

Cross-disciplinary Collaboration Between
Two Science Disciplines at a Community College

by

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ABSTRACT

Health science students like students in many disciplines exhibit difficulty with transferring content from one course to another. For example, the problem explored in this study occurred when overlapping concepts were presented in introductory biology and chemistry courses, but students could not transfer the concepts to the other disciplinary course.

In this mixed method action research study, the author served as facilitator/leader of a group of colleagues tasked with investigating and taking steps to resolve this student learning transfer problem. This study outlines the details of how an interdisciplinary community of practice (CoP) formed between chemistry and biology faculty members at a community college to address the problem and the benefits resulting from the CoP.

Quantitative and qualitative data were obtained from transcripts of meetings of the faculty members, notes from other formal and informal meetings, classroom visits, a questionnaire containing Likert and open-ended items and interviews. Transcripts, notes, and interviews were coded to determine common themes.

Findings suggested the CoP was an effective means to deal with the matter of student transfer of content across courses. In particular, the CoP agreed to use similar terminology, created materials to be used consistently across the courses, and explored other transfer specific approaches that allowed for transfer of course content. Finally, the benefits of the CoP were due in large part to the collaboration that took place among participants.

DEDICATION

I dedicate my work to my husband, Jonathan. His love and support stabilized me during my trek into educational leadership and research.

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Chapter 1 Introduction and Purpose of Study

The pervasive and increasing shortage of registered nurses in the United States has prompted a dramatic increase of nursing programs to meet the demand for nurses (Rosseter, 2009). This results in increased demand for the prerequisite courses needed by students pursuing a career in nursing. Estrella Mountain Community College (EMCC) in Avondale, Arizona has experienced a significant increase in enrollment for prerequisite courses in science that support students on the path to nursing (EMCC web page). This increased demand has been especially acute since the establishment in spring 2007 and subsequent expansion of a nursing program at EMCC. In addition, the recent economic downturn has spurred an interest in pursuing marketable careers, of which nursing is one.

The increase in enrollment has prompted hiring new faculty. Presently, there are three full-time chemistry instructors and three full-time biology instructors teaching the introductory courses required for students pursuing jobs in the field of Allied Health. The two courses, BIO 181 and CHM 130, will be referred to as complementary courses in the remainder of this text. The students need both of these courses for pre-nursing, pre-pharmacy, pre-medicine and other pre-professional tracks in the health care field. Students can take them in any order; neither has a pre-requisite course although chemistry is recommended for BIO 181.

The researcher of this project taught BIO 181 when this project started to take shape. The researcher has since then become division chair of Science and senior faculty member of the group of instructors who teach the complementary

courses. The close proximity of our offices to one another facilitates sharing of instructional methods, ideas and procedures. These interactions are usually elicited by frustrations with student learning issues which are reflected in low student success rates for both courses. We constantly share insights or perspectives with one another in groups of two or three in an attempt to find solutions but we had not previously addressed student learning problems formally as a group.

In spring 2007, chemistry faculty adopted a new pedagogy, modeling to help improve student success. The new pedagogy emphasizes developing students' conceptual understanding as opposed to focusing on abstract formulas, equations and reactions. Biology faculty members wanted to determine whether this pedagogy could be applied to BIO 181. In fall 2008, I spent time observing modeling in one of the CHM 130 courses. One of the students in the course had taken my BIO 181 the previous semester. As he worked on problems concerning energy, I was surprised that he was struggling because I remembered him as a strong student who had mastered energy concepts in biology. I realized he did not make connections to his previous learning. I shared this with my colleagues and each professed amazement that students do not appear to transfer learning between courses. We agreed to meet to discuss the inability of students to connect knowledge across courses and disciplines.

Our first meeting led to discussions of content and to identify overlapping concepts between the complementary courses. As these areas were identified, biology faculty members explained to chemistry faculty members why intra-

molecular bonds, for example, were presented in a specific manner and the chemistry faculty countered with equally interesting insights about the same concept. We became aware of a lack of cohesion between the courses for certain concepts and hypothesized that this may be why a “disconnect” occurs for students. To address the disconnect we decided some common concepts could be presented using identical terminology or approaches to learning. For other concepts instructors could alert students to differences in presentation of the concept in the complementary course and provide a glimpse of the other learning perspective.

This initial meeting provided me with the realization that our group had approached a student learning problem from a very unique and innovative perspective. As explained below, the traditions and culture of post-secondary instruction are not conducive to collaboration within disciplines let alone across disciplines. Utilizing this approach and documenting changes in instruction and instructor behavior became the basis of the action research project carried out in fall 2010. The research provided a picture of the operations of cross-discipline collaboration in the context of a community college. It is hoped this method will be incorporated into the science division at EMCC as a standard operating procedure and later found to have a positive impact on student learning.

Chapter 2 Review of the Related Literature

Three areas of theory and research guide the proposed action research project: the research work on interdisciplinary and collaborative methods in higher education, the theoretical framework on Communities of Practice (CoP) established by Wenger and his colleagues (Wenger, 1998; Wenger, McDermott, & Snyder, 2002), and the theoretical work and research on transfer of learning exemplified in the work of Haskell (2001) and Leberman, McDonald, and Doyle (2006). In the following three sections, each of those frameworks or areas of research is described. The fourth section is a review of data collection methods utilized in various descriptive studies. This provided the researcher with the knowledge of instruments and methods to appropriately gather and analyze qualitative data.

Interdisciplinary Methods in Higher Education

Interdisciplinary approaches to higher-level science instruction have been and continue to be strongly recommended by educational and governmental organizations that recognize commonalities between disciplines, particularly chemistry and biology as described below (Moore, 2002):

With such large numbers of biology students in our undergraduate courses, one might expect that the myriad connections between chemistry and biology would be emphasized, but often they are not. A recent report from the National Research Council (NRC) indicates that these connections are not emphasized in biology courses either. To ameliorate

this situation, chemistry teachers and biology teachers will need to communicate and collaborate. (p. 1287)

In addition to strengthening connections between science courses for students, this type of collaboration provides informal professional development for instructors as they work to align content. Unfortunately, interdisciplinary collaborations are not the norm for instructors in post-secondary institutions. Traditional methods of individual lecturers teaching in isolation persist even when the instructors teach about collaborative teaching techniques (Jones & Morin, 2000). A review of the literature concerning interdisciplinary instructional methodologies in college and university settings reveals a paucity of information especially with respect to interdisciplinary efforts in science disciplines.

Horn, Stoller, and Robinson (2008) documented and reviewed nine English language teaching collaborative case studies; three of which occurred at a post-secondary level. The objective of the article was to determine best practices in establishing interdisciplinary collaborations in education. The following best practices were derived from the case studies: (a) novel and effective solutions were developed by crossing traditional boundaries and collaborating outside a discipline, (b) small manageable tasks and activities were carried out rather than planning many tasks or complicated methods, (c) materials already developed were utilized, and (d) one or two people stabilized and focused the group. These best practices were used to inform and support the study.

In addition, Horn et al. (2008) concluded interactions among faculty members provided unique professional development for instructors and improved learning

experiences for students. This perspective is echoed by national education organizations, committees and councils who strongly recommend interdisciplinary instructional approaches to improve undergraduate education in the sciences (Moore, 2002; National Research Council, 2003).

Unfortunately, this level of collaboration will require a major change in science instruction paradigms and may prove to be difficult to accomplish according to Moore (2002) who states, “Cross-disciplinary teaching is something that neither chemists nor biologists can do alone, and it is perhaps the most difficult aspect of improving undergraduate education in the sciences” (p. 1287). A review of the literature reveals instructors in the area of language have embraced this interdisciplinary approach as they wisely look for ways to apply their content to real life contexts. Horn et al. (2008) list 18 collaborative efforts involving English and math, engineering, history, and sociology to name a few. However, there are very few collaborative efforts in education which paired a science discipline with another discipline at the post secondary level. They include an anthropology instructor working with administrative staff at a nursing facility (Pearsall & Kern, 1967), biochemists working with business faculty in upper level undergraduate courses (Keller & Cox, 2004) and philosophy instructors working with physicists (Jordan, 1989). Unfortunately, these studies do not lend themselves as models for interdisciplinary methods applied to introductory college level science courses.

Among the reasons there has been so little collaboration among science instructors are the isolationist-type practices modeled for them in both research

and instructional training, as described previously in the introduction of this proposal. To facilitate participation in collaborative efforts, it will be necessary to construct an environment and procedures, which are enticing to instructors. It is likely they will be motivated to work together if they feel strongly about the project and if their opinions or viewpoints are valued among the group. Providing time for faculty to relate to one another and realize their peers are experiencing similar problems and circumstances also strengthens the group. Clearly, a top down autocratic approach will not elicit support or commitment from faculty. It will be necessary to shape the intervention around a different model.

Communities of practice (CoPs) serve as an excellent model for collaborative endeavors aligned with the criteria outlined above. Several key components of a CoP will be used to frame the operations of the group. CoP are elaborated in the following section.

Communities of Practice

Many educational studies document the use of collaborative processes by educators to address and resolve learning or other related issues (Goodnough, 2008; Horn et al., 2008; Pearsall & Kern, 1967; Perry & Stewart, 2005). A common feature of these groups is that the members experience an issue or problem and participate in the group to resolve it. This ensures the outcomes are feasible and effective because the end users develop the processes and tools to solve the problem.

Communities of practice are one example of this type of professional group. A CoP is characterized by three fundamental elements: (a) domain, (b)

community and (c) practice (Wenger et al., 2002, p. 45-46). A CoP has an identity defined by a shared domain of interest to which the members are committed. Community refers to the collection of individuals interacting and having shared experiences involved in the domain. Practice refers to the members experiencing the domain as they carry out their job, duties or activities.

The domain binds the group together and provides legitimacy to actions and outcomes of the group. It must be a common interest or individuals will not be motivated to participate (Wenger et al., 2002). Domains are not necessarily jobs or tasks but may arise because certain jobs or tasks need to be completed. In education as teachers maneuver to develop optimal learning opportunities, many related problems arise along the way requiring adjustments to methods and strategies of teaching or dealing with students. In this way, domains can be moving targets depending on contexts, conditions and logistical features of a CoP.

The community shares the domain and interacts regularly to address issues pertinent to the domain and the CoP itself. The regular interaction, however, is a natural outcome of the professional group because the group coalesces in an informal fashion. The leader or facilitator is a member of the group (Wenger et al., 2002) and is not necessarily appointed, but may serve in this capacity to address logical or logistical circumstances to best support the group. The designation of a domain-sharing peer facilitator eliminates the authoritarian approach and produces a more inviting group setting. The efforts

of the group are driven by the group as the CoP negotiates meaning. Wenger (1998, p. 53) artfully describes negotiation of meaning as “a flavor of continuous interaction, of gradual achievement, and of give-and-take.” As a result, the members are highly motivated to share, learn and resolve problems. Members are actively engaged in the context of the problem and participate in opportunities to share and work with their peer community.

CoP members are practitioners; they work in their areas performing tasks and procedures to support a process, produce a product or achieve a goal. As members function in the CoP and develop tools, materials or share knowledge they are also carrying out a practice of functioning as a professional group. Although, this practice may or may not resolve an issue or concern, it, nevertheless, provides a type of informal professional development for the members. Individuals bring a variety of view points, expertise and education to the CoP. Discussions evolve and track in a manner to support the needs of the participants; sharing of ideas, viewpoints and even contentions result in rich learning experiences for all participants (Wenger, 1998).

Utilizing the CoP construct to support collaboration among college instructors works well for the dynamics at this level of education. Flexibility in scheduling meetings is important due to the teaching schedules of a handful of faculty; finding blocks of time to meet can be challenging. Because the members drive the operations of the group and we are located close to each other we are able to respond to more impromptu meetings. The informal setting facilitates interaction and exchange leading to an increase in knowledge and

awareness for each participant. Although sustainability of the group is not assured, it is more likely to continue if it is problem focused and if the facilitator is a member of the CoP.

Transfer of Learning

In addition to the constructs associated with the CoP, literature concerning transfer of learning is important to the action research project. As previously explained, a CoP will not function unless it has a domain. For this action research project the shared problem spanning the introductory science courses is student inability to transfer ideas or knowledge from one course to another. Generally, transfer of learning (also referred to as transfer) is viewed as learning in one context that is applied to another learning experience and influences how the person learns in the new setting (Haskell, 2001; Leberman et al., 2006; McKeough, Lupart & Marini, 1995; Perkins & Solomon, 1988).

