Insights into Systemically Transforming Teaching and Learning

Dr. Sam Spiegel, Colorado School of Mines

Dr. Spiegel is the Director of the Trefny Innovative Instruction Center at the Colorado School of Mines. He previously served as Chair of the Disciplinary Literacy in Science Team at the Institute for Learning (IFL) and Associate Director of Outreach and Development for the Swanson School of Engineering's Engineering Education Research Center at the University of Pittsburgh. Prior to joining the University of Pittsburgh, he was a science educator at Biological Sciences Curriculum Study (BSCS). Dr. Spiegel also served as Director of Research & Development for a multimedia development company and as founding Director of the Center for Integrating Research & Learning (CIRL) at the National High Magnetic Field Laboratory, Florida State University. Under Dr. Spiegel's leadership, the CIRL matured into a thriving Center recognized as one of the leading National Science Foundation Laboratories for activities to promote science, mathematics, and technology (STEM) education. While at Florida State University, Dr. Spiegel also directed an award winning teacher enhancement program for middle grades science teachers, entitled Science For Early Adolescence Teachers (Science FEAT).

His extensive background in science education includes experiences as both a middle school and high school science teacher, teaching science at elementary through graduate level, developing formative assessment instruments, teaching undergraduate and graduate courses in science and science education, working with high-risk youth in alternative education centers, working in science museums, designing and facilitating online courses, multimedia curriculum development, and leading and researching professional learning for educators. The Association for the Education of Teachers of Science (AETS) honored Dr. Spiegel for his efforts in teacher education with the Innovation in Teaching Science Teachers award (1997).

Dr. Spiegel's current efforts focus on educational reform and in the innovation of teaching and learning resources and practices.

Dr. Stephanie Ann Claussen, Colorado School of Mines

Stephanie Claussen's experience spans both engineering and education research. She obtained her B.S. in Electrical Engineering from the Massachusetts Institute of Technology in 2005. Her Ph.D. work at Stanford University focused on optoelectronics, and she continues that work in her position at the Colorado School of Mines, primarily with the involvement of undergraduate researchers. In her role as an Associate Teaching Professor, she is primarily tasked with the education of undergraduate engineers. In her courses, she employs active learning techniques and project-based learning. Her previous education research, also at Stanford, focused on the role of cultural capital in science education. Her current interests include engineering students' development of social responsibility and the impact of students' backgrounds in their formation as engineers.

Dr. Renee Falconer, Colorado School of Mines
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After completing a B.S. in Chemistry at the University of South Dakota, I studied laser micro-spectroscopy and X-ray microscopy at the University of California-Berkeley and Lawrence Berkeley National Lab, earning my PhD in Physical Chemistry. I rounded that out with a post-doc in Bioengineering at the Anschutz Medical Campus in Aurora, CO, where I found that my true passion was in explaining problem-solving skills and the workings of nature to those with varied interests. I joined the Teaching Faculty at the Colorado School of Mines in Golden, CO in 2012, where I teach and write new lecture and lab curriculum for General Chemistry, Physical Chemistry and Thermodynamics. There, I have been truly inspired by the bright and motivated students that fill our campus. Like many Coloradans, I enjoy as much hiking and camping in the beautiful Rocky Mountains as I can fit into my schedule, a little bit of skiing, as well as listening to and performing music.

**Insights into Systemically Transforming Teaching & Learning
at the Colorado School of Mines**

A work in progress

Introduction and Background

Universities and colleges are interesting systems in that their primary focus is education, and yet historically most faculty are not prepared as educators. While we are seeing some shifts in this trend, there exists significant need to help faculty become more proficient in educational research, theory and practice to improve student learning in higher education. Many institutions have been exploring ways to support and encourage faculty to try new approaches, to more effectively engage and advance student learning, and to innovate their own teaching practices.

Innovations in university-level teaching have sometimes occurred as heroic efforts by individuals who pioneer change, or as part of an externally funded research project. Recently, institutions have begun to create centers to support innovations systemically. This study looks at the early efforts of a new center established to systemically advance STEM teaching and learning at the Colorado School of Mines. The study is intended to both document the design and initial impact of the center, as well as share our lessons learned with other centers and institutions .

This paper begins with a brief description of the center's historical evolution, in order to provide rationale and insight into its design and theoretical framework, and how this informs our current efforts at the Trefny Innovative Instruction Center at the Colorado School of Mines.

