and the engineering workplace. To this end, the effort will employ visible course redesigns in a "test bed," a sounding board of potential adoptions, and a project management approach based on rapid application development (RAD).

The course redesigns will incorporate problem- and project-based learning, which is a constructivist learning approach. This moves away from the traditional deductive method that begins "with theories and progress(es) to the application of those theories"[1]. The constructivist approach this project will implement is an inductive method that begins with an ill-structured genuine problem that students will work on as a team. Through this process, the students will learn to think critically, find and utilize appropriate learning resources, and demonstrate effective verbal and written communication skills [9]. The course redesigns will also implement strategies that help aid the students to inbound into their community of professional practice. One of these strategies is to use project mentors from the professional engineering community. These mentors will help students by answering questions concerning engineering, providing support for their project-based learning experiences, and introducing them into the local engineering community. The course redesign will also use webinars and live lectures to introduce the students to practicing engineers outside of the local community. Engineering faculty and other interested parties throughout the university will be able to observe these strategies in action in the redesigned test bed courses.

The test bed will also allow the team to collect formative and summative student data regarding learning, motivation, and emerging involvement in the larger community of engineering practice. By introducing the students to the professional engineering community of practice, the E^2R2P expects that the students will undergo a number of inbounding activities. To help identify the inbounding activities of the students, the research team conducted a literature review to determine how freshly minted engineers successfully enter into their professional community of practice (See Appendix A). This literature review began with the analysis of some foundational books regarding communities of practice and the analysis of these books returned a broad

overview of inbounding activities into communities of practice[3, 4, 10, 11.] The research team used the broad overview from the initial analysis to serve as the foundation for the second round of the literature review. During the second round, the research team conducted a Google Scholar search using the several variations of the following terms: engineering, community of practice, survey, questionnaire, confirmatory factor analysis, exploratory factor analysis, and path analysis. The results of both of these searches informed the creation of a community of practice inbounding survey that aims to measure the students' inbounding into a professional community of practice.
The review of the literature produced 10 factors related to inbounding activities. Of the 14 factors, 6 are supported by multiple sources from the literature. The E2R2P team will create an initial version of the survey during the Summer, 2011, semester and pilot it with students during the Fall.

III. Promoting Faculty Adoption through the Sounding Board

To support the implementation and adoption of the instructional strategies used in the E^2R2P Test Bed, the project team will incorporate the help of a Sounding Board. Sounding Board members include faculty from materials science engineering, mechanical and biomechanical engineering, electrical and computer engineering, and civil engineering. Other members include liaisons to the Engineering College's administration as well as other parties from the Colleges of Business and Economics and Arts and Science. The sounding board acts as a change tool. They will observe and guide the efforts of the E^2R2P team and the courses they redesign in the test bed. The multidisciplinary membership of the sounding board brings a diverse range of expertise and experiences to broaden the perspectives of the course redesign efforts. They will evaluate the effectiveness of the course redesigns. The sounding board is the mechanism for promoting faculty adoption of research based instructional strategies. Drawing on change theory, they will provide input on the changes that could affect them. In viewing the redesigned courses and their instructional components and participating in workshop activities at each meeting, sounding board members will participate in a risk-free venue where they can observe and try out research based instructional strategies without having to commit to large-scale course redesign. In providing guidance, offering feedback, and participating in workshop activities, sounding board members will also voice concerns, which can be addressed within the sounding board or escalated to college administration.

Another important purpose of the Sounding Board is to gather feedback and suggestions regarding the use of instructional strategies in the Test Bed. The data collection for this effort will take the form of a focus group where the research team will guide the discussion toward each instructional strategy and record the suggestions presented by the Sounding Board. Each meeting will focus on different instructional strategies which will allow the team to gather data about multiple instructional strategies. In each meeting of the sounding board, the E^2R2P will administer a survey to monitor faculty adoption of research-based instructional strategies. Based on the change theory of Rogers, the survey measures faculty perceptions of themselves as adopters, perceived levels of adoption of research based instructional strategies and activities, and the extent to which these strategies and activities demonstrate characteristics that encourage adoption. A copy of the survey along with compiled data appears in Appendix B.