McKeough et al. (1995) appropriately assert that the ultimate goal of education and teaching is transfer of learning, however, teaching for transfer has been challenging. With respect to the challenge associated with transfer, McKeough et al. (1995, p. vii) aptly state, "Researchers have been more successful in showing how people fail to transfer learning than they have been in producing it, and teacher and employers alike bemoan students' inability to use what they have learned." Leberman et al. (2006) echo this sentiment indicating the multi-factorial nature of transfer has elicited contention and discord for the 100 years since it was recognized and identified as an important component of teaching and learning. To make the issue of transfer more amenable to study and

classroom implementation, McKeough et al. (1995, p. vii) suggested letting go of precisely identifying transfer and shifting the focus to knowledge generalization when they state, "Learning generalizes and transfer is not under our control." Thus, McKeough and her colleagues re-define transfer as degrees of knowledge generalization and indicate this should be the instructional focus.

Taking a slightly different approach, Dr. Robert Haskell (2001) indicates transfer of learning can be described and be made concrete by a complex schema defining levels, kinds and types of transfer, which he has fashioned. He developed the schema as a result of extensive review of 99 years of literature concerning transfer and his own experiences as an instructor of psychology and as a cognitive psychologist. As a result of his work, Haskell developed eleven instructional principles designed to help an instructor teach for transfer. These principles are enumerated as follows (Haskell, 2001, p. 45):

1. Learners need to acquire a large primary knowledge base or high level of expertise in the area that transfer is required.
2. Some level of knowledge base in subjects outside the primary area is necessary for significant transfer.
3. An understanding of the history of the transfer area(s) is vital.
4. Motivation, or more specifically, a "spirit of transfer," is a primary prerequisite for transfer to occur.
5. Learners need to understand what transfer is and how it works.

6. An orientation to think and encode our learning in transfer terms is necessary, for significant transfer doesn't happen automatically.
7. Cultures of transfer need to be created.
8. An understanding of the theory underlying the transfer area is crucial.
9. Hours of practice and drill are requisite.
10. Significant transfer requires time to incubate; it tends not to occur instantaneously.
11. Finally and most importantly, learners must observe and read the works of people who are exemplars and masters of transfer thinking.

A common theme for several of the above principles focuses on directing learners to thinking about transfer or to creating an environment emphasizing transfer. This theme was derived from commonalities experienced and observed by Haskell concerning the context of learning and how "... what is learned in everyday, instructional, and workplace settings tends to stay welded to those settings" (Haskell, 2001, p. xvii). Haskell concludes a "disconnect" between learning and transfer exists across all conceptual models of transfer currently proposed. Specifically, he suggests the *welding* of knowledge to a specific context in which it is learned remains unaddressed by the models of transfer.

A universal theme recurring throughout the literature on transfer and education in general is preparing students or workers for the classroom or workplace with an emphasis on the ability to transfer previous knowledge and skills (Haskell, 2001; Leberman et al., 2006; McKeough et al., 1995). The ultimate goal of all educators is to provide students with information and skills,

which support their educational and career paths. The CoP at EMCC continues to develop and investigate pedagogical methods to support students in this manner as they pursue careers in Allied Health and other professional positions.

Consistent with the literature on transfer, three of the transfer principles were used to guide the CoP discussions about transfer. These principles were numbers one, seven and nine. As students move between the two science courses we hope they will acquire a large knowledge base and expertise in the area by capitalizing on learning opportunities as part of their educational experiences. Developing transfer support systems and creating cultures of transfer were underlying constructs addressed during the CoP meetings and essential points of discussion as the CoP considered changes in instructional methods to foster transfer.

Review of the Methodological Literature

To determine if the researcher aligned appropriate tools and instruments to gather data about how the CoP functions, a review of literature pertaining to studies of CoP and team teaching at the post-secondary level was conducted. The research in these studies focused on how the collaborating groups functioned. Not surprisingly, these studies indicate the use of primarily qualitative methods for data collection and analysis. The methods were interviews, videotaping of instruction, surveys, focus groups and transcripts of meetings, workshops and classroom observations. These methods provide data rich in details enabling the researcher to “. . . understand *what is happening* and why (Gay, Mills & Airasian, 2009).”

Leberman et al. (2006) reviewed three case studies of teams of teachers or instructors interested in finding best practices for training for transfer for their specific contexts. They wanted to learn about transfer of learning from a student perspective and factors that facilitated transfer of content to the workplace.

Results showed students preferred learning information that directly applied to their work contexts. From a pedagogy standpoint, the researchers identified four factors related to transfer for these adult learners: (a) learner characteristics (motivation, where a learner is placed at their job), (b) course design (emphasis on application), (c) the learner's work environment and (d) the learner's individual culture. Leberman et al. (2006) contend attention to cultural factors facilitates transfer and is an important feature that has been overlooked. The three qualitative studies reviewed in the book depended heavily on interviews or open ended survey questions. The use of these tools provided the researchers with enough information to put together a picture of learning from the student and instructor perspective as noted above. In addition, the researchers were inspired to develop a model of transfer for adult learners in the workplace. The implications of the overview of these studies for the proposed research are the importance of interviews or open ended questions and a thorough review of responses collected to synthesize an accurate picture of the dynamics of a group of adults in their work environment.

With respect to the research literature on team teaching, Perry & Stewart (2005) conducted a study to determine how effective partnerships for team teaching with instructors from different colleges were developed and sustained.

They relied on two sets of videotaped interviews of instructors from two consecutive years which they transcribed and coded. The goal was to uncover partnership issues and provide a more detailed process for effective team teaching.

A unique aspect of this study was the adjustment of the interview method from the first year to the next. The themes derived from the first round of interviews were used to modify questions for the second round of interviews. This process also inspired the researchers to modify the interview process itself. The first round of interviews occurred with the pairs of team teachers; the second round occurred individually. The idea was to evoke more candor from the participants and obtain information at a more personal level concerning the dynamics of teaching as a team. The responses from the interviews were analyzed and coded. Three thematic areas emerged: (a) experience, (b) beliefs about teaching, and (c) personality and working style (Perry & Stewart, 2005). The findings also revealed the importance of reflective processes during teaching. As the pairs of teachers worked together each one benefited by articulating their ideas to one another. They learned from each other as they discussed their pedagogy during their team teaching planning sessions. This study provided the authors with insights from the 'inside out' concerning team teaching as opposed to mere observational data.

Based on information from this study, the implications for this project are (a) the usefulness of individual interviews, (b) allowing flexibility to data gathering by using information obtained to inform next steps, and (c) activities

permitting instructors to share experiences and work as a team promote reflective processes which provide learning experiences for teachers. These outcomes support the proposed intervention and provide ideas about flexibility concerning the research process.

Goodnough (2008) and Feryok (2009) studied a CoP and team teaching respectively. Their tools included transcriptions of meetings, journals of participants, field notes, taping of teaching and semi-structured and informal interviews. The questions to be answered by both of these studies concerned the characterization of the process of the collaborative efforts of instructors and how instructor behaviors were changed. Again, both of these studies provided information to the researchers concerning best practices for these types of processes. One example from Feryok (2009) included the observation of imitation practices helpful to foreign instructors teaching math or science and introducing English into their lessons. Goodnough (2008) summarized benefits for researchers concerning reflective action research practices when studying a collaborative group. The reflective practices led the author to adjust her role as she proceeded through the study. She states that initially she was in a more organizational role but later became more of a supporter and even provided workshops not planned for in the original design of the study (Goodnough, 2008).

Taken together, the literature supports the use of qualitative methods when studying the operations of a group of professionals. This type of data is clearly descriptive and provides a more complete picture concerning the details of a working group. Such an approach requires the researcher to be more reflective

concerning the information to make sense and find meaning in the data gathered (Gay, Mills & Airasian, 2009; Stringer, 2007).

In addition, the literature provides ideas concerning adjustments to research methodology as a study progresses. The research studies reviewed above revealed two examples of research that was modified as the studies proceeded (Goodnough, 2008; Perry & Stewart, 2005). Reflective processes by the researchers provided the impetus to adjust methods or roles. This allowed the researchers to be responsive to the needs of participants or provide a more efficient flow of the method as the study proceeded.

In the same vein the constant comparison method (CCM) is built upon reflective practices and data analysis that occurs throughout an investigation (Strauss & Corbin, 1998). The key features of CCM include analyzing data by coding and then organizing these codes into larger categories and finding themes, reflecting on the themes by questioning and digging deeper into the meaning of themes. Use of the CCM allows the researcher to derive meaning from data gathered and put together a complete and accurate picture of the situation being studied. When this occurs patterns and relations become evident which is the basis of theory building allowing the researcher to develop explanations for observed phenomena (Strauss & Corbin, 1998).

Chapter 3 Method

In the following section the design of the action research project is described. The design was constructed to provide a well rounded and focused study on how an interdisciplinary group of college science instructors functioned in a synergistic manner to address student learning issues of transfer.

Research design

The design of this study was a mixed-method design with an emphasis on descriptive qualitative data. Data from CoP meetings and classroom observations provided the bulk of the data. Interviews of the participants to capture their individual insights and perceptions provided another source of qualitative data. Quantitative data were incorporated to strengthen the findings empirically. This data consisted of a questionnaire about participants' perspectives about the operations of the interdisciplinary CoP, changes concerning instruction, and knowledge gained concerning transfer. The blending of methods facilitated support of outcomes from each method and indicated areas that needed to be re-examined which strengthened assertions or hypotheses generated by the researcher (Creswell, 2008, Johnson & Christensen, 2007). In the sections that follow, the instruments used are described and a timeline provided.

Setting and Participants

As described previously, the research project took place at Estrella Community College in Avondale, Arizona. The participants consisted of three biology and four chemistry faculty members who teach the introductory science courses (BIO 181 or CHM 130) required by students seeking careers in Allied

Health professions. During the initial stages and pilots of this project I taught BIO 181 but by the time the project was executed in fall 2010 I no longer taught the course. My role as participant observer shifted to participating in meetings and observing faculty members involved in the project. The four chemistry faculty members consisted of three full-time and one adjunct that recently joined the group. The biology faculty members consisted of two full time faculty members. We all have research backgrounds in chemistry or cellular and molecular biology. I and one of the chemists have degrees or certificates in education as well. I am the science faculty member who has been at the college the longest, 10 years, and I currently serve as science division chair. One biology faculty member has six years of experience and the other only one year of experience at EMCC. The chemistry faculty members have fewer years of experience at EMCC. Each of them has taught three years respectively at EMCC. The full-time faculty members in the CoP had offices in the same building and on the same floor which facilitates both scheduled and informal meetings. The chemistry adjunct member works 20 hours a week in our tutoring facility in addition to teaching two courses. She was present on campus very often and worked downstairs in the same building in the adjunct office. Her perspectives and feedback concerning student interactions at the tutoring center were very helpful to the CoP.

Prior to the first meeting participants were contacted and officially asked to participate in the research. Consent forms (Appendix A) were provided and signatures collected. Faculty members were able to participate at whatever level

they chose, they did not have to be part of the study, however, all members decided to participate.

Role of the researcher. The primary role of the researcher was facilitator of the cross-disciplinary CoP. For fall 2010 I was not involved in teaching one of the introductory courses; summer 2009 was the last time I taught BIO 181. I have taught the course for years and instigated revision of the course roughly 10 years ago so I am well versed with the struggles concerning student learning. My role was semi-participant observer; I facilitated and participated in meetings but did not teach the course. I felt this did not hamper my involvement in the project and felt very included in the group and completely engaged. The year before this action research project I became division chair. Again, I felt this did not impinge on the dynamics of our group since we had informally begun the interdisciplinary dialogue before the change of my status.

Intervention

The study was an action research study that documented the utilization of a cross-disciplinary approach to address a common student learning issue. Members of the CoP have noticed that students fail to transfer knowledge and skills from one science course to another. It seems students learn about a concept in one context and struggle to see how it is used in another context. Haskell (2001) investigated this phenomenon which prompted him to develop eleven principles for teaching for transfer. Three of these principles were utilized by the facilitator to provide a framework as the CoP worked on the problem of transfer.