Historical Context of the center

Nearly twenty years ago the Colorado School of Mines (Mines) envisioned a center that would support faculty in learning about, adopting, and implementing instructional innovations. Dr. John Trefny, the president of the university at the time, created an endowment to fund the center. At that time there was a small group of faculty who were very active in engineering education research. Some of those individuals took on the role to lead the center and organize resources. The faculty sought additional funding through grants and focused on projects that were of special interest to them. They had a small allocation of time to direct or support the center during the academic year as well as during the summer through grant funding.

These faculty members were dedicated and enthusiastic, and they developed educational resources, and published informative studies that influenced the wider field of engineering education. However, the center did not impact the university systemically, nor did the work become a strategic focus. The work of the center was the work of the individual faculty members. The structure of the center, the theory of action, and how it was situated within the university prevented the center from creating systemic changes. Over time, some faculty left the university, others retired, and the remainder focused on personal projects and were driven to follow funding sources. The strategic vision of the effort was lost, due in part to unintentional lack of institutional support.

Fifteen years later, facing the challenges of financial shifts, changing perspectives about universities, new competition from for-profit and online universities, and changes in student and parent expectations, Mines organized committees and began a formal strategic planning process. Through this process the faculty and staff agreed that there was a need for greater emphasis on teaching and learning. The plan identified four goals for the university. Explicit within three of

the four goals was a call for a center to provide the leadership and support to innovate instruction systemically.

Faculty were asked to submit proposals to begin efforts to meet the goals set forth in the strategic plan. Two proposals were accepted to begin to support instructional innovations. Two faculty were selected to serve as interim co-directors to begin to lay the foundation for the new center. Their efforts focused on identifying areas faculty would like improve regarding their teaching practices, as well as areas they would like to learn more about related to learning and teaching. The interim directors also set about learning what other universities were doing to advance teaching and learning. These efforts helped to inform the vision and structure for the new center.

In the winter of 2015, Mines began a search to hire a permanent director for the new center. This search led to the hiring of a director who brought to the university an understanding of STEM education, curriculum design, professional development, adult learning, and systemic reform. There was significant buy-in from faculty for both the creation of the center and the hiring of the director. It was decided that the center would be situated as a strategic extension of the Provost's office with the center director reporting directly to the Provost. This would help make possible the institutional support that earlier versions of the center were missing.

Simultaneously to the search and hiring of the center director, the university began a search for a new president. Dr. Paul Johnson came onboard four months after the center director, Dr. Sam Spiegel. Dr. Johnson is very focused on students, student success, and academics. His priorities and interactions with faculty have further strengthened the center's efforts.

Vision of the Center

The vision of the new center is that it should serve as a strategic extension of the Provost's Office, providing leadership, guidance, support and resources to systemically advance learning and teaching across the university. This is a significant charge that has broad implications on the focus and work of the center. To accomplish this, the center has established some boundaries and parameters. These are based on the theoretical framework we use as our theory of action. We present our framework below, which is derived from research on professional development, systemic reform and teacher education. The boundaries and parameters include the following:
- The work of the center will focus first and foremost on learning and teaching at the university. It will not focus on K-12 efforts or outreach efforts.
- Center faculty will not be directly involved in any faculty evaluation for promotion, tenure or performance evaluations. This is to ensure that the faculty know they can be open about their struggles and practices, without fear that it will negatively impact their evaluations.
- The work of the center is to be systemic and strategic at the university level. This has significant implications on evaluation and promotion of the center. The President, Provost and Center Director came to consensus that the impact of the center should not be distinguishable from that of the university. Since the center's work will be influencing, and will be influenced by, policies enacted at the university, staffing decisions, and enrollment trends, it would be challenging to have to argue which changes are a direct result of the center. Similarly, if the center is successful, then the university should be the

point of measure – more so than the center. This is not intended to take accountability away from the center, but to change what kinds of evidence and benchmarks will be used to evaluate center effectiveness. The later part of this paper will share some of the evidence of impact we have begun to gather.

- The center currently has a director, two part-time faculty members, and a handful of part-time engineering students to focus on the work and mission. We are currently involved in fundraising efforts to increase the center's capacity.
- The center will exist under the umbrella of the Provost's office to ensure university wide perspectives and impact, rather than in one particular College or Department.