IV. Managing the Effort Using Rapid Application Development (RAD)

To create a demand ("pull") for these strategies and redesigned courses while mitigating project risk, the team will use a software engineering approach called RAD[8, 12]. In particular, the team will draw on collaborative analysis and design, prototyping, specialized tools and skills, and ongoing prioritization based on collected data. This approach will identify what topics are of the greatest interest to the Sounding Board and allow the research team to provide more information regarding these topics.

V. Future Efforts

The future directions of this research effort are aimed at implementing the data collection tools the team created as well as developing new tools to further the teams understanding of the factors surrounding project-based learning in an engineering setting. During the beginning of next year, the research team will start creating a survey that aims measure the students' motivation towards the projects required in the Test Bed course. To inform this survey the research team will synthesize two motivation models. The first is the works of John Keller and the Attention, Relevance, Confidence, and Satisfaction (ARCS) model. The team will also review and synthesize the works of Richard Clark. By integrating these two motivation models the team hopes that they will capture data regarding the students' perceptions of the effectiveness and usefulness of the projects in the Test Bed.

Bibliography

1. Butun, E., H.C. Erkin, and L. Altintas, *A new teamwork-based PBL problem design for electrical and electronic engineeering education: A systems approach.* International Journal of Electrical Engineering Education, 2008. **45**(2): p. 110-229.
2. Jonassen, D., J. Strobel, and Chwee Beng Lee, *Everyday problem solving in engineering: Lessons for engineering educators.* Journal of Engineering Education, 2006. **95**(2): p. 139-151.
3. Wenger, E., *Communities of practice: Learning, meaning, and identity*. 1998, Cambridge University Press: Cambridge, United Kingdom.
4. Wenger, E., R. McDermott, and W.M. Snyder, *Communities of practice and their value to organizations*, in *Cultivating communities of practice*. 2002, Harvard Business School Press: Boston.
5. Rogers, E.M., *Diffusion of innovations*. 5th ed. 2003, New York, NY: Free Press.
6. Dormant, D., *Implementing human performance technology in organizations, in Handbook of human performance technology: Improving individual and organizational performance worldwide,* H.D. Stolovitch and E.J. Keeps, Eds. 1999, Jossey-Bass/Pfeiffer: San Francisco, CA. p. 237-259.
7. Martin, J. *Rapid application development*. 1991, New York: Macmillan.
8. Villachica, S.W., and D.L Stone, *Rapid application development for performance technology: Five strategies to deliver better interventions in less time*, in *Performance improvement interventions: Performance technologies in the workplace*, P.J. Dean and D.E. Ripley, Eds. 1998, International Society for Performance Improvement: Washington D.C. p. 343-399.
9. Duch, B.J., S.E. Groh, and D.E. Allen, Eds. *The power of problem-based learning*. 2001, Stylus Publishing: Sterling, VA.10. Lave, J., and E. Wenger, *Situated learning: Legitimate peripheral participation*. 1991, Cambridge University Press: Cambridge, United Kingdom.
11. Brown, J.S., and P. Duguid, *Balancing act: How to capture knowledge without killing it.* 2000, Harvard Business Review. **78**: p. 73-80.
12. Villachica, S.W., and D.L Stone, *Cognitive task analysis*, in *Handbook of improving workplace performance*. Vol. 1: Instructional design and training delivery, K.H. Silber and W.R. Foshay, Eds., 2010, Jossey-Bass/Pfeiffer: San Francisco.
13. R. Pascual, "Enhancing project-oriented learning by joining communities of practice and opening spaces for relatedness," *European Journal of Engineering Education,* **35**, pp. 3-16.