Initially, the CoP was a loose confederation of instructors. Previous cycles of action research solidified the group and initial meetings consisted of cross training each other concerning presentation of concepts by faculty members from the complementary discipline. Participants reviewed or learned about concepts presented from the complementary discipline specific perspective. These activities provided the CoP with ideas concerning overlapping concepts and how a common approach could occur in both courses. These cycles occurred during the fall 2009 and spring 2010 semesters. These cycles however, were very informal and not organized. The research cycle conducted in fall 2010 provided structure, purpose and focus concerning the interdisciplinary approach that had been initiated. The project provided a bit more accountability for the members while maintaining a CoP culture. By tightening up the group and collecting descriptive data, the researcher documented a unique operational process that is not a common occurrence among college instructors. Or at least, is not well documented. The remainder of this section provides an overview of the intervention with details and explanations later in the document.

Five meetings occurred during fall 2010. The topics of the first meeting included the introduction of the three principles (Haskell, 2001) concerning teaching for transfer. The majority of the members of the CoP do not have an educational background; using ideas pertaining to learning to shape instruction is not standard procedure. It ended up the principles were a natural fit or common sense concerning the methods determined to help students with transfer. Two of the principles that served as guides dovetailed together; the first, teaching students

or making them aware of transfer was easily embedded in the second, creating a culture of transfer in the classroom. To this, the CoP agreed creating a culture of transfer included teaching the students concepts learned in one class will carry to the next. The third principle, repetition or drill of basic concepts to provide a basis of understanding that will foster transfer, was readily accepted as common sense. The CoP addressed this by making sure common terms and materials were used in the two courses.

The first meeting also consisted of a review of the metric packet utilized the previous semester and how each instructor had implemented its use. The packet was originally designed to serve as a standalone review or practice resource for students who needed to brush up on the metric system and conversions between measuring units. A couple of adjustments to the packet were made: (a) it was decided to include English to metric conversions since this is important in nursing and other allied health careers, (b) biology faculty members conceded the quick and easy method taught to students about how to do metric to metric conversions based on logarithms to base 10 should be replaced with equivalencies and an introduction to dimensional analysis to align with chemistry, and (c) the table of equivalencies based on chemistry needs to be included in the packet.

An additional outcome of the first meeting was a discussion to decide a third overlapping topic. The metric system and energy were two concepts decided previously; the next that came to light was molecular motion. During the second meeting this topic was confirmed and common methods determined.

Classroom observations occurred during the semester and helped to inform topics for discussion at subsequent meetings. For instance, chemistry introduced molecular motion before biology. A demonstration concerning how perfume particles spread in a classroom was carried out by each chemistry faculty in their classrooms. This was discussed during the second meeting and it was decided that biology instructors would refer to this demonstration, use the term particles and make sure to include the term collisions.

The third meeting consisted of a thorough discussion and review of the concept of energy and how each discipline introduces this common concept. This was one concept agreed upon in the previous semester that was used across courses; this meeting allowed us to reinforce the ideas of transfer students need between the courses. The curriculum for chemistry focuses on a couple types of energy while biology introduces a wider range of energy. It was agreed to make sure each course addressed how the other discipline focused on energy differently, but energy still had the same meaning across the two courses.

The fourth meeting consisted of a conversation about learning theories; again, this is not a common topic for post-secondary educators since our backgrounds are in science, not education. The newest biology faculty member of the group was also pursuing a doctorate in education and initiated the discussion. All those present were interested in an overview of learning theories and how they were used to guide educational practices.

The big discussion during this meeting concerned an instructional disconnect brought to light by a chemistry faculty member. It was communicated

that students from biology courses were coming in with incorrect information concerning a type of chemical bond. This led to an agreement that biology would re-align instruction to better support student learning in preparation for chemistry courses. This session provided a good snapshot of the collaborative nature of the group and is detailed in a later section labeled FONCIPS.

The fifth meeting consisted of a review of the document concerning our activities and outcomes. It was suggested during the fourth meeting our agreed upon common methods needed to be solidified in a document since members could not remember what they needed to do as they moved through the semester. Ideas about what to convey concerning the other discipline, when demonstrations and materials were used and common terms needed to be captured and provided to members. During the review of the common document it was suggested to expand it to be more useful to other adjuncts and faculty members who were not members of the CoP so they understood the logic of our agreed upon common methods.

The last meeting took place as interviews were conducted. Individual interviews provided a nice capstone piece to the study because each member elaborated on their unique perspective of the CoP experience. The anonymous questionnaire provided members an opportunity to honestly indicate if they felt the CoP experience was beneficial or not. This piece of quantitative data was very important because the researcher became division chair and the supervisor of the members of the CoP. It was critical to the study to provide as many avenues as possible for participants to indicate their perspectives about the CoP and its

operations. The questionnaire worked well to support data derived by qualitative methods.

Data Collection

This study was designed to elicit a change in the normal operations and behaviors of a small group of science college faculty. The nature of this study lent itself to descriptive qualitative methods in order to provide a complete picture of the operations of the CoP as both a cohesive group and as individuals functioning in their own contexts. Data collection was descriptive in nature to answer the research questions of how the group functioned, what outcomes were generated by the group, and whether faculty members changed instructional methods and behaviors in attempts to facilitate student transfer of knowledge. In addition, this study examined how the faculty members felt about the experience and if they perceived any changes with regards to student behavior. My role in the study was facilitator of the CoP.

Concurrent with the CoP meetings, data collection occurred. Further, data on the participants' attitudes about the usefulness of the CoP and the concepts were gathered using the Instructor Questionnaire. Additionally, classroom descriptive field notes were gathered to determine whether efforts to foster transfer were implemented in the classrooms of CoP participants. Finally, interviews of participants were conducted at the conclusion of the project to aid in triangulation of the data.

Instruments

A more detailed description of instruments used for qualitative and quantitative data in addition to a timeline (Table 1) concerning data collection events is provided in the following sections.

Meetings. On the average, meetings were one hour long, recorded, and immediately transcribed. Although most members made the majority of meetings, one member missed three out of five meetings due to her teaching schedule. Meeting times could not be decided until shortly before the semester started and unfortunately teaching schedules dictated when the group could meet. This meant one member missed three meetings but was informed of what happened overall the following work day. Information from meetings provided agenda items for subsequent meetings and in addition to data concerning the operations of the CoP.

Classroom field notes. Descriptive field notes were collected during fall 2010 to document how instructors addressed transfer in overlapping topics and implemented changes to instruction and materials utilized in the classroom. All participating faculty members were observed. The logistics of schedules, when topics were covered during courses and whether or not the instructor used lab, lecture or both lab and lecture for the topic resulted in a total of 26 observations or 4.3 observations per instructor.

Instructor questionnaire. At the end of the semester, participants responded to a 16-item questionnaire (see Appendix B) using a 4-point Likert scale. The questionnaire consisted of three constructs: (a) the usefulness of the meetings and (b) the usefulness of the concepts discussed in the CoP with an

emphasis on instructor learning and (c) ideas about transfer. For example, with respect to the usefulness of the meetings, one item was, “At times, the discussion at the meetings provided me with new information.” With respect to the concepts discussed, one item asserted, “I felt the interdisciplinary approach to concepts was helpful.” And aligning with transfer of knowledge for students, one item stated, “I feel I understand what transfer of learning is for my students.” This questionnaire augmented data concerning how the instructors’ behaviors and attitudes changed in addition to how the CoP operated.

Structured interview. The last instrument was an instructor interview conducted at the end of the semester. The interview provided data for a more in-depth analysis concerning topics in the questionnaire. The interview protocol consisted of six open-ended questions asking faculty about how the CoP functioned, if the faculty member felt they learned from the CoP and if they noticed any changes or differences among their students concerning a culture of transfer. The complete list of interview questions is provided in Appendix C. These data helped to answer the question how the CoP functioned, how the instructors utilized materials and methods generated by the CoP and whether learning occurred for the instructors during the project.

Table 1, below, shows how data collection activities were carried out around the curriculum schedule for each course:

Table 1

Schedule of data collection

Fall semester 16 weeks								
Weeks	Prior to school	Wk 1-2	Wk 3-4	Wk 5-6	Wk 7-8	Wk 9-12	Wk 13-14	Wk 15-16
Meetings	Meeting 1	Mtg 2		Mtg 3		Mtg 4		Mtg 5
Observations occur when concepts are taught during the course		Metric - both BIO and CHM	introduces first part of energy	Molec motion - BIO	BIO - Energy		CHM finishes energy	
Interviews/ Questionnaire								XXXXXX

Member checks. Member checks were conducted throughout the study to validate the accuracy concerning concepts and information derived from the data (Gay, Mills & Airasian, 2009; Stringer, 2007). In each meeting a brief review or summary of ideas pertaining to major concepts was conducted in addition to a review of overarching themes from meetings during the fourth meeting. Information from interviews was communicated individually to each member for verification. In addition, the common methods document generated to capture the work of the group also provided a way to check the validity of the information gathered concerning shared methods and materials. The document was sent around to the group for editing or comments; this allowed the participants to provide their perspective concerning the outcomes of the group's efforts.

Chapter 4 Results

In this chapter data analyses and results are organized into two main sections: results based on qualitative data from meetings, observations, and interviews; and results based on quantitative data from the questionnaire. Results of qualitative data are further divided into five sections based on assertions derived from data analysis.

Data Analysis

Qualitative data analysis. Qualitative data included transcripts of CoP meetings, transcripts of interviews and field notes from classroom observations. Immediately following data collection, transcripts or notes were assigned initial codes using HyperRESEARCH (software for coding). Next, the information was exported to Excel where codes were regrouped and axially coded until themes emerged. The constant comparative method (CCM; Strauss & Corbin, 1999) which allowed themes or codes to inform subsequent data collection events was employed. For meetings and interview transcripts the first stage of analysis (open coding) was conducted utilizing an approach similar to the Key Word in Context (KWIC) method (Leech & Onwuegbuzie, 2007). This approach allowed the integrity of the information to be maintained. Because the CoP consisted of scientists talking about scientific concepts, it was important to preserve the scientific context in which it was communicated and not immediately tag the information in a more general form. For example, during a meeting a biology instructor shared frustration with teaching the metric system using a dimensional analysis (DA) emphasis in order to align her teaching more closely to chemistry

instruction. Merely coding this “frustration with teaching” or “metric system issues” would not provide the complete picture and in the first example, the link to the metric system would be lost. The comment was coded with metric system as the key word but included “frustration with DA approach.” Metric system was one of the key words which then was expanded using the context of the comments of the participants.

The analysis of the qualitative data revealed five major themes and theme-related components which were translated into assertions as presented below in Table 2. The themes are (a) cross-disciplinary sharing, (b) collaboration, (c) classroom implementation, (d) professional development, and (e) future considerations.

Table 2

Themes, components and assertions from Qualitative Data Analysis

Themes	Theme-related components	Assertions
<i>Cross-disciplinary exchange</i>	1) CoP members shared ideas concerning concepts specific to each course and discipline. 2) Members shared ideas concerning instruction of concepts specific to each course and discipline. 3) Participants shared concerns about student learning issues pertaining to concepts and in general.	Instructors became knowledgeable concerning common concepts in a different disciplinary context through extensive interdisciplinary collaboration.