These boundaries and parameters are intended to maintain the focus on systemic advancement. These also help the center prioritize the work to balance limited resources and staffing.

Theoretical Framework

The theory of action we are working from is articulated in our theoretical framework. The framework is derived from Dr. Spiegel's earlier work and is informed by researchers in professional development, systemic change, social reform, and engineering education.

We use the metaphor of acupressure to describe the work of the Trefny Innovative Instruction Center in simple terms. In acupressure, a skilled acupressure therapist will consider the body as a whole, assess needed changes, and then apply pressure to stimulate a series of reactions whereby the body's muscles do the work to facilitate the changes. Over time, the pressure and work of the muscles form patterns that become the norm for the body or system, leading to a sustained change. In our case, the center administers appropriate pressure through direct interactions with faculty and staff (initiated by center efforts or through faculty requests for support), learning opportunities designed and delivered by the Center, and the faculty, staff, administration and students are the muscles that work to facilitate the changes.

Stepping away from the metaphor, the framework that informs our work focuses on four settings and three lenses from which to consider each setting. The four settings are:
1. Faculty,
2. Class/Students,
3. Administrators, and
4. the University.

While the first three may be obvious, the forth is included not as an umbrella for the first three. The University is identified as a setting so that we explicitly consider the University as a whole, considering the institutional needs and strategic shifts. Considering the needs and shifts of the institution alongside those of faculty, students, and administrators provides a broader vision. It is the function of the center to apply pressure in all four settings to create systemic improvement in teaching and learning. Applying pressures at the University level sometimes requires engaging and participating stakeholders and policies outside of the institution. It also involves paying attention to the broader field to anticipate changes.

As we engage in the work of the center, we consider the work through three lenses: **Cognitive**, **Symbolic**, and **Organizational**. The importance of identifying the lenses is that it makes more explicit and intentional what we pay attention to and how we think and act in our work[1]. Each lens narrows our focus and filters our perceptions on important aspects core to our work. The cognitive lens is concerned with consciousness, thinking and behavior, which is essential to the work of teaching. The symbolic lens considers the meaning and interpretations that occur within and across the human interactions, which is essential for motivating educators to change some of their practices. The organizational lens helps us keep in mind what is necessary to manage change throughout the system. We most often use the cognitive psychology school of thought to inform our work, as the cognitive lens emphasizes the instructor's knowledge and beliefs[2]. Symbolic interaction represents the sociological perspective as it recognizes and highlights the interpretive process in establishing the socio-cultural context.[3] The organizational lens addresses the practical considerations of maintaining and implementing an organization or program. While each lens is significant in its own right, it is the interaction of the three that determines the success of a program.[4]
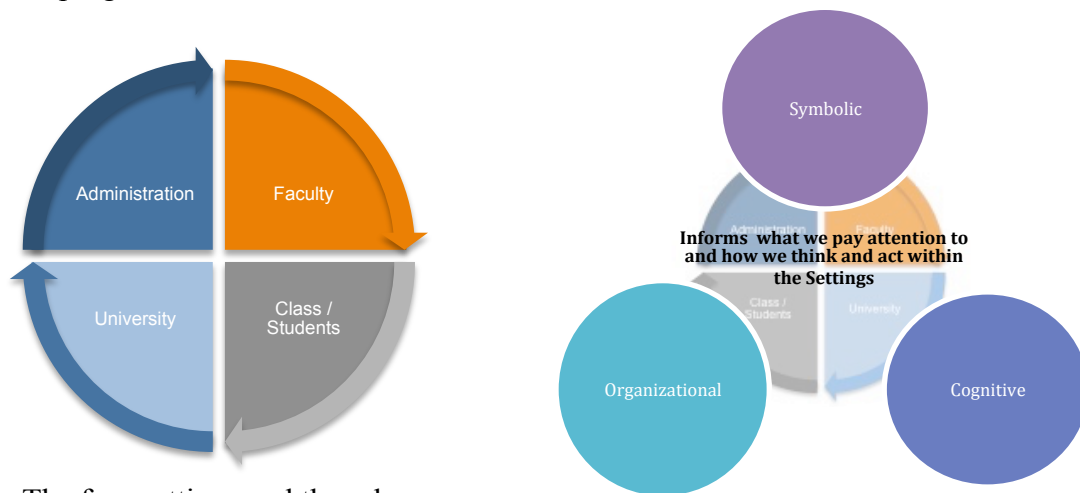

Figure 1. The four settings and three lenses.