14. J. Lave and E. Wenger, *Situated learning: Legitimate peripheral participation*. New York: Cambridge University, 1991.
15. J. C. Dunlap, "Problem-based learning and self-efficacy: How a capstone course prepares students for a profession," *Educational Technology Research & Development*, **53**, pp. 65-85, 2005.
16. Z. Tohidinia and M. Mosakhani, "Knowledge sharing behaviour and its predictors," *Industrial Management & Data Systems*, **110**, pp. 611-631, 2010.
17. C.-C. Huang, C.-H. Yen, J. Chiu, W.-J. Hwang, and M.-H. Hsu, "Establishing knowledge sharing in virtual community through trust, self-efficacy and IS Success Model," in *PACIS*, 2005.
18. R. Sabherwal and I. Becerra-Fernandez, "Integrating specific knowledge: insights from the Kennedy Space Center," *Engineering Management, IEEE Transactions on*, vol. 52, pp. 301-315, 2005.
19. Y.-H. Fang and C.-M. Chiu, "In justice we trust: Exploring knowledge-sharing continuance intentions in virtual communities of practice," *Computers in Human Behavior*, **26**, pp. 235-246.
20. K. N. Shen, A. Y. Yu, and M. Khalifa, "Knowledge contribution in virtual communities: accounting for multiple dimensions of social presence through social identity," *Behaviour & Information Technology*, vol. 29, pp. 337-348.
21. J. Yi, "A measure of knowledge sharing behavior: Scale development and validation," *Knowledge Management Research & Practice*, **7**, pp. 65-81, 2009.
22. P. Chee Wei, A. Kankanhalli, and R. Sabherwal, "Usability and sociability in online communities: A comparative study of knowledge seeking and contribution," *Journal of the Association for Information Systems*, **10**, pp. 721-747, 2009.
23. A. Bandura, "Self-efficacy mechanism in human agency," *American Psychologist*, **37**, pp. 122-147, 1982

Appendix A: Community of Practice Inbounding Survey (in-progress work)

Factor influencing acceptance into CoP	Comments	Source
1. Engaging with practicing professionals	Engaging with members of a community of practice is the first step to establishing legitimacy and peripherality. By working with members of a community, the enteree is able to begin showing their value to the community along with their willingness to learn.	Wenger, 1998 p. 100; Wenger et al., 2002, p.102
2. Who is who in the discipline	Knowing who knows what information can help the enteree to find the information they need and establish their presence among the community. Wenger et al., 2002 present this as the contribution of CoP members. They indicate that his construct has two facets, the first being the benefits of contribution, i.e. recognition, visibility and the second being the value of learning from other experiences.	Wenger et al., 2002, p 84-86
3. Alignment of course activities and engagement with CoP	Pascual argues that active learning furthers engagement of students in a CoP when the active learning extends beyond the classroom. By extending active learning beyond the classroom and into professional communities of practice, it allows for positive interactions in the context of the work, which builds legitimate peripheral learning.	Wenger, 1998, p.101; Pascaul[13], 2010, p. 7
4. Struggle to define Mech. Eng. And reconcile their role within it	Interacting with a community allows the enteree to see what the community the community does on a daily basis while also allowing the community to take notice of the enteree.	Brown & Duguid[11], 2000, p.162; Lave & Wenger[14], 1991, p. 93-96
5. Creating self efficacy	Being confident in ones abilities and knowledge comes across in interactions with other people. Also, accurate confidence and self-efficacy allows and enteree to identify what it is that they know and what it is that they need to find out. Dunlap (2005, p. 66-67) used Schunk's (1989) definition of self-efficacy that is "an individual's level of confidence and self judgment regarding ability to organize and implement actions needed to perform effectively" Tohindini & Mosakhani (2010) operationally defined self-efficacy, citing Bandura[23] (1982), as a "person's beliefs about their ability to produce desired effects" (p. 614). Huang et al. (2005) also use Bandura's definition of self-efficacy. Despite the sources used to define self-efficacy, all of the definitions point in the same direction and explain the same concept using different words. All of these studies found a significant relationship between self-efficacy and knowledge sharing, which indicates that this factor must be included when measuring knowledge sharing.	Dunlap[15], 2005; Tohindini & Mosakhani[16], 2010, p. 614; Huang et al. [17], 2005, p. 103
6. Common Knowledge and Specific knowledge integration within a COP	In order to gain knowledge, and ultimately acceptance among a group, you must enter the group with a basic amount of common knowledge.	Sabherwal[18], 2005, p. 302-303

7. Trust	Social interaction is hollow without a degree of trust from both parties involved	Fang & Chiu[19], 2010, p. 238; Huang et al. [17], 2005
8. Social identity (how people view themselves within the community) (contextual stimuli make these salient to the individual)	Establishing oneself among a group is a step to entering into that group. A person must find their role in a group and play that role	Shen et al.[20], 2010, p. 338
9. Success and failure stories	Trading war stories is a signal that one has socialized into a group. Yi (2009) used this concept as a specific measure of knowledge sharing contribution. Yi (2009) internal reliability using Chronbach's alpha and determined a reliability value of .939 for CoP. It should also be noted that the CoP subscale Yi created had factor loadings twice their standard error and the AVE for CoP was .678 meaning that the subscale did possess convergent validity. Discriminant validity was measured through correlations with other factors and returned a Pearson's correlation coefficient of .224 that was significant at the $p< 0.01$ level.	Yi[21], 2009, p. 80; Chei Wei et al.[22], 2009;
10. Balance between knowledge sharing and knowledge seeking	This falls in line with the economic principle of supply and demand. If people are not receiving information then the providers of the information will stop or reduce the amount of information they provide.	Phang et al. [19], 2009, p. 720-730, p. 722-725