<i>Collaboration</i>	<ol style="list-style-type: none"> 1) CoP members determined common concepts/materials/methods to be used in each course with the emphasis on using exactly the same terminology, methods, and materials as much as possible. 2) Members discussed transfer issues related to current courses and how to provide a knowledge base for optimal articulation. 3) Members considered transfer issues for subsequent courses, programs and jobs. 	<p>The group worked well as a team formulating ideas that would work across both introductory courses and disciplines while considering future coursework and students' needs for their prospective professions.</p>
<i>Implementation or in the classroom</i>	<ol style="list-style-type: none"> 1) Members discussed issues of implementing common methods and expressed concerns about how to implement for best fit. 2) Members noted concerns about student recognition of common methods. 	<p>Instructors demonstrated some initial concerns as they integrated common methods to foster student recognition of trans-disciplinary material.</p>
<i>Professional development</i>	<ol style="list-style-type: none"> 1) Members learned or reviewed content knowledge aligned to the other discipline. 2) Members learned instructional methods of the other discipline for application across lecture and lab. 	<p>Instructors were appreciative of the review of content by their peers so they felt more knowledgeable about the subject and instructional methods.</p>
<i>Future considerations</i>	<ol style="list-style-type: none"> 1) Members indicated assessment was needed. 2) Participants noted the project should continue and expand. 3) CoP participants suggested documentation was needed. 	<p>To improve effectiveness of the approach, documentation of meetings, assessment, and expansion of the project are warranted.</p>

Cross-disciplinary exchange. Assertion 1—Instructors became more knowledgeable concerning common concepts in a different disciplinary context through extensive interdisciplinary collaboration as described below. Meetings served as the vehicle for exchange. Five meetings occurred during the semester, each lasting 1 to 1.5 hrs. The theme-related components in Table 4 illustrate the nature of the dialogues that took place. First, a discussion concerning concepts and identifying shared concepts occurred. Next, members would contribute to discussions about how the concept was presented in each course. The last step was a sharing of the learning issues for students from each disciplinary perspective. The following dialogue during the first meeting (August 16) captures this progression. Comments are interjected showing connections to the theme-related components.

BIO 1: I want to suggest the idea of molecules and molecular motion [as our third common topic for the two courses].

CHM 1: That would go well with what we do.

Members of the CoP shared ideas of central common concepts to determine whether the other discipline agreed it was a good fit.

Instructors then described how the concept was presented and the points that were important from the perspective of the discipline.

BIO 1: I really try to emphasize that it is not planned out. Molecules do not have a map; they are just jiggling around and happen to bump into each other at the right time and the right way. It ties into our enzyme information.

In this case, BIO 1 indicated the importance of molecular motion and how it was related to enzymes inside a biological organism. The idea of randomness

concerning motion is an important concept in biology; imparting the disciplinary perspective was an important key in our interactions.

CHM 2: What BIO 1 is talking more about is ‘Brownian Motion’, which we spend a lot of time going over. We explain the randomization (sic) process of everything in Chem 150.

CHM 2: Yes, we do the perfume and diffusion. We talk about the fact that they are bouncing around everywhere. What BIO 1 talks about, we thread through the entire year. BIO 1 is right, these are fundamental ideas.

The perfume demonstration used by the CHM 130 instructors is an example of sharing both the activity and the context in which it is presented.

This allowed members of one discipline to see how the students were obtaining knowledge as presented by the other discipline. What was observed in the exchange above was a sharing of methods in addition to confirmation from chemistry to biology instructors about the validity of the concept. This was also evidence of the collaborative nature of the CoP and how ideas flowed and were considered by the group as a team.

After an idea was identified as a shared concept, the next step in the process was to brainstorm common methods across disciplines about the shared concept. The following occurred during the first meeting, it was our first attempt to connect diffusion as presented in chemistry to biology.

BIO 2: Is there some kind of common thing we do? I don’t know about you guys, but diffusion is always with air, like perfume you smell. How can we take this back down to biological or fluid setting?

CHM 2, 4: We do that. They take food coloring in hot and cold water, and watch the difference (the way the dye spreads)

The conversation ended at this point but it was resumed during the second meeting (September 3).

CHM 2: . . . I wonder if we could name the water something else, for instance... ‘The one with Red coloring and the one with Blue coloring’? Try to put a Biology spin on it.

BIO 1: It’s analogous to anything that happens in your body.

In the end, it was agreed chemistry instructors would emphasize the random distribution of dye in the water and tie it to biological organisms which are basically bags of water. A chemistry instructor then chimed in with a recommendation to run the demonstration in both courses and “. . . have the students whiteboard [draw particle diagrams on whiteboards] and they come up with molecules hitting each other” (CHM 2, September 9).

“That helps a lot. I will use those examples. It is very important that we use the same wording and the same sentences” (CHM 2, second meeting, September 3). This quote concerned the discussion of molecular motion and referred to sharing of examples from a biology perspective. Again, cross-disciplinary sharing was punctuated with providing disciplinary insights. Examples and methods were threaded together as members worked closely together in a collaborative fashion. The remainder of the exchange is provided.

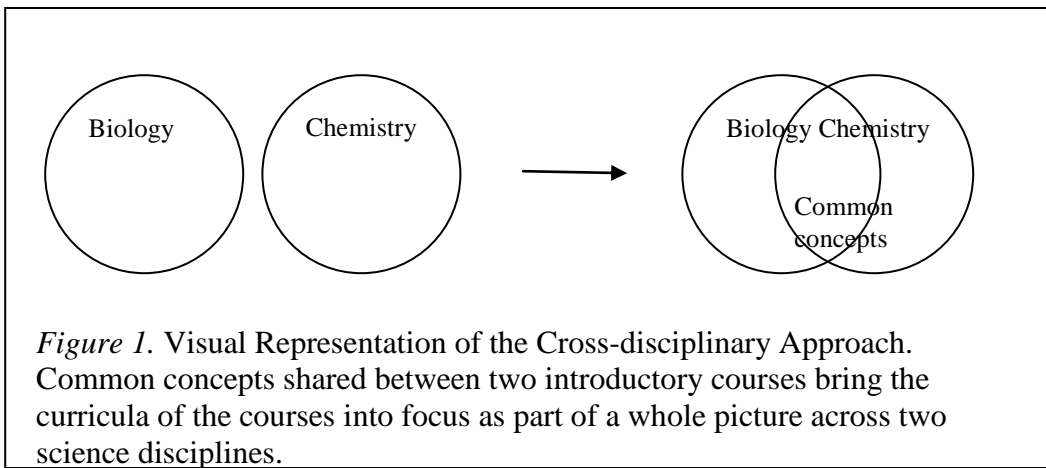
BIO 1: What words do you use talking about random molecular motion? (several say) Collisions.

CHM 2: Kinetic molecular theory. But in 130 we don’t go very deep.

BIO 1: Okay, as long as we say ‘collisions.’

As indicated, the group decided to use the term *collisions* across both courses. Instructors shared they had been saying molecules ‘banged into each other’ or ‘slammed into each other.’ Using the term collision was one way the group bound together more closely concepts that were spread across biology and

chemistry. A visual representation of the outcome of this and similar discussions is provided in Figure 1.



Another theme-related component often repeated centered on student learning issues. The issues usually pertained to concepts being discussed but sometimes they were more general. Discussing student learning issues was important for two reasons, (a) we were frustrated with our perceived lack of student progress during instruction and hoped to find a way to help students, and (b) we were relieved to find it was not just us as individual instructors; our colleagues experienced the same problems. Table 3 provides examples of instructors sharing student learning issues.

Table 3

Some Student Learning Issues Discussed During the Project

Quote from Participant	Explanation
<p>"They understand what to do but they have a problem with decimals; 1/1000 you know that it is .001, they have a problem with that." (BIO 3, second meeting, September 3)</p>	<p>A biology instructor shares frustration with the low level math skills students have upon entering the course. The students can mechanically do problems but conceptually do not understand decimals. It was shared that students think a number such as 0.01 is a negative number or less than zero.</p>
<p>"It's like all the molecules know what they are doing and where they are going. I think that causes conceptual problems with students. They don't know about the randomness." (BIO 1, first meeting, August 16)</p>	<p>People in general believe molecules (such as drugs) know exactly where to go and what to do inside a biological organism. To address this, the CoP decided to capture this idea as a common concept so students learn multiple times about random motion of molecules and particles.</p>
<p>"Students don't really have an understanding of this even though they were taught in third grade about solids, liquids and gases." (CHM 2, third meeting, October 1)</p>	<p>The chemist was emphasizing the lack of knowledge concerning spacing of molecules or particles in different states of matter. This level of knowledge is important as a base so ideas of motion, diffusion, and osmosis can be applied.</p>

Sharing problems such as those indicated above facilitated learning about student thinking not considered previously. For instance, the idea that 0.01 would be considered a negative number was a new thought for some members of the group. This idea was introduced because one instructor had a conversation with students. Interactions between students and an instructor provided specific instructor with insights about misconceptions; other instructors typically do not receive this information same information from students. Each instructor will obtain different insights or no insights at all. Our sharing of student problems broadened and expanded our knowledge of how to present a concept to correct student's misconceptions, for example, pointing out 0.01 is not a negative number just a very small number. This sharing of ideas and revising concept presentations was central to the meeting discussions.

During interviews, one instructor who obtained his/her degree in Britain indicated the cross-disciplinary approach aligned with the normative expectations of the education he/she experienced in which students mastered a group of courses before proceeding to the next educational level. The instructor believed this is one of the reasons why we experienced many student learning issues and felt our students were underprepared:

“That’s why I think it is important to link things together and show students how it builds. I felt this definitely makes it more of a holistic learning experience rather than check-the-box for a bunch of credits” (BIO 1, December 5). Exchanging ideas and experiences across disciplines and agreeing on common

concepts resulted in a holistic approach to learning by binding the curricula of the courses together as diagrammed in Figure 1.

Collaboration. Assertion 2—The group worked as a team formulating ideas that would work across both introductory courses and disciplines while considering future coursework and students' need for their prospective professions. The team had worked on the common concepts of energy and the metric system previously. A collegial environment had been established which facilitated collaboration. "I would say it was reasonably effective mainly because the people we had all knew each other fairly well; there is a lot of commonality" (CHM 2, December 12). "I think the group was pretty effective. I think we are pretty collegial" (BIO 1, December 5). "I believe we work together really well, but we worked together well coming into this . . . so there was the easy level of communication to begin with" (CHM 4, December 8). The project strengthened our connections and provided a well-appreciated experience for the newest faculty member, "I think we got a lot closer as colleagues, we are a lot more comfortable and me personally because I was new to the division" (BIO 3, November 28). The organic nature of the group reflected that of a CoP and fostered a free, open, and collaborative exchange with the researcher or facilitator gently nudging discussions in certain directions when needed.

The theme of collaboration had three theme-related components. The first, deciding on common methods was exemplified in the previous section concerning the use of the term *collisions* and the dye demonstration. Either specific terms would be identified for everyone to use or sometimes a bridging term was

identified between the two courses such as the beakers of water and dye being similar to an organism. At times a member said something like, “so which ones [common terms] did we agree to use? Ech, Eth, . . . [represent types of energy, chemical, thermal, etc]” (BIO 2, meeting 3, October 1). Then, a reply, “yes, Ech, Eth, Eli, Esound – BIO 1 does this” (BIO 3, meeting 3, October1) for affirmation. Each instructor wanted to make sure they understood the agreed upon common elements and how they would apply them. The acronyms Eth, Ech, Eli were designations chemistry had used for a while. They are not written as E_{th} but as Eth; biology instructors agreed to use the exact same notation.

The interdisciplinary exchange also featured instructors sharing instructional methods with suggestions on how to embed it into the other course or enhance a method used in both courses. A good example is in the dialogue concerning molecular motion.

CHM 4: In 150 we do sugar in alcohol vs. sugar in water. Essentially in the alcohol it stays solid, but [it] becomes a sludge in the water.

BIO 2: We do something like this in 181 – right? (to BIO 3) the sugar in the test tubes?

BIO 3: Oh yes, we do.

CHM 2: Do you use a sugar cube?

BIO 2: No, we don't.

CHM 2: If you put a cube in a beaker of ethanol and a beaker of water and put it on your pad cam so everyone can see it, it is really cool. You watch the cube in the water just get decimated and have them draw a particle diagram as to why, what happened.

BIO 2: Great idea!

The chemistry instructor provided the biologists with an enhanced and more visual activity for the investigation of solvation (dissolving substances) in addition to a strategy to help students develop a conceptual understanding of what

they observed. The idea was simple: change the use of granulated sugar to a sugar cube to increase the visual effect. The idea from the chemist to enhance the activity was easily accepted by the biologists and more discussion of using this as a learning system ensued. “. . . they usually say the cube just collapsed, but the sugar you see in the bottom does not equal the amount started with” (CHM 2, meeting 3, October 1). The chemistry instructor provided insight concerning the experiment and how to prompt students to think about what they were observing conceptually. It was interesting to see a frank response from a biologist, “I ask them about Kool-Aid – what happens if you don’t stir it? I didn’t think to actually do it” (BIO 3, meeting 3, October 1). It must be noted this remark elicited laughter from the group, something that occurred quite often. The casual atmosphere supported joking with each other and also provided a safe environment where we opened up and indicated our surprise at considering something new. Because concepts in chemistry are the bases for biology, the chemists often provided ideas on how to improve demonstrations and student activities.