Each lens influences what we focus on and what details we pay attention to in each of the settings that the center serves. Being explicit and intentional with the use of each lens helps us to consider the critical issues necessary to facilitate reform. Often a program will fail, not due to lack of effort, but rather because of limited focus or the lack of consideration of multiple lenses.[5] For instance, program staff may become so focused on organizational issues such as managing time, budget and resources that the symbolic lens is over looked. These programs are often described as uncaring, or business oriented. Table 1 outlines some illustrative examples of the kinds of questions each lens pushes us to consider in each of the settings.

The early work of the center (first four months) focused on understanding the four settings. To learn the culture of the groups and to develop initial relationships, the Director gained a sense of the landscape, identified areas of need, and obtained a sense of the university focus and strategic vision. The Director spent time meeting with administrators, faculty, staff and students. He taught a section of our freshman success course to gain further insights into the students' experiences at the institution. Some of these efforts are highlighted in figure 2.
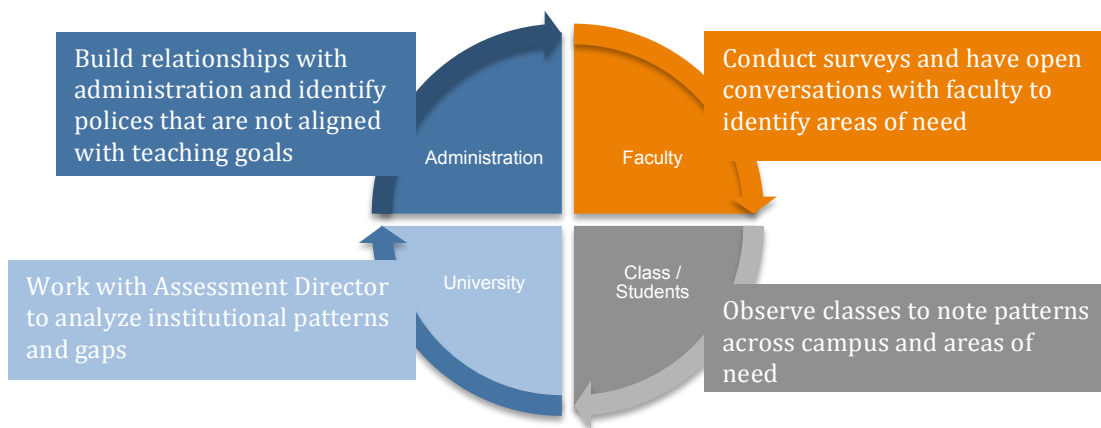
Figure 2. Initial focus on the four settings

The next stage of the center development focused on working intensely with a group of interested faculty members. The intent was to begin to seed the work of the center, to build the trust and confidence (symbolic lens) of faculty and administration, to build capacity (cognitive lens) in consistent understanding and use of language related to teaching and learning with a core group of faculty, and to develop resources and supports (organizational lens) to accomplish the work of the center. The following two cases briefly provide a vision of the type of work underway and some insight into how we went about the efforts.

Illustrative Cases

To further illustrate the framework and to explore initial efforts and impact of the center, we present two cases. The cases present two of the Center's efforts to apply acupressure on teaching practices across two STEM disciplines (electrical engineering and chemistry). In each case the center faculty began working with faculty who were interested in increasing student engagement and improving student end-of-course success. The work presented here occurred during a six-month period.

In each case we documented a general description of how the course was previously taught, what were identified needs or areas of concern warranting change in the course, how we worked through the course re-design, and what changes were planned and implemented. In Chemistry, the course has multiple sections, so we were able to utilize a quasi-experimental design[6] to explore the impact.

Within this study, we focus on innovations around three target areas:
1. Course design to create a conceptually coherent and rigorous instructional sequence[7]
2. Creating shifts in classroom and university culture towards an efforts-based learner[8]
3. Active learning approaches that engage students in cognitive wrestling around key concepts[9]

Table 1. Illustrative examples of how each lens orients thinking and actions across each setting.

