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# Technology and Motivation : Can the use of Technology Increase Student Motivation in the Science Classroom?

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*The College at Brockport*

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**Technology and Motivation**

**Can the use of technology increase student motivation in the science classroom?**

by  
**Kelly M. Kinde**  
Fall 2007

A thesis submitted to the  
Department of Education and Human Development of the  
State University of New York College at Brockport  
In partial fulfillment of the requirements for the degree of  
Master of Science in Education

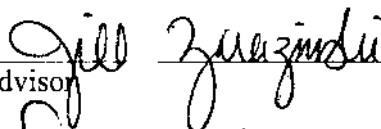
Technology and Motivation

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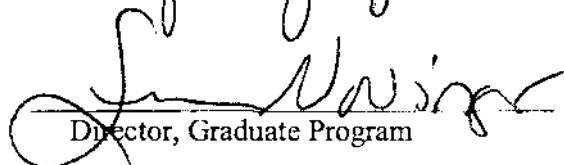
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## Chapter One: Introduction

Motivation refers to the forces that cause people to behave in certain ways. The students who spend the weekend in the library and the students who cannot wait to get out of class to go to the beach are both motivated, but they have different goals and interests.

Of course, motivation is not the only factor in student performance. To perform well, a student must also have the right abilities and resources (Broussard, 2002). Without motivation, however, even the most capable working student with excellent support will accomplish little (Boggiano, 1991).

### *Problem Statement*

Students in today's high schools feel disconnected from subject matter and the benefits of learning. Motivation and engagement are difficult to achieve in any classroom. Why do some people seem to be successful and driven while others seem to have trouble making themselves get out of bed in the morning? Where does that energy, direction or motivation come from? Motivation has been a topic of study for many generations and the reason is all people want to be successful.

Establishment of classroom conditions in which students are motivated to learn academic course content continues to be an important but elusive goal of educators. Teachers and administrators from all academic disciplines are continually perplexed by some students' limited efforts in the classroom. Why is this student not motivated to learn? What can be done to cause this student to want to know more?

While teachers seek answers, educational researchers provide few concrete solutions. In fact, despite its recognized importance, motivation continues to play a

curious role in instructional literature. While many studies ignore the concept altogether, others view student motivation as just another independent variable: a personality attribute over which educators have little influence. Motivation to learn in the classroom is rarely examined as a dependent measure: a factor which may be influenced in order to enhance learning. As a result, the knowledge of creating and sustaining student interest in learning pales in comparison to the knowledge of facilitating learning once the student wants to learn.

### *Significance of Problem*

As a teacher in an impoverished inner city school, I know it is hard to motivate students to learn. Many of my students are struggling with abuse, gang violence or caring for their own children. It is harder still to motivate students to learn material they do not believe will help them with future goals. The sciences are misunderstood by students today as a non-essential part of their future. The truth is that science is the driving force of modern culture. In today's world of high tech, high-speed communications, it is more critical than ever before for teachers to hook and hold students' interest in science, mathematics and technology.

### *Purpose*

The purpose of this study is to increase my own knowledge of motivational factors specific for my students and to share this information with my colleagues. In this study, I will investigate the research regarding student motivation, particularly pertaining to the use of technology in the classroom. It is my intention to not only use technology to present material to the students, but to also involve students in the use of technology for research, investigations and presenting what they have learned.



Teachers know that encouraging student interest and motivation for school-related learning activities is a complex task. Part of this complexity comes from the fact that students may have multiple goals or many and varied reasons for studying. The individual goals that are strived for through learning and achieving in school can be situated on two dimensions: intrinsic versus extrinsic goals and immediate versus future goals. In many places, student academic achievement is poor and behavior even worse. In my class in particular, there is a high percentage of students repeating a class, some for the second time. Often just getting them to sit down and not hurt each other is a difficult task. They see little point in academic achievement and science is a course for which they do not see a practical purpose.

#### *Rationale*

With the importance of education as a means of preparing the youth of America for their future role as active citizens and the rise of legislation such as the No Child Left Behind Act, it is increasingly important for all students to be successful. With this study, I hope to improve my own teaching skills and to reach more students through using motivational strategies and technology in my lessons.

#### *Definition of Terms*

Technology in schools can be the basis for positive changes in teaching and learning. Evidence studied by Bauer et al. (2005) indicates that when “used well, technology application can support high-order thinking by engaging students in authentic, complex tasks within collaborative learning contexts” (p.519).