The CoP worked collaboratively to arrive at common methods to support transfer of learning. The focus of the discussion was always to find at least one, if not more, methods that could be used in an identical manner across the courses. However, the group also supported flexibility. During discussions concerning energy, it was decided to eschew the terms potential and kinetic energy. A chemistry instructor provided insight: “There is no difference between kinetic and potential, energy is energy. There is no difference with something moving or with

stored energy, there is just a state above $E=0$ [no energy]; the interactions between particles is what dictates the final state” (CHM 2, October 1).

As the discussion continued, however, CHM 2 stated, “I only say kinetic and it is equivalent to E_{th} ”, that is, he/she uses only the term kinetic and interchanges it with E_{th} or thermal energy. We acknowledged this presentation is prevalent in many science textbooks and acceptable to use. A couple of the chemistry instructors stated they would use thermal energy along with kinetic while the remainder of the group indicated they would avoid both terms. Everyone agreed the discussion was very helpful with the insight above providing each instructor the knowledge of why terms are used or not used; if students asked questions about the terms we felt prepared to address what they might perceive is a discrepancy. The process of review, discussion and brainstorming of common concepts in this collaborative manner supported articulation across the two courses.

More examples concerning transfer of the terminology across courses are provided in Table 4.

Table 4

Examples of Transfer

Quote from Participant	Explanation
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"Yeh, first is English to English, English to metric, then metric to metric" (CHM3, first meeting, August 16).

A chemistry instructor who helped with the last revisions on the metric packet pointed out the progression of units as presented in the packet. Incorporating English units is new; the idea is to start with familiar units was agreed upon to facilitate transfer coming into the courses and between the courses.

"What is interesting and what we've learned through nursing and talking with fitness instructors is that pounds-to-kilograms, inches-to-centimeters, those two are huge" (BIO 2, first meeting, August 16).

Meetings with instructors from other areas informed the group about transfer to future careers and jobs. The CoP agreed to mention these connections in courses.

(a) "What I am confused about as to what we say is that the energy is in the bonds and that is not good. How do we say this?" (BIO 3).

Quotes (a), (b), and (c) represent a conversational flow concerning bonds that occurred during meeting 3. Although this was not an official common concept, it was brought up by the chemists as a concept causing problems for students who were coming from biology into chemistry courses. It was agreed to have bonds be the next focal point for the group. This exchange is a good example of how members interacted to address transfer and establish commonalities across the courses.

(b) "I try to hook it up to electrons being involved but I don't know that I am saying that right . . ." (BIO 1).

(c) "Yes, you will never be able to say all the right things according to physics, etc., but the one thing we want to get away from saying is high energy bonds or you get energy out of breaking a bond. The key is that it always takes energy to break a bond otherwise it would not exist . . ." (CHM 2).

"That is another term . . . you learn about particles in 130, molecules in 181 but sometimes when they work on the scope I have to say you are looking at particles of debris, it is not just cells and molecules, so I am trying to use that more also" (BIO 2, meeting 3, October 1).

The biology instructor refers to the term particles, one of the common terms agreed upon to use across both courses.

As shown above, articulation was not confined to the introductory courses. Participants explained how they tied some of the common methods to subsequent courses they teach. In addition, the group always kept in mind skills or learning necessary to support students as future nurses and other allied health professionals. The following exchange occurred during the discussion concerning energy (meeting 3, October 1).

CHM 2: Yes, I mention that the health sciences use calories.

CHM 4: We have a problem where they convert from Joules to calories.

BIO 1: Is Joule or calorie metric?

CHM 2: Joule is the actual metric measurement. A calorie is the amount of energy to heat one gram of water 1°C which is 4.18 Joules. You guys basically shortened the process by just making everything with water 1. That is what the chemists did with the atmosphere rather than 760 torr; we just call that 1 atm.

This exchange led to the discussion of how dietary calories are not *real* or scientific calories. Members indicated they already point out this discrepancy to students concerning diets and counting calories (if a Snickers bar is 235 Calories, it is really 235,000 scientific calories). We then agreed to also point out to students if they are considering a career as a nutritionist or dietician they need to understand the basis of calories and that calories are only one type of unit used to measure energy.

Classroom implementation. Assertion 3—Instructors demonstrated some initial concerns as they integrated common methods for fostering student recognition of interdisciplinary material. Data from field notes during classroom observations revealed a high level of commitment to the implementation of interdisciplinary methods, albeit with these initial concerns. Table 5 provides an example of summary findings for two of the common concepts.

Table 5

Number of Faculty Observed Using Common Methods

Metric system methods	Number of faculty
Handed out or made available the metric packet	100%
Mentioned connections to jobs in health field or other disciplines (physics, engineering)	67%
Mentioned connection to dimensional analysis	50%
Mentioned how metric system aligned to other discipline	100%
Molecular motion	Number of faculty
Used the term kinetic motion	100%
Used Brownian motion applet	50%
Referred to osmosis	50%
Referred to other discipline	50%

Not surprisingly, classroom observations conducted during the time when molecular motion was presented across the courses revealed a lower level of implementation because it was the latest common concept adopted by the CoP as shown in Table 5.

Overall, the average for all areas was 50% which meant at least half of the instructors were implementing all methods. Table 6 provides examples of field notes from classroom observations of faculty incorporating interdisciplinary methods in the classroom.

Table 6

A Sample of Observations

Observation	Comment
CHM 3 mentions we are warm blooded . . . Energy flows always just like in osmosis water flows (December 1).	Establishing ties to the other discipline are a common method. Warm blooded and osmosis are directly associated with biology.
BIO 1 introduces energy accounts and asks if students are familiar with this from CHM 130. Half the students raise their hands. BIO 1 continues to introduce energy accounts using Eth, Eli, Es, Egr, and Ech (October 8).	CHM 130 instructors have always used the analogy of bank accounts concerning different types of energy. In this case using the same analogy is the common method. In addition the use of the terms Eth, Ech, etc is another common method.
CHM 1 informs the students the metric packet is used in both BIO 181 and CHM 130 and that there is a math review in the appendix (August 27).	The use of the same metric packet across both courses is a common method.
BIO 3 uses the Brownian motion applet and mentions water diffuses across a membrane (osmosis) by collisions taking place (September 28).	The applet was introduced just this semester. Using the same animation or tool is a common method. In addition, the instructor used the term collisions, another agreed upon term that is to be used in both courses.
CHM 4 indicated perfume molecules collide; these collisions are the reason for diffusion of the perfume particles (September 20).	Again, the use of the term collisions is shared between biology and chemistry.

However, instructors did express some concerns about how to infuse methods into existing units of information, demonstrations or laboratory exercises. This was the first semester the biologists incorporated English units along with metric units and conversions. The biologist from Britain commented, “Oh I was just thinking how I hate teaching English units...but I will have to do it, that’s alright” (BIO 1, meeting 1, August 16). Previously before the biologists started collaborating with the chemists it was agreed for BIO 181 to drop English units because metric units were the standard in science and medicine. However, articulation with chemistry faculty during the pilot semester last spring resulted in a rethinking of our approach. It was assumed the metric system was taught in high school and students would be prepared to do conversions, understand exponents, and be able to do simple algebra. The chemists pointed out that the students do not have these skills and abilities, which was reiterated at the first meeting, “You know I go over the water bottle thing--500 ml, half a liter--because they are used to the ounces and the equivalency there. Because a lot them have no idea what a liter is” (CHM 3, August 16). BIO 3 added, “Yeah, because on the quiz, they can’t do how many micro-liter doses are in a 50 ml vial. Yet they can go from pounds to ounces, like that (snapped fingers).”

Then, as a group we decided to reach back to the English system and incorporate it into the metric packet because the English system is still utilized in the US. In addition, recent conversations with nurses and fitness specialists indicated the need to be able to practice converting between English and metric systems. Both stressed conversions such as pounds to kilograms and inches to

centimeters need to be readily accessible knowledge for nurses or physical therapists. The idea was brought to the CoP and members agreed to include this emphasis for students concerning future jobs. The transfer efforts between the two courses was important, but one of the key features concerning the collegiality of the CoP was the commitment by faculty to take on new methods and techniques even if it felt uncomfortable as noted above.

Concerns emerged toward the end of the semester. One was related to remembering the agreed upon actions and how to integrate them seamlessly. “. . . when you came in to observe my class, I had forgotten to mention the biology stuff, but I had done it in the other two classes” (CHM 2, interview, December 12). Several of the members suggested a list of finalized methods that would be helpful as we move through the semester, but which would also serve as a review or recap of the semester. “At the end we can go through the list and see how it went. Then we can make our changes” (BIO 3, interview, November 28). The list or table of methods was generated for each common concept and reviewed by each member. Another instructor mentioned limited time as a factor not allowing him/her to focus completely on integrating methods. “I need to emphasize the collision thing and if I had been more proactive I could be adjusting my PowerPoints a bit or have additional materials ready to go” (BIO 1, interview, December 5). It was evident the members were committed to the project and wanted to work through challenges to better integrate common methods into their courses. This is reflected in the following statement, “And the materials, well, I

think if we come up with more written documents, it will really help me make sure I fulfill those things” (CHM3, December 10).

Another member indicated concern that students will not get the idea about transferring knowledge: “Yeah, that is the whole point of it all, but sometimes I think it might get lost on the students just because they are students . . .” (BIO 3, interview, November 28). Consistent with this comment, the chemists pointed out misconceptions students were picking up in biology courses and carrying to chemistry courses outside of CHM 130. “Why does biology do CIPS [explaining hydrogen bonds form with the elements chlorine (Cl), phosphorus (P), and sulfur (S)]? Chemistry does FON [fluorine (F), oxygen (O), and nitrogen (N)]. We teach that fluorine, nitrogen and oxygen are the only ones that will give you hydrogen bonds. You guys do the ‘CIPS’ also and it’s causing confusion” (CHM 1, meeting 4, October 29). It was agreed this needed to be adjusted or addressed when possible in BIO 181 and CHM 130. Most of the problem stemmed from information presented in BIO 181 and transported to subsequent courses. Another example concerned bond breaking and formation between atoms in a molecule. “We have a huge problem with students saying I broke a phosphate bond so I got energy out of it – no you didn’t, you had to put energy in to break that bond . . .”(CHM 2, meeting 3, October 1). Discussion ensued concerning bonds and energy. It was agreed that bonds needed to be the next common concept on which the group will work.

Professional development. Assertion 4—Instructors were appreciative of the review of science content by their peers. It had been a while for all the

biologists since we had chemistry courses. Learning about the chemistry again and methods for instruction provided a deeper understanding. Data from interviews and meeting transcripts revealed the cross-disciplinary sharing of information provided an aspect of professional development concerning scientific concepts, instructional methods and pedagogy. Members commented this was a huge benefit of the CoP. For the newest full time faculty member, learning about instructional methods from another discipline provided the member with more confidence concerning teaching:

Yes, I learned a lot from the chemists and how they approach things. I think it is cool that they give the learning to the students; that they ask them the questions and the students have to figure it out. I think I also have the students do a lot more group work in class, giving them problems and having them solve them; that sort of thing. This is from taking the lead from the chemists. So I have really changed a lot in my teaching. I think it is a combination of getting used to being in the classroom also. I feel much more comfortable. This has really helped; my teaching is totally different from when I started. I was a little afraid, but now I am very confident. I used to get stressed, but now I know it will work out (BIO 3, November 28, 2010).

During discussions, scientific concepts were reviewed in depth to increase the base of conceptual understanding. Together, the CoP would pull apart a concept, examine the parts and how they worked together then reconstruct it. Not only did this augment our knowledge but permitted us to better visualize the connection to the other discipline. The examples explained above concerning misconceptions brought to light by the chemists resulted in an in depth and ongoing review of what bonds are and how to present them appropriately to students as illustrated in the following “. . .the products gave you more energy than you put in, so you have a net gain”(CHM 2, meeting 3, October 1), and “We

need to focus on the fact that the products are more stable . . . so we should just talk about rearranging the molecule” (BIO 1, meeting 3, October 1).