	Cognitive	Symbolic	Organizational
Faculty	How will this experience enhance the instructor's understanding of teaching and learning?	What will be the meaning or significance of this experience to the faculty member?	How much time will be required for the faculty member to thoughtfully complete the work?
	What type of educational support will the instructor need to think differently about their teaching?	How might participating in this experience change the image of the faculty to others?	What resources (e.g., space, materials) might the faculty member need to facilitate the changes planned?
Class / Students	Will this experience lead to an enhancement of the student's learning?	How will students interpret the instructional changes (i.e., valuable, frustrating, etc.)?	Will students have sufficient time and access to materials to complete new assignments?
	How might this experience change the students' understandings and abilities in their professional practices?	How can we help students perceive active learning as valuable rather than as seeing it as faculty are "not teaching"?	What resources might be needed in the classroom to support the instructional changes (e.g., equipment, Wi-Fi, power outlets, etc.)?
Administrators	What will administrators need to know and understand about the effort to be able to support faculty?	What messages do administrators send about the value of innovative teaching?	How much time will administrators need to support the instructional changes (i.e., observing and providing feedback to faculty, mentoring, etc.)?
	What educational experiences should be developed to enhance administrators understandings about teaching and learning?	What experiences should be provided so that administrators perceive the program as valuable and important to support?	How much funding will different departments need to support instructional changes?
University	Does this experience complement understandings from other experiences in the system?	Will the experience add to the perceived rigor and coherence of the program across the university?	How much funding will be required for all the efforts? What models might balance financial costs with significant benefits?
	What will this experience allow the group to do (skills and understandings) that group members could not do before?	Will the experiences fit within the culture of the university or be positive disruptive events to shift the culture in desired directions?	How might changes in practices require changes in infrastructure (e.g., classroom layouts or space, registration logistics, etc.)?

Case 1: Electrical Engineering EENG 386

EENG 386, "Fundamentals of Engineering Electromagnetics," is a required core undergraduate electrical engineering (EE) course. Enrollment is typically 40-60 students, with mostly juniors taking the course. The course provides an introduction to electromagnetic theory as applied to electrical engineering problems in areas such as wireless communications, transmission lines, and optics. It relies on foundational knowledge in vector calculus and introductory physics. Undergraduate Electrical Engineering students typically view Engineering Electromagnetism as a challenging course with abstract concepts that are difficult to visualize and apply to physical problems.

Since the spring of 2013, EENG 386 was taught in a mixed application mode. Course time was used for a combination of short lectures and small group work. In-class assignments were short, typically consisting of students discussing difficult concepts with those around them or beginning to solve snippets of problems. In an attempt to make the applications of the course obvious to the students, each class began with a student presenting for two minutes on an application of electromagnetism that corresponded to the current course topics. Course assessment was largely traditional: weekly homework assignments, midterm and final exams, and a final project. The final project required students to propose an electromagnetics-related problem they would like to explore computationally, develop a computational model for their problem using MATLAB or a similar software package, and present their results in the form of a scientific journal paper. Example problems included finding a way to reduce lossy reflections off solar cells and determining the maximum distance a railgun can launch a projectile.

The professor perceived a few problems in this previous version of EENG 386. Students would frequently clamor to see more example problems and applications during class time. While a clear attempt was made to devote time to these aspects of the course, it was difficult to do in a meaningful way while also introducing new content and answering initial questions. Second, students' retention of the material was questionable. Though no concerted effort was carried out to track students after they completed the course and progressed to upper-level courses, anecdotal evidence by the instructor seemed to point to retention being an issue, despite an emphasis on conceptual understanding. Finally, the computational final project proved to be a huge challenge to the students. The main difficulty lay not with the MATLAB programming or the technical writing, but rather with the modeling. Students had an incredibly difficult time applying the concepts and practices studied in eth course. For instance, one application problem students struggled with asked them to use the magnetic properties of a current-carrying wire to explain how a maglev train works and then taking it a step further to determine which parameters (the magnitude of the electrical current, mass and size of the train) would impact the performance of the train.