Technologies that can be used for student-student and student-teacher communication include e-mail, instant messaging, listservs, blogs and discussion

groups. For presenting material and for students to demonstrate what they have learned, PowerPoint and web design are options. Students may search the internet for data for research projects after being taught how to recognize the difference between reliable and unreliable sources. Web Quests are activities that guide a student's online search.

Motivation is a desire to accomplish a particular goal, combined with the energy and intelligence to work towards the goal. There are two main types of motivation: positive motivation and negative motivation. According to Dweck et al. (1995), negative motivation or motivation by fear involves achieving goals because there will be undesirable results if tasks are not completed and positive motivation or motivation by self-interest, motivation by reward and motivation by desire involves personal interest or desire to achieve any particular goal.

### *Summary*

I want to know if increased motivation can lead to increased performance and better learning outcomes. How can teachers motivate students to learn in the science classroom? Can the use of technology in the classroom increase student interest? In this paper, I will explore the research regarding motivation, science teaching and the use of technology in the classroom. I will teach my students to use technology as a tool for their science learning and assess whether this has an effect on their participation and motivation levels in the classroom. I plan to measure student participation in class during traditional lessons and during technology-based lessons such as Web Quests, internet research and web design activities. With this

information, I intend to discover new ways of motivating students and therefore, student performance in my science classes.

## Chapter Two: Literature Review

The more learning is rewarding and enjoyable and the less it is boring or anxiety-producing, the more students will seek it for its own sake. Therefore, students' experiences in classrooms—motivationally and emotionally—are crucial to their attitudes, behaviors and achievement. Although an impressive amount of research has focused on students' motivations, especially on their perceptions of classroom environments, little is known about the relationship between students' affect and motivation, and their affective responses to classroom instructional environments.

### *Motivation*

As emotion theorists emphasized, when a goal is important to a student, it is likely to have affective associations. Whether a student seeks to engage in learning or to avoid it, such goals are affectively charged. Emotion is important as an outcome of experience, it also provides information about context, provides information about competence and offers an incentive for performance because students seek activities that are associated with positive affect. Yet, the affective meaning of classroom motivational experience has been largely ignored.

Although a few theories of motivation have communicated explicitly the relationship of motivation and affect, researchers have devoted more attention to motivational mechanisms than to the affect associated with them, with the exception of flow theory. Because flow theory explicitly incorporates affect in the study of motivation, it serves as the theoretical basis for the present research.

Csikszentmihalyi (1975) developed flow theory to describe the experiences of intrinsically motivated persons, those who were engaged in an activity chosen for its own sake. In contrast to other intrinsic motivation research that focused on behavioral outcomes, this researcher attempted to describe the quality of subjective experience or how persons sensed intrinsic motivation and to explain why such activities were rewarding. Those two components form the theoretical framework of flow theory.

According to flow theory, an activity is rewarding in relation to whether individuals find it attractive or challenging and whether they believe that they have the skills to accomplish it. Optimal experience, or flow, occurs when a person perceives the challenges and his or her skills in a certain situation as balanced and above average. When challenges and skills are unbalanced, such as when challenges outpace skills, an activity is not necessarily rewarding and could evoke anxiety. Various ratios of challenges and skills are predicted to be associated with different qualities of experience. When the challenges and skills are both high, the quality of experience is strong. When both the challenges and skills are low, the resulting experience is apathy. People become anxious when the challenge is high and their skills are low and become bored or uninvolved with low challenges and high skills (Aikenhead, 1992).

Flow theory has not gone unchallenged on either theoretical or empirical grounds. Theoretically, Wigfield and Eccles (2001) disagreed with the premise of flow theory, contending that students do not necessarily value optimally challenging tasks, but rather, tasks in which they believe they can succeed. Eccles and Wigfield (1995) found that task difficulty is related negatively to task value and ability

perceptions, suggesting that students perceive a challenge as a threat to their sense of competence.

At least two possible explanations exist for the contradiction about the role of challenge. First, the researchers measured challenge differently. Csikszentmihalyi, Rathunde and Whalen (1993) measured the level of challenge while Eccles and Wigfield (1995) measured task difficulty and required effort. It is also possible that challenge is perceived as a more positive term than difficulty. Second, Csikszentmihalyi, Rathunde and Whalen (1993) examined the quality of adolescent and adult experience, whereas Eccles and Wigfield questioned fifth through twelfth grade students. Although Eccles and Wigfield did not mention age-related differences, younger children may perceive challenge differently than do teenagers and adults. The interrelated nature of affect with the balance of challenge and skill in flow theory remains unclear; various forms of analysis may contribute to a better understanding of these relationships.