As the CoP dissected bonds and the forces resulting in bonds it was clear biologists, actually biology texts, had simplified and omitted basic ideas. It was also apparent there was a need to communicate the entire idea to support student transfer to subsequent courses. This discussion was very enlightening for the members as revealed during instructor interviews,

For instance FONCIPS [in reference to elements and hydrogen bonding] – that is a huge, huge thing, you know, a huge concept that we were not even realizing we were doing and if we weren’t working together like that we wouldn’t have even known that chemists think we are the lesser scientists (said in a joking manner) (BIO 3, November 28, 2010).

I learned, or found it was interesting, that you guys did not distinguish between hydrogen bonding and dipole-dipole interactions, and I think that’s kind of important. But I have always talked about the importance of hydrogen bonding in biological molecules (CHM 3, December 10, 2010).

It is hard because I can’t not (sic) say hydrogen bonds; it is so ubiquitous in biology. I will try to use the term dipole a little bit more, and we are going to drop off the CIPS [elements], so we will just deal with the negativity [charge] of fluorine, oxygen and nitrogen. That was something that was new for me too; the whole dipole hydrogen bond idea (BIO 1, December 5, 2010).

Discussions such as these reinforced our knowledge of content and provided a very engaging and useful way to review science content. It permitted us to see the content through the other disciplinary lens and understand why our different approaches could be causing problems concerning transfer for students. ‘

Part of professional development is being exposed to new ideas or perspectives. Repeatedly we talked about student deficiencies in basic skills, particularly mathematics. During one of our conversations concerning this deficit,

a CoP member from Britain noted the US educational system does not embrace a holistic approach to ensure students obtain basic skill sets so they are successful in subsequent courses. This member commented how our collaborative work was similar to this approach and stated the following:

. . . this was very interesting to see this happen with the faculty and I hope students gained a feeling that this is a program and it is a cumulative process to become a nurse or whatever you're going to be. It is more than just ticking off credits (BIO 1, December 5, 2010).

This perspective was well received by the group and it was acknowledged that our system does not support mastery of learning before moving up one more rung on an academic ladder. It helped us to realize how our approach may help our students be more successful as they progress through courses.

In summary, the participants of the CoP obtained professional development concerning content, pedagogy and other ideas pertaining to teaching in learning; the exchange amongst colleagues with different experiences and backgrounds provided each member with richness of knowledge to which they would not be normally exposed. “For the teaching aspect of it, it’s a good way to get new ideas on different concepts that are threaded throughout the program” (CHM 2, interview, December 12, 2010).

Future considerations. Assertion 5—To improve effectiveness of the approach, documentation of meetings, assessment, and expansion of the project was warranted. When asked during interviews about what could improve the process, a biology instructor said, “It would have been better to have a way to measure or assess the effect of the group, but it is hard to do” (BIO 1, December

5, 2010). A chemistry instructor posited, “One thing that could be adjusted is that we don’t really know how effective we are until some more time passes’ (CHM 2, December 12, 2010). The chemistry instructor continued, “A lot of decisions we are making right now, they are early in the game at this point. We won’t know how effective we were until the students go on.” Every member agreed some kind of assessment would be helpful but to answer the question, “Did transfer of knowledge occur?” would not be easy because it would require tracking individual students, which is difficult in the community college setting where students tend to “swirl” to other colleges, that is take courses across various community colleges when pursuing their programs.

As indicated earlier, members also agreed agendas, notes concerning meetings and scheduling of meetings need to be codified and preserved to increase the efficacy of the group and to ensure sustainability. Another consideration for future operations is to include another discipline such as mathematics or physics. As one chemistry instructor contemplated future considerations, she stated,

Then we can expand them throughout the entire curriculum for chemistry, bio and include math. That would be awesome. But this is what, a five year process? It just takes a long time. I wish we could come up with a test, like an exit test for the courses (CHM 3, December 10, 2010).

The qualitative data provided a rich picture of the operations and outcomes of the interdisciplinary CoP. The participants were vested in the process; the evidence showed engagement in meetings, willingness to work on materials and implementation of common methods. The following section

describes how the quantitative data provided support for the findings from the qualitative data.

Quantitative data analysis. The anonymous instructor questionnaire was analyzed by assigning points to the items from the Likert scale, Agree Strongly was assigned four points, and Disagree Strongly assigned one point. In this way, greater agreement was reflected in higher scores. The means and standard deviations were calculated to examine the degree to which the CoP believed the group and its work was beneficial.

The questionnaire was originally framed around four constructs. However upon analysis it was found the questions could be grouped into the following five topics: CoP Benefits, CoP processes, interdisciplinary knowledge, classroom application and transfer. Table 7 shows the data.

Table 7

Means and Standard Deviation for Five Topics from the Questionnaire^a

Topic	Average	Standard Deviation
Benefits of the CoP	3.46	0.25
CoP processes	3.50	0.24
Sharing interdisciplinary knowledge	3.56	0.19
Application to classroom	3.58	0.12
Transfer	3.42	0.22

^a*n* = 6

Overall, the quantitative data indicated the group agreed meeting as a CoP was beneficial concerning several aspects, (a) sharing interdisciplinary knowledge, (b) application to the classroom, and (c) transfer. Taken together, these quantitative data suggest the CoP members found the processes and outcomes to be beneficial, which is consistent with the findings from the qualitative data.

Chapter 5 Discussion

In this final chapter four areas are discussed. The first is lessons learned as a researcher, which encompasses what the researcher has learned as a result of performing action research and answers the research questions, (a) “How did the CoP function or operate?”, (b) “How are outcomes used in the classroom?”, and (c) “How are instructor behaviors and attitudes changed?” The second area consists of personal lessons learned; the third, implications for practice; and the last, implications for future research.

Lessons Learned as a Researcher

The purpose of the action research project is to capture the workings of an ongoing interdisciplinary CoP among college science instructors by describing the character and process of meetings and to discover whether members feel the experience is beneficial. In conducting the work, the objective is to maintain the CoP character of the group and add meetings allowing the group more opportunities to interact and develop changes in instruction that support transfer of knowledge for students.

Research Question 1 – How did the CoP function? The results are consistent with the 14 characteristics that indicate a CoP has formed as outlined by Wenger (1998). Of the 14 listed, eight are evident in the data from this project. Indicators 1, “sustained mutual relationships – harmonious or conflictual” and 11, “local lore, shared stories, inside jokes, knowing laughter” taken together describe the relational framework of a CoP. The interdisciplinary group of science educators clearly meets these criteria. Data from meetings and interviews reveal a

congenial, collaborative and open culture among the members. Discussions are lively but never heated nor disrespectful. Participants express they enjoy the sessions and feel their relations with their peers are reinforced. Every meeting is punctuated by joking, laughter and referring to inside stories. These respites are appropriate and well-timed since the group exhibits intense focus on finding solutions to learning problems and appreciates the relief from the intensity of the sessions. These breaks are not distracting; rather they are relaxing and promote a feeling of comfort and camaraderie during work.

The CoP functions comfortably and in an effective manner. Indicators 2, “shared ways of engaging in doing things together”; 3, “the rapid flow of information and propagation of innovation”; and 9, “the ability to assess the appropriateness of actions and products” (Wenger, 1998, p. 125) together describe the efficacy of a CoP as it functions. The group shares information in an expedited manner because we work to make changes for upcoming topics in both courses. In addition the group consists of experts in the field who determine the appropriateness of methods or exercises for use in the classroom. It is beneficial that the group has instructors with various levels of experience including a new instructor to bring different perspectives to the CoP. The themes and theme-related components from the data about cross-disciplinary exchange and collaboration support the indicators described above. Instructors work amicably to exchange ideas, develop common methods, and integrate them into their classroom instruction. The CoP members produce tangible outcomes as exemplified in Appendix D. The outcomes include a list of student learning

problems for the common content, agreed upon activities, and notes about how instructors will present information in a cross-disciplinary fashion as they teach common concepts in their courses.

Indicators 7, “knowing what others know, what they can do, and how they can contribute to an enterprise”; 10, “specific tools, representations and other artifacts”; and 14, “a shared discourse reflecting a certain perspective on the world” (Wenger, 1998, p. 125-126) refer to a common knowledge base for the group and a shared perspective. The pilot studies of this action research resulted in the identification of some common concepts across courses in addition to preliminary construction of a shared knowledge base. The themes of collaboration and cross-disciplinary exchange from the data support the operations of the group as a CoP and align well with a majority of CoP indicators posited by Wenger.

An underlying and pervasive element throughout the CoP interactions is the focus on learning and transfer which comprises a pedagogical mindset. The data show instructors agree to use the same methods to support not only a common approach but an emphasis on conceptual learning. As we discuss activities for students to do or demonstrations to perform, ideas are always presented from the perspective of encouraging the students to not just memorize information, but to be independent learners with an emphasis on conceptual understanding. Further, the newest faculty member is appreciative of the sharing of knowledge concerning instructional strategies. The most recent round of research codifies, defines and identifies more elements common to both of the introductory science courses bringing the disciplinary spheres even closer

together. Again, qualitative themes, theme-related components and quantitative data show these indicators aptly describe the operations and interactions of the CoP. Wenger (1998, p. 126) provides an appropriate summary, “So characterized [a CoP], the notion of practice refers to a level of social structure that reflects shared learning. Note that this is a level both of analysis and experience.”

The results of this study also show the operations of the CoP reflect best practices of collaboration in an educational setting as described by Horn et al. (2008), including: (a) novel and effective solutions are developed by crossing traditional boundaries and collaborating outside a discipline, (b) small manageable tasks and activities are carried out rather than planning many tasks or complicated methods, (c) materials already developed are utilized, and (d) one or two people stabilized and focused the group.

For the CoP, thinking outside the box or crossing boundaries is a common occurrence for CoP members as they share information in a cross-disciplinary fashion. Outcomes such as new approaches to instruction and sharing materials and methods are evidence of this fact. It is also evident as faculty members describe eye-opening moments when learning about curriculum and instructional problems associated with the other discipline. Reviewing and reflecting upon our instruction in a non-routine fashion elicits innovational techniques and novel approaches to help address student learning issues.

The group follows a mantra of *keep it simple* in addition to utilizing any materials or methods already in place. The idea is not to completely rewrite curriculum or alter many activities but to enhance or alter at a minimal level what

is in place. This is one reason the CoP functions so well; members are willing to share methods and materials already in place. In addition, if an item is modified a bit, the changes are accepted by everyone in the group.

With respect to the last consideration listed above, responses to previous research indicate that CoP members want a facilitator or leader to guide the group. Interview data from the current research strengthen this finding; members indicate they would not have focused on the project if a leader had not been in place to plan meetings and direct work.

Research Question 2 - How are outcomes used in the classroom? CoP members implement many common methods depending on classroom time and whether they remember to implement them. The data show at least half of the instructors utilize every common method or material the group decides to use. For the most recent common concept, molecular motion, instructors struggled a bit more about how to present the idea and address the other discipline. This tends to be the most common problem, remembering what to say about the other discipline when teaching a concept. However, the common concepts related to the metric packet and energy are more familiar so the results showed more of the agreed upon methods are used in the classroom.

One of the serendipitous outcomes from the research is use of the materials and methods that go beyond implementation in the introductory level science courses. CoP participants apply the approach and utilize materials in subsequent courses. For example, several members indicate they made copies of the metric packet for the higher level chemistry courses beyond CHM 130. One

chemistry instructor said in general she is working to weave more biology themed problems into homework and examples. And another instructor asks whether it is appropriate to give the metric packet to a mathematics instructor wanting examples of science problems. These actions suggest the CoP members value the interdisciplinary approach to instruction and believe items generated by the group are useful in other contexts.

Research Question 3 - How are instructor behaviors and attitudes changed? The preceding discussion around classroom implementation of methods aligns with how instructor behaviors and attitudes change because observations provide a direct record of changes in the classroom. Appendix F includes a complete table showing percentages of faculty employing common methods. Overall it is evident that all instructors change their behaviors to utilize common methods to the best of their ability.