To address these issues, EENG 386 was redesigned in the summer of 2015, and the new version is currently being taught for the first time as this paper is being written. To begin, center faculty met with the instructor to better understand the instructors perspectives on the course and to co-analyze course data. We approached the opportunity to work wit this faculty member using the lenses to focus our efforts: [cognitive lens] to understand where the faculty member stood in terms of pedagogical practices and understandings; [symbolic lens] we took the time to build

trust with the faculty member; and [organizational lens] we worked with the faculty member during times that fit their schedule best and utilizing existing resources. As we, the center faculty and the faculty member, gained a richer understanding of the course we worked to more clearly identify the learning outcomes. We did this through a collaborative concept mapping process [cognitive and symbolic lenses]. In the process we considered not only the course, but also the students progression (previous courses and next level courses) [class/student setting]. We also discussed how to situate the changes so that administration [administrators setting] was aware of the changes and we could share the shifts with other faculty in the sequence and in the broader university setting. The new learning outcomes are listed in Table 2. Together, we explored the intended outcomes and considered the organizational structure of the course [organizational lens] – how much time was available and how that time was being allocated to achieve the goals. Other organizational questions considered the organization of resources and assessments.

Table 2. New Learning Outcomes for EENG 386

By the end of the course, you will be able to:
1. Solve electromagnetic problems through both pencil-and-paper solutions (for the simpler problems) and computer simulations (for the more complex ones).
2. Explain, in words, a range of electromagnetic phenomena, such as how an electromagnetic wave propagates and what happens to an EM wave at the interface between two materials.
3. Identify applications of electromagnetics in your daily life and your work as an engineer, and employ EM concepts and terminology to explain how these technologies work.
4. Complete basic design problems on topics such as EM wave propagation on transmission lines and simple dipole antennas.
5. Propose, model using computational tools, and communicate your solution to a significant electromagnetics problem.

A concept map was created for the course content, to optimize the order and presentation of topics, and to identify which were foundational to the remainder of the course. The concept map also helped us to create a more conceptually coherent instructional sequence.

We considered cognitive questions [cognitive lens] to identify what knowledge and skills students were anticipated to bring with them to the course and what knowledge and skills were expected for next sequence of courses. To make room for a more in-depth look at important content and further development of engineering skills, the concept map helped identify which concepts could be removed from the course or re-sequenced. A new class schedule was made, and objectives were written for every day of the course.

To enable the meeting of those objectives and to push for more active learning and efforts-based approaches[7], in-class time was redesigned. The course was flipped, so that content delivery would take place before the students step into the classroom, in the format of daily assigned readings. Each reading is accompanied by a Guided Understanding and In-Depth Exploration (GUIDE) assignment, which includes questions to assist the students in targeting what is most important in each reading. The GUIDE assignments also sometimes contain a problem to practice what was introduced in the previous section or in earlier courses.

The syllabus was also reworded to more clearly define the professor's expectations of student active engagement [cognitive lens], provide clearer guidance as to how time would be organized [organization lens], as well as shifting wording so that the syllabi represented the instructor's vision of the course [symbolic lens] and intended class culture. We further explored symbolic interactions in the instructor's approach to orient students to the course and task. The instructor had some concerns that students might be resistant to taking on more active learning roles.

In-class time is now used to work on the hard stuff: solving problems, wrestling with challenging concepts, applying difficult content, and developing engineering skills like model-building and working in teams. To scaffold the students' modeling skills and to make applications of the course material apparent, the course is split into five units, each of which is centered on a single application. For example, in the first unit students learn about electronic ink (e-Ink), the technology used in the display of an Amazon kindle. Throughout the unit, students practice estimating the voltage required to switch a capsule of e-Ink from black to white and the total charge contained in one capsule.

Finally, the course assessments have been changed to be more in line with the course objectives. There are more frequent but lower-stake exams, each of which tests problem-solving skills, the ability to explain a challenging concept, and model-building. Though there is still a final exam, the final project is now emphasized as the primary summative assessment. These are more consistent with the intended outcomes and in alignment with the course sequencing and university culture.

The course is underway and we are collecting artifacts from the class to assess student outcomes. The assessment will consider measures against the new outcomes and, where appropriate, will measure against past class assignments and assessments.

Case 2: Chemistry CHGN 121

Chemistry 121 has been a taught as a traditional lecture course. Typical enrollment in the fall semester is about 800 students, comprised of mostly freshman. The content follows the topic list of a standard chemistry textbook. Each lecture section enrolls approximately 250 students in a large amphitheater. There is limited student–to-student interaction during class time. Clickers, or student response devices, have been used in a limited capacity by some of the instructors. While student pass rates are consistent with other courses and institutions, student overall satisfaction with the course, and more significantly perceived value of the course [symbolic lens] is lower than faculty would like. Additionally, faculty were interested in increasing student excitement about the field and to increase higher order learning outcomes [cognitive lens].