Appendix B: Sounding Board Survey (in-progress work)

Thank you for attending the __*date*__ meeting of the E^{2}R2P Sounding Board. This workshop addressed the following topics for improving learning and transfer to subsequent coursework and the engineering workplace.

Topic 1: _____ Topic 2: _____ Topic 3: _____

Thank you for providing your anonymous and candid responses to the items in this survey. By completing this survey, you are giving your consent to participate in this study. Feel free to answer or leave items blank as you wish. As always, please feel free to contact any of us with any questions or concerns.

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1. Which statement best describes your typical response to new ways of teaching? (pick one)
   - ○ Innovator: I adopt new teaching practices, even when they're so new that others consider them risky.
   - ○ Opinion Leader: I adopt new teaching practices after they've been proven but before many others are likely to have tried them out.
   - ○ Adopter: I adopt new teaching practices when they've been proven and the processes have been formalized into our way of teaching.
   - ○ Traditionalist: I adopt new teaching practices only when forced by circumstances or when there is no other choice

   Comment: ____

Directions

Please fill in the ratings that indicate the extent to which you agree with the following statements.

Item	Topic 1: _____					Topic 2: _____					Topic 3: _____				
	Strongly Disagree		No Opinion		Strongly Agree	Strongly Disagree		No Opinion		Strongly Agree	Strongly Disagree		No Opinion		Strongly Agree
2. I saw an instructional strategy that could benefit me as an instructor.	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
3. The instructional strategy I saw could benefit my students.	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○

4. Using the instructional strategy I saw would be worth the effort.	Strongly Disagree ○ ○ No Opinion ○ ○ Strongly Agree ○	Strongly Disagree ○ ○ No Opinion ○ ○ Strongly Agree ○	Strongly Disagree ○ ○ No Opinion ○ ○ Strongly Agree ○
5. The instructional strategy I saw is better than other possible alternatives for improving learning and instruction.	Strongly Disagree ○ ○ No Opinion ○ ○ Strongly Agree ○	Strongly Disagree ○ ○ No Opinion ○ ○ Strongly Agree ○	Strongly Disagree ○ ○ No Opinion ○ ○ Strongly Agree ○
6. The instructional strategy I saw is simple enough to try on my own.	Strongly Disagree ○ ○ No Opinion ○ ○ Strongly Agree ○	Strongly Disagree ○ ○ No Opinion ○ ○ Strongly Agree ○	Strongly Disagree ○ ○ No Opinion ○ ○ Strongly Agree ○
7. The instructional strategy I saw is compatible with other instruction I provide my students.	Strongly Disagree ○ ○ No Opinion ○ ○ Strongly Agree ○	Strongly Disagree ○ ○ No Opinion ○ ○ Strongly Agree ○	Strongly Disagree ○ ○ No Opinion ○ ○ Strongly Agree ○
8. The instructional strategy I saw is compatible with my department culture.	Strongly Disagree ○ ○ No Opinion ○ ○ Strongly Agree ○	Strongly Disagree ○ ○ No Opinion ○ ○ Strongly Agree ○	Strongly Disagree ○ ○ No Opinion ○ ○ Strongly Agree ○
9. The instructional strategy I saw is compatible with COEN culture.	Strongly Disagree ○ ○ No Opinion ○ ○ Strongly Agree ○	Strongly Disagree ○ ○ No Opinion ○ ○ Strongly Agree ○	Strongly Disagree ○ ○ No Opinion ○ ○ Strongly Agree ○
10. I can adapt the instructional strategy I saw to work with the instruction I provide.	Strongly Disagree ○ ○ No Opinion ○ ○ Strongly Agree ○	Strongly Disagree ○ ○ No Opinion ○ ○ Strongly Agree ○	Strongly Disagree ○ ○ No Opinion ○ ○ Strongly Agree ○

11. Is there anything else you'd like to tell us? (Feel free to use another page if you want.)