Another attitudinal change is a shift in perspective concerning the other discipline and its specific instructional needs. When instructors from one discipline explain to instructors of the other discipline why a concept is presented in a certain manner or only a portion of a concept is taught, there is a shift in attitudes. Sharing at this level permits understanding and appreciation of the other discipline's perspective and actions. This occurs several times when discussions take place and members ask faculty of the other discipline why they teach a concept in a certain manner. Usually, the questioning shows the faculty members are completely unaware of the other perspective and welcome this insight from the other discipline. Sharing at this level helps to prevent any possible

competition or antagonism between the two disciplines. Although this did not occur among the group, most have experienced this as a norm at other colleges where science faculty members are more competitive or contentious across disciplines. At the conclusion of the study during interviews, every member indicates a time when they have a profound learning experience resulting in an appreciation for members of the other discipline. Horn et al. (2008) describe how this learning experience via cross-disciplinary sharing allows us to “push ourselves (and our partners) to develop new ways of thinking and teaching that would never be possible if we had played it safe . . .”

During meetings and interviews, members of the group express beliefs that students will benefit by seeing concepts presented in identical ways across the two introductory science courses. CHM 3 indicates her agreement with this premise when she says, “The more you see things, and the more you see them repeated, the more you understand them . . .” (Interview, December 10). Such repetition and drilling are consistent with the principles of teaching for transfer (Haskell, 2001). These principles become the basis of discussion about transfer by the CoP. Two other principles from Haskell suggest establishing a culture of transfer in the classroom. Members embrace these principles and work hard to achieve them. Participants frequently want to incorporate more references or problems relating to the other discipline to establish the culture of transfer and to let students know the instructors coordinate their instructional methods across courses and disciplines. One member describes this agreement as a united front.

In terms of implementing transfer methods, the most significant change occurs when biology members struggle with metric system conversions and setting up equivalencies for dimensional analysis. One person in particular works valiantly to plan for the upcoming semester by devising a step-by-step plan on how to work through equivalencies and dimensional analysis. During the research project, this instructor feels inept about teaching dimensional analysis in her class. Nevertheless, as with all the members, this CoP participant is so vested in the idea of teaching for transfer to ameliorate student learning problems, she is willing to completely change her instruction in spite of feeling uncomfortable with the approach. Observation of the instructor this semester revealed one problem area during her presentation; her presentation is much improved from the previous semester. These and other changes in behaviors and attitudes concerning the members of the CoP are quite evident in all the data.

Personal Lessons Learned

Structure. Although a CoP approach is a good way to ensure free flow of thoughts and establish collegiality among members, the frame must be strengthened with more formal processes for the group to be and feel more effective. Interviews reveal the efficacy of the group could be increased if discussion items are made available to the group prior to meetings. Suggestions include providing an agenda prior to each meeting and maintaining an inventory of agreed upon methods or materials for instruction. Additionally, participants suggest notes from meetings be kept as a reference to contribute to the continuity of the CoP's efforts.

Not only would increased documentation help focus the group, it would help with measuring change because actions and history would be kept and allow for review and comparison. Maintaining documentation and tracking processes is an important part of being a leader. I feel comfortable in this role, but again it is helpful to be more structured when working with people limited by time constraints. In tackling a future action research project, I would establish more structure and increase the level of documentation of outcomes, actions and decisions.

Professional development. Upon reflection, I believe I have received development in three areas; (a) action research, (b) science content and instruction, and (c) leadership. When I embarked on the program, I had no idea about action research as a method for implementing and studying change in education. Now, as I read educational papers, I feel more comfortable assessing the information; I am able to understand information from specific studies. I can distinguish between strong and weak studies, understand methods and why they are used, and learn from the literature I read. As an educator, learning about and conducting action research is a powerful learning experience.

Along with the other CoP members, I experienced professional development related to science content, pedagogy and instructional methods. The deconstruction and reconstruction of knowledge and concepts allow a learner to view the details of content and determine how they come together to build that knowledge. Adding insights from another disciplinary perspective increases the depth of knowledge.

Flexibility is a necessary part of leadership. It is not possible to control the actions of others to the extent you wish. To maintain the functioning of the whole group some individual inconsistencies must be overlooked. In spite of this, I learned I am an able leader and enjoy working with my colleagues.

Another part of leadership entails learning about those who work around you. Learning more about how my colleagues function in their professional environment, what concepts they emphasize and how they present information is very empowering. Data from interviews, meetings, and the questionnaire reveal CoP participants reflect the same appreciation of learning about colleagues. For example, a chemistry instructor indicates knowing about instruction in the other course means he knows his “audience” or students better, that is, what they are learning in the other course. This helps him direct their learning concerning transfer of concepts between courses.

Another facet of this type of empowerment is the ability to address concerns of students when they share information about the other science class. Knowledge concerning instructional objectives and pedagogy of the other course permits us to explain why they are learning a concept and why it is presented in a certain manner. For instance, when a student describes class activities (in the other course) and is puzzled or expresses frustration we can provide information concerning the learning objectives of the course. I have often stated “I think you need to look at X and Y for this project – I am aware of what your instructor has assigned” when they share they do not understand something assigned in chemistry. They usually show relief that I know what I am talking about and I

help them with any confusion they may have concerning the project or assignment on which they are working. Most of the time I go back to the individual chemistry instructor and inform them about the conversation with the student. I believe this helps us to function as a cohesive and supportive group.

It is important during this project to consider my position as division chair and how it may influence action research participants. Because this project coincided with my move to the role of division chair, this made me very cautious concerning my interactions with colleagues and how they viewed the project. Fortunately, our group had formed just prior to me taking the position. Shortly after, a new faculty member joined our group and I had to ensure this person did not feel pressured to participate due to my position. I am glad I had this opportunity to be in this position and learn how to consider things from participants' perspectives.

One of the most important lessons I learned is the importance of bonding with my colleagues. Indeed, every participant feels this is an important aspect of our group. Sharing problems concerning students, student learning, and instruction helps us realize others have the same struggles. It empowers us; we know we are not alone nor are we crazy. In particular, learning from other instructors about how students perceive information and how we can modify instruction to help with misconceptions is very useful. The analysis of the data and the writing of this document allow the researcher to reflect and plan to include more inquiries of student misconceptions in meetings and conversations.

Implications for Practice

Faculty working collaboratively across science disciplines in a college setting is a radical change of practice. My colleagues and I do not hold to the traditional stance and we have a desire to continue to meet and expand connections for transfer. We are interested in expanding our efforts by inviting mathematics faculty to join the CoP. Informal talks indicate the interest in participation is mutual. We are interested in providing them with the metric packet, which will allow them to use the same problems providing more opportunities for transfer of concepts across disciplines. A coalition of disciplines presenting the same material in several introductory courses may help our students to establish strength in basic knowledge that they can more easily transfer to subsequent courses.

Our group will continue to sift through the content of our courses to determine where common concepts occur and how we can adjust our courses to promote transfer and better learning. A significant finding from this action research project is the discrepancy between teaching approaches and information about inter- and intra-molecular bonding. We agree this will be the next area to tackle in our CoP. This knowledge which is fundamental to our students provides another opportunity for us to share cross-disciplinary information, determine a mutually agreeable approach for teaching, and implement materials and instructional processes that will support transfer and benefit learning.

Implications for Future Research

A key component for future research is to maintain a clear goal as indicated by Hill et al. (2007). The goal must be easily incorporated into actions taken by participants. For example, our discussions keep circling back to the lack of preparedness of our students and how we are compelled to go back and re-teach basic mathematics skills. This is complicated and not aligned to curriculum for our courses. We need to ‘pick our battles’ as one chemistry instructor reminds us and focus on how to facilitate transfer between courses in a comfortable and reasonable manner.

The CoP met as a group this semester (spring 2011) and an agenda and important items were provided prior to the meeting to allow members time for review of information. Because members were apprised of the topics to be covered, the meeting was more efficient. Our goal this semester is to determine if there are any indications by students that transfer is occurring. We are pilot testing a common survey of knowledge that will be administered the first day of class in both the CHM 130 and BIO 181 courses being taught by the CoP members. The survey will consist of questions that align with the metric system, dimensional analysis and basic mathematics skills. In addition, the students will be asked if they have had the other science course. We intend to track the students and obtain a baseline about knowledge or skills they have coming into each course and determine whether there is a relation to their persistence and performance in class. Data from this pilot test will inform the CoP about areas for future research. All of

us are interested in this research and eager to determine, if possible, effects of our collaboration on student learning.

This is a beneficial and exciting learning experience for me at various levels. Bonding with colleagues, obtaining directed and applicable professional growth experiences and working on leadership skills are very rewarding. Other benefits include added depths and dimensions of knowledge concerning education and educational research. Nevertheless, the most valuable piece is that my colleagues also feel they benefit by our sessions together as one faculty member indicated when he said,

For the teaching aspect of it, it's a good way to get new ideas on different concepts that are threaded throughout the program . . . it gets to a kind of understanding between professor to professor of what the expectations are on an individual basis (CHM 2, interview, December 12).

References

- Bransford, J., Brown, A., & Cocking, R. (Eds.). (2000). *How people learn: Brain, mind, experience and school*. Expanded edition. Washington, D.C.: National Academy Press.
- Calais, G. (2006). Haskell's taxonomies of transfer of learning: Implications for classroom instruction. *National Forum of Applied Educational Research Journal* 20(3), 1-8.
- Clifton, R. A., & Rubenstein, H. (2002). Collegial models for enhancing the performance of university professors. Retrieved from: Fraser Digital Publication. [http://www.fraserinstitute.ca/admin/books/files/Collegial Models.pdf](http://www.fraserinstitute.ca/admin/books/files/CollegialModels.pdf).
- Coleman, J. (1988). Social capital in the creation of human capital. Supplement: Organizations and institutions: Sociological and economic approaches to the analysis of social structure, *The American Journal of Sociology*, 94, S95-S120.
- Creswell, J. W. (2008). Mixed methods research. *The Sage encyclopedia of qualitative research methods*. SAGE Publications. Retrieved March 13, 2010 from http://www.sage-reference.com/research/Article_n269.html.
- Estrella Mountain Community College enrollment data. Spring 2009. Retrieved March 17, 2009 from http://www.emc.maricopa.edu/ie/ie_reports.asp
- Feryok, A. (2009). Activity theory, imitation, and their role in teacher development. *Language Teaching Research*, 13, 279–299.
- Gay, L. R., Mills, G. E., & Airasian, P. (2009). *Educational research: Competencies for analysis and application* (9th ed.). Upper Saddle River, NJ: Pearson Education.
- Gibson, C. B. (1999). Do they do what they believe they can? Group-efficacy and group performance across tasks and cultures. *Academy of Management Journal*, 42, 138-152.
- Goodnough, K. (2008). Moving science off the "back burner": Meaning making within an action research community of practice. *Journal of Science Teacher Education*, 19, 15-39.
- Haskell, R. E. (2001). *Transfer of learning: Cognition, instruction, and reasoning*. San Diego, CA: Academic Press.

- Hill, L., Kim, S., and Lagueux, R. (2007). Faculty collaboration as faculty development. *PeerReview, Fall 2007*, 17-19.
- Ho, S. (n.d.) Social capital and education. State University Education Encyclopedia. Retrieved from: <http://education.stateuniversity.com/pages/2427/Social-Capital-Education.html>.
- Horn, B., Stoller, F., & Robinson, M. (2008). Two heads are better than one: Interdisciplinary collaboration. *English Teaching Forum*, 42, 2–13.
- Johnson, B., & Christensen, L. (2007). *Educational research: Quantitative, qualitative, and mixed approaches (3rd edition)*. Boston, MA: Pearson Education Inc.
- Jones, S., & Morin, V. (2000). Training teachers to work as partners: Modeling the way in teacher preparation programs. *The Delta Kappa Gamma Bulletin*, 67(1), 51-55.
- Kearsley, G. (2009). Explorations in learning and instruction. The Theory Into Practice Database. Retrieved from: <http://tip.psychology.org/bandura.html>.
- Keller, H., & Cox, J. (2004). The proteomics stock market project. A cross-disciplinary collaboration in biochemistry and business education. *Journal of Chemical Education*, 81, 519.
- Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. New York, NY: Cambridge University Press.
- Leberman, S., McDonald, L. & Doyle, S. (2006). *The transfer of learning: Participant's perspectives of adult education and training*. Burlington, VT: Gower.
- Leech, N. L., & Onwuegbuzie, A. J. (2007). An array of qualitative data analysis tools: A call for qualitative data analysis triangulation. *School Psychology Quarterly*, 22, 557-584. doi:10.1037/1045-3830.22.4.557.
- McClure, C. (2008). The benefits of teacher collaboration: Essentials on education data and research analysis. *District Administration*. September 2008. Online version. Retrieved from: <http://www.districtadministration.com/viewarticle.aspx?articleid=1682>
- McKeough, A., Lupart, J., & Marini, A. (1995). *Teaching for transfer: Fostering generalization in learning*. Mahwah, NJ: Lawrence Erlbaum Associates.