The center began working with two faculty members as they were starting to re-envision the course. In this instance, the role of the center faculty was to slow down the Chemistry faculty members in order to push them to be a little more explicit in their intensions and design. We were also able to develop a quasi-experimental approach to the changes so that we could assess the impact. We were able to assign two faculty to teach the revised sections, and have one faculty member teach the other sections. All the instructors used common exams and homework

assignments. The course instructors had been using a pre-assessment at the start of the course for a few years, so we have several years' worth of baseline data. The final exam used similar items to previous semesters for comparison on key ideas. Students were randomly assigned to sections to avoid bias in any of the groups. Students were required to also enroll in chemistry laboratory classes. The laboratory sections were not yet revised during this study period. Student scores are being examined in all sections and across the laboratory sections.

The symbolic lens was a significant area of concern for the reform of this course. Both student and faculty perceptions of the course were constantly considered through the course redesign. Cognitively, we explored ways to ensure that no harm was being created by the changes, while also considering how to help students advance to deeper understandings and to be more actively engaged as learners. Through the organizational lens we considered how to manage the shift from 250 student sections to an experimental section of 50 students. This required coordination with administrators to coordinate room shifts, registration shifts, and slightly more flexible accounting for faculty loads.

Like with EENG 386, we spent considerable time redefining and clarifying the learning goals. The learning goals did not change dramatically in terms of scope from the previous course offerings, but became more explicit about what was intended. This was important at several levels. First, as a core course that has transfer agreements with multiple institutions, it was important that we kept the same goals. We could add to or refine, but not remove significant goals that were agreed upon with other institutions. Secondly, the other sections mapped to the same content and goals, since we agreed to use common assessments. The learning goals were constantly used as a reference point when considering activities and assessments.

The instructors designed active tasks for each class session, moving from a mostly passive course to one where students spend about three-quarters of the class time actively engaged in instructional tasks. Student feedback was regularly collected and used to inform further refinement to the course. Student feedback was analyzed considering the cognitive and symbolic lens. For instance, how groups are formed was a point of concern by many students. The instructors tried a few different grouping strategies to see which ones worked best (students perceptions of the group interactions [symbolic lens] and performance on assessments [cognitive lens]) with the group dynamics [class/students setting] and with the university culture [university setting].

Preliminary data indicates that the new sections are significantly improving student learning. Interestingly, students in the active learning course not only did better in the common lecture assessments, but they performed slightly better in the laboratory course. This helped to address an initial concern expressed by some faculty that students would not get enough content in the active learning course, and therefore, would not do as well in the laboratories and common assessments.

The challenge we now face with this particular course is situated in the organizational and symbolic lenses at the university and administrator settings. We are experimenting with the design such that the active learning could be facilitated with class sizes up to 100 students. However, the traditional lecture holds 250 students. The shift we are proposing will require

different staffing models and classroom space. Making this shift department-wide may require a slower implementation pace than the faculty prefer, but the University setting needs to be able to realistically facilitate and sustain the changes which we expect to take a few semesters to complete.

Discussion

In these two illustrative cases we highlight some of the procedural and focal points of Trefny Center's work with individual faculty. In the meantime, we are working to create shifts across all four settings as illustrated in Table 2.

The general steps we typically follow are:
1) Clarify learning outcomes. Either confirm agreed upon outcomes already in existence, or fine-tune outcomes through concept-mapping, and consider eliminating overages.
2) Change assessment practices to better align what is being assessed to the course learning outcomes, and to create more opportunities to demonstrate understanding and competency.
3) Determine content that can or should be delivered outside of class meeting time.
4) Determine active learning activities that can take place during course meetings in support of students working toward the learning outcomes.
5) Engage in task design for course meetings.
6) Revise syllabus and course calendar, as necessary.

We also conduct intentional learning with groups of faculty (e.g., a department focusing on reforming their programs or core courses, new faculty during orientation, and so forth). We build from the symbolic lens by establishing and maintaining a relationship of trust. Considerable thought and effort goes into building trust by being honest, following through with details and tasks, being supportive, and keeping the focus on student learning. We have a systemic vision that is consistent with the mission of the university: the work of the center is not to promote the director or the center; rather it is to advance the faculty and university. We are able to keep this focus due to organizational commitment and support.

We encourage and guide faculty to be reflective practitioners, taking a stance as a learner. Our approach is to create some level of cognitive dissonance around teaching and learning, and make it relevant to instructors' individual practices. This may be facilitated through a genuine learning experience, through analysis of student data or artifacts, or through a probing conversation reflecting on a course, student learning, or their practices. Creating a level of cognitive dissonance through a disruptive routine or analysis leads to changes in instructors' practices and beliefs.[10] Faculty need time to reflect and respond following the disruptive routine and then guidance to move forward in a productive manner.

Table 3. Shifting emphasis in teaching and learning at Mines.

CHANGING EMPHASIS		Main Settings & Lenses				
Less Emphasis on	**More Emphasis on**	Faculty	Student	Admin.	University	C=Cognitive S =Symbolic O = Org.
Viewing course as "lecture' or "laboratory"	Thinking about courses as learning opportunities that fit within a sequence (from the learners perspective)	X	X	X	X	S, O
Discrete, isolated lessons, units, modules, and/or courses	Coherent learning progressions and conceptual story lines within and across a degree program	X	X	X	X	C, S, O
Focus on information and computation	Focus on concepts and application in professional contexts along with scientific and engineering practices through investigations, reading, writing, and talking	X	X			C, S
Driven by textbook or topics	Driven by clearly defined learning outcomes in consideration of course sequence, learners and context	X	X		X	C, S, O
Faculty as instructors	Faculty as designers of learning experiences and opportunities	X	X	X	X	C, S, O
Instructor as "edu-tainer" (educator & entertainer)	Instructor as mentor, apprenticing novices in their field/discipline	X	X	X	X	C, S, O
Treating all students alike and responding to the group as a whole	Understanding and responding to individual student's current understandings and skills, strengths, experiences, and needs	X	X	X		C, O
Working alone in planning and assessing	Working with collaboratively and openly with other faculty to enhance learning	X			X	C, S, O
Assessing what is easily measured	Assessing what is most highly valued	X	X	X	X	C, S, O
Testing students for factual information at the end of the unit or chapter	Students engaged in ongoing assessment of their work and that of others	X	X	X	X	C, S, O
Evaluate recall, recognition, or computation	Evaluate mastery of knowledge and professional practices	X	X		X	C, S, O
Students as passive receivers of information	Students empowered and held accountable for their own learning	X	X	X	X	C, S, O
Students working mostly individually	Students working in small groups, sharing ideas, pushing each others' thinking, and applying their learning – instructor as guide	X	X	X	X	C, S, O
Students doing the complex work out-of-class as homework	Students reading, gathering and learning information during out-of-class time, and tackling complexity during class meetings with both peer and instructor support and feedback	X	X		X	C, S, O

Administrators are engaged to ensure that the work is both supported and consistent with the strategic vision of the university. The engagement includes developing learning opportunities, meeting periodically to discuss teaching and learning, observing classes together, co-facilitating conversations with faculty around teaching and learning issues, and joining in together on strategic planning for the center.

Organizational theory tells us that interdependence of people is what defines an organization.[11] It also tells us that people see priorities both from what is articulated and where the money or resources are allocated. Our university has asserted that advancing teaching and learning experiences for students is an institutional priority. Providing time, resources, and support to faculty so they can thoughtfully work to enhance their courses reinforces this priority. Using the organizational lens to think about the university priorities, needs of faculty and students, and how administration can lead the effort has helped in the evolution of the Trefny Innovative Instruction Center.

The work of the center is further refined through the cognitive lenses. We surveyed faculty (62% responded) regarding their understandings and perceived needs related to active learning and course design. We further explored faculty understandings through interviews and responses to questionnaires that faculty submitted to participate in the program. This information is being used to design the learning outcomes for faculty workshops, learning modules, and professional learning offerings for faculty.

From a symbolic perspective, we are working to ensure that across the system participation with the center is viewed as a benefit. We work hard to build the community sense that teaching and learning (faculty as learners) is prestigious and of value.

Returning to the acupressure metaphor, we will continue to apply pressure to empower the body to change and align itself. Keeping an eye on the four settings through the three lenses causes us to be thoughtful in our practices and to inform the work of others. We will continue to collect data on these courses and additional work underway. Student outcome data and classroom observational data is being generated and collected to document changes within individual classes as well as patterns across the university.

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