- Moore, J. (2002). The chemistry–biology connection [Electronic version]. *Journal of Chemical Education*, 79, 1287. Retrieved March 9, 2009 from: <http://jchemed.chem>.
- National Research Council. (2003). *Transforming undergraduate education for future research biologists*. Washington, DC: National Academies Press.
- Pearsall, M. & Kern, M. (1967). Behavioral science, nursing services and the collaborative process: A case study. *The Journal of Applied Behavioral Science*, 3, 243-266.
- Perkins, D. N. & Solomon, G. (1988). Teaching for transfer. *Educational Leadership*, 46(1), 22-32.
- Perry, B., & Stewart, T. (2005). Insights into effective partnership in interdisciplinary team teaching. *System*, 33, 563–73.
- Rosseter, R. (2009). Nursing shortage [Fact Sheet]. *American Association of Colleges of Nursing*. Retrieved from: <http://www.aacn.nche.edu/Media/FactSheets/NursingShortage.htm>
- Strauss, A. L., & Corbin, J. M. (1998). Basics of qualitative research: Techniques and procedures for developing grounded theory (2nd ed.). Thousand Oaks, CA: Sage.
- Stringer, E. (2007). *Action research* (3rd ed.). Thousand Oaks, CA: Sage Publications.
- Sunal, D., Hodges, J., Sunal, C., Whitaker, K., Freeman, M., Edwards, L., Johnston, R., & Odell, M. (2001). Teaching science in higher education: Faculty professional development and barriers to change. *School Science and Mathematics*, 101, 246-257.
- Uekawa, K. , Aladjem, D., & Zhang, Y. (2006, August). *The impact of comprehensive school reform on teachers' social capital and students' achievement*. Paper presented at the annual meeting of the American Sociological Association, Montreal, Canada.
- Tschannen-Moran, M., & Woolfolk Hoy, A. (2001). Teacher efficacy: Capturing an elusive construct. *Teaching and Teacher Education*, 17, 783-805.
- Wenger, E. (1998). *Communities of practice*. New York, NY: Cambridge University Press.

Wenger, E., McDermott, R., & Snyder, W. M. (2002). *Cultivating communities of practice*. Boston, MA: Harvard Business School Publishing.

APPENDIX A
INSTRUCTOR CONSENT FORM

Recruitment Script

My name is Bronwen Steele and I am a biology faculty member at Estrella Mountain Community College. I am conducting a study concerning utilizing a *community of practice (CoP)* to fulfill requirements for my doctorate in education.

I am recruiting colleagues in my division in biology and chemistry who teach introductory courses for students on an allied health track. Instructors will be asked to attend approximately 6 meetings, allow observations of their classroom instruction, take a survey and participate in interviews. The former two will take place during the semester, the latter two at the end of the semester. Interviews may take 1-2 hrs. Your participation in this study is voluntary. If you choose not to participate or to withdraw from the study at any time, there will be no penalty. You may participate in the CoP without participating in the study. Additionally, your participation in this study will be completely confidential. The participants will be given a number or pseudonym by which they will be identified. This number/pseudonym will not be tied to your name or personal identification in any way in order to maintain your anonymity. I will only use the results of this study as part of my EdD dissertation.

I hope you are able to help me by participating in discussions and by allowing classroom observations. The responses to the survey, interviews and observations notes will be used to help the science division to improve classroom instruction and hopefully have a positive effect on student success in science courses.

If you have any questions concerning the research study, please contact me at: bronwen.steele@emcmail.maricopa.edu If you have any questions about your rights as a subject/participant in this research, or if you feel you have been placed at risk, you may contact our faculty Institutional Review Board representative on campus: Bill Farrar (5-8478).

Thank you for your time and participation.

Sincerely,
Bronwen Steele

Are you willing to participate in this Action Research Study?

- I agree to participate in this research study.
- I decline to participate in this research study.

Signature and date: _____

APPENDIX B
INSTRUCTOR QUESTIONNAIRE

1-Agree Strongly 2-Agree 3-Disagree 4-Disagree Strongly

About the meetings:

1. The meetings were appropriate to our objectives.
2. The meetings were helpful overall.
3. The discussion at the meetings provided me with new information.
4. The discussion at the meetings provided me with a review of concepts.
5. It would have been beneficial to have more meetings.
6. Everyone had opportunities to contribute to the discussions and outcomes of the meetings.
7. The meetings provided an opportunity to bond/interact more with my peers in the other discipline both professionally and personally.

About the concepts covered:

8. The concepts upon which the group focused were appropriate as overlapping concepts.
9. I understood the teaching perspective(s) for concepts that align to the other discipline.
10. The interdisciplinary approach to working with concepts was helpful.
11. I adequately understood the approach to the teaching and learning to allow me to comfortably teach the overlapping concepts.
12. I utilized all of the materials and methods developed by our biology-chemistry group.

About transfer:

13. I understand what transfer of learning is for my students.
14. I believe the processes put in place by the group help to address the transfer issue.

15. During this semester I observed student behaviors indicating they were transferring knowledge.

16. I feel this is a valid process to help with issues of transfer for students and would participate in another community of practice with another discipline (example: math).

APPENDIX C
INSTRUCTOR INTERVIEW QUESTIONS

1. What were the benefits of participating in the CoP?
2. Discuss the effectiveness of the group as it worked together.
3. Concerning the common concepts, what did you learn that was new or different?
4. How did you use the materials and methods developed by the CoP? Were they useful? Why or why not?
5. Please describe your ideas of transfer and how this has been incorporated into your instructional methods.
6. What do you feel needs to be adjusted or improved for this process to be more effective?

APPENDIX D
COMMON METHODS

BIO 181/ CHM 130 connections

Summary of BIO and CHM faculty pedagogy or approach to learning:

- 1) Instructors are facilitators of learning, not lecturers spewing information. If 20 minutes has passed and you as the instructor are still talking, stop and make the students do work in class. Assess their knowledge; do they understand what you have been saying?
- 2) Students need to be pushed to work on problems on their own without ready access to answers. Students need to be asked more about HOW they arrived at their answer, what is the logic, how did they set it up, does the set up make sense, does the answer make sense? Do not confirm immediately if answers are right or not, let them think about it and confer with their neighbor.

Common concept	Activities	BIO 181	CHM 130	Calendar
<p>Metric system/conversions</p> <p><i>Problems:</i></p> <ol style="list-style-type: none"> 1) <i>students are not familiar with the metric system</i> 2) <i>students have poor math skills; powers of ten is a real challenge</i> 3) <i>students not used to working with equivalencies which supports dimensional analysis</i> 4) <i>students struggle with understanding volume, mass, length and how they are measured</i> <p>Both CHM and BIO cover:</p> <ul style="list-style-type: none"> • Metric – metric conversions • Metric – English • Emphasis on equivalencies • Dimensional analysis 	<p>The common packet is to serve as a standalone tool that students can use as a review of the metric system AND basic math skills.</p>	<p>Metric packet is handed out at the first meeting? Students work outside the classroom. It is then reviewed during the first lab? Used in first lab, instructors go over metric prefixes</p>	<p>The metric packet is made available (copies in classroom) or students are instructed to pull it off of blackboard or pick up at NASA center.</p> <p>Covered briefly at the end of Unit 1, but only as a review – students <i>should</i> have the math skills since MAT 082/092 are prerequisites for CHM 130.</p>	<p>First week for both</p>
	<p>Both BIO and CHM:</p> <ol style="list-style-type: none"> 1) indicate equivalencies/dimensional analysis is used in the other discipline/ class – students will get the same packet 2) it will be seen repeatedly as students take more chem courses 3) Conversions are important in allied health, exercise, nutrition, etc type careers – calculating meds, converting body weight from lbs to kg, calculating grams of protein, catbs, etc. 4) Direct students to NASA center or math lab for help on the packet 			

APPENDIX E
THEMES FROM MEETINGS AND INTERVIEWS

Themes and Theme-Related Components from Meetings and Interviews

Meetings	Description
Cross disciplinary exchange	Instructors sharing ideas about concepts and how they are taught specific to each discipline. Student learning issues come to light as instructional methods are reviewed. Professional development occurs as sharing information about content takes place.
Sharing of information	
Discussing general student issues and concerns	
Providing instantaneous professional development	
Collaboration	Instructors developing common materials and determining delivery in each course to address transfer. Exact same terminology is decided in addition to instructors mentioning importance of concept in other course or discipline.
Determining common concepts/materials/methods	
Discussing transfer issues related to current courses	
Considering transfer issues for subsequent courses, programs and jobs	
Implementation	Concerns about implementing in lab versus lecture which is dictated by curriculum schedule. A couple of instructors provide feedback concerning students recognizing common materials.
Indicating concerns related to classroom implementation	
Providing indications of student recognition of common methods	

Interviews	
Transfer	Providing students with exactly the same terms, materials and ideas about concepts helps students to learn.
Repeating concepts is important	
Utilizing same materials is important	
Professional development	Learning about content from peers provided review of content knowledge.
Relearn or learn content	
Characteristics of group	The group functioned effectively, it was enjoyable and sharing with colleagues about student issues was beneficial.
Worked well together, fun	
Sharing of frustrations about students	
Cross disc approach	Learning about content and approaches to instruction from the other discipline was beneficial and empowers instructors when students ask about the other discipline.
provided insight into other disc concerning content	
provides cohesive front to students	
Implementation	Concern about not implementing each method or material discussed but the group believes repetition of concepts, ideas and using common methods will help students.
Student learning issues	
Implementation of CoP methods	To improve effectiveness of the approach, documentation of meetings, methods decided is needed in addition to assessment. The project should be expanded to include other concepts and other disciplines such as math.
Future considerations	
Assessment needed	
Project should continue and expand	
Documentation needed	

Future considerations	To improve effectiveness of the approach,
Assessment needed	documentation of meetings, methods decided is
Project should continue and expand	needed in addition to assessment. The project should
Documentation needed	be expanded to include other concepts and other
	disciplines such as math.

APPENDIX F

NUMBER OF FACULTY OBSERVED USING COMMON METHODS

Number of Faculty Observed Using Common Methods

	Number of faculty
Metric system	
Handed out or made available the metric packet	100%
Mentioned tie to jobs in health field or other disciplines (physics, engineering)	67%
Mentioned tie to dimensional analysis	50%
Mentioned how metric system aligned to other discipline	100%
Molecular motion	
Used the term kinetic motion	100%
Used Brownian motion applet	50%
Referred to osmosis	50%
Referred to other discipline	50%
Energy	
Indicated chemistry focuses on Eth	100%
Energy transfers in and out of systems	100%
Used common terminology	100%
Used or mentioned the terms exergonic and endergonic	83%
Mentioned chem focuses on Eth	33%
Mentioned particles/collisions	67%

APPENDIX G
INSTITUTIONAL REVIEW BOARD APPROVAL



Office of Research Integrity and Assurance

To: Ray Buss
FAB

From: Mark Roosa, Chair *sm*
Soc Beh IRB

Date: 06/29/2010

Committee Action: Exemption Granted

IRB Action Date: 06/29/2010

IRB Protocol #: 1006005266

Study Title: Investigating an interdisciplinary collaboration between science faculty

The above-referenced protocol is considered exempt after review by the Institutional Review Board pursuant to Federal regulations, 45 CFR Part 46.101(b)(1) (2) .

This part of the federal regulations requires that the information be recorded by investigators in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects. It is necessary that the information obtained not be such that if disclosed outside the research, it could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.

You should retain a copy of this letter for your records.