The relationship of other items on the student motivation scale (e.g., cooperative) to flow has been less examined and there has been no thorough, published examination of how such items are related to each other. Csikszentmihalyi, Rathunde and Whalen (1993) suggested six categories of items (affect, potency, cognitive efficiency, motivation, self-esteem and other), but did not provide empirical justification for these categories or the items that comprise them. The earlier researchers have addressed that issue by factor analyzing students' motivation responses, including affective ones, to determine how these items are grouped

according to the underlying factors responsible for their co-variation and how the factors are related.

Finally, much of the research on flow theory and affect has been conducted with talented teenagers in their talent areas. Results might have differed for students who participated in required classes rather than in elective classes. Csikszentmihalyi, Rathunde and Whalen (1993) found that talented teenagers were happier and more cheerful in school settings than were non-talented teenagers. That finding suggests that students in regular school classes, not necessarily in their talent area, might perceive the classroom environment differently than do students in classes involving their talent areas.

Although student characteristics play a role, a growing body of research demonstrates that instructional context also influences students' motivation, which includes perceptions of challenge, skill, competence and affect. Teachers help create classroom instructional contexts with feedback and evaluation, support for autonomy or control, provision of challenge, support for competence, emphasis on task importance, affective support and social support. Those strategies likely do not operate independently of one another to influence motivation and affect. According to Cothran (2000), it is more likely that students respond to the climate created by the holistic effect of the practices.

Research suggests that feedback is most useful when it is immediate, links success with effort and provides information about improvement and mastery. Providing substantive feedback about competence and goal progress increases self-efficacy, enhances interest and persistence, and increases intrinsic motivation.

Providing non-constructive performance feedback however, can result in diminished motivation. Non-constructive feedback practices, such as criticizing a person rather than a process, also can result in a more negative affect (Borgford, 1995).

Support for student autonomy can result in increased intrinsic motivation and increased happiness. Teachers can support student autonomy by minimizing external controls, allowing students to set goals and offering choices to students. Those practices facilitate conceptual understanding, promote self-efficacy and increase positive affect.

Because teachers encourage students to engage in activities that students choose, students are more likely to demonstrate heightened interest. Conversely, controlling behaviors can result in a negative emotional tone in the classroom. Teachers can create a motivational environment by imposing deadlines, emphasizing grades and performance rather than independent thinking and requiring set solution paths rather than allowing multiple solutions to problems. However, by permitting students to have personal control over their own learning, teachers can encourage positive affect, interest and motivation.

Csikszentmihalyi (1997) suggested that a balance between challenge and skill is the critical component for creating an environment for flow. Optimal challenge can be maintained through awareness of students' skills and provision of activities that students can accomplish with reasonable effort (Brophy, 1999). As students' skills improve, teachers should increase the difficulty of tasks. Challenges that are too great for students can result in anxiety and reduced feelings of success (Csikszentmihalyi, 1997). To maintain an optimal level of challenge, teachers can scaffold tasks, provide



enough time for students to complete tasks and condense long-term goals or large, difficult tasks into smaller units to temper the difficulty of tasks.

In addition to constructive feedback, other practices can support competence, such as using mistakes as learning opportunities and providing opportunities to demonstrate skill. According to Kazemi and Stipek (2001), by treating mistakes as opportunities to learn, teachers convey that understanding content (mastery) is important. By encouraging personal empowerment through similar mastery experiences, a teacher can create a strong, resilient sense of efficacy in students. In contrast, defining competence in terms of relative performance can diminish student interest. However, emphasizing mastery of material over performance is not enough to support student competence if students do not have the opportunity to demonstrate their competence. So, when teachers provide opportunities for students to succeed and to use practices that enhance feelings of competence (i.e., encouraging mastery of material rather than relative performance), then increased competence and positive emotions can result (Davies, 1984).

Activities in which students are most likely to seek the rewards of challenge and skill growth are those that they find personally important (Csikszentmihalyi & Nakamura, 1989). For example, applying chemistry to real-life problems can increase students' perceptions that chemistry is important, enhance students' enjoyment (Middleton, 1995) and stimulate students' situational interest (Csikszentmihalyi, 1997). Teachers also can emphasize the importance of a topic by pressing students to explain and justify their answers. Specifically, teachers can emphasize the relevance of tasks to life outside the classroom by encouraging students to form meaningful

conceptual relationships rather than to focus solely on procedures or algorithms (Kazemi & Stipek, 2001). When teachers present students with a clear idea of how tasks are important to their goals, they can encourage engagement and enjoyment (Csikszentmihalyi et al., 1993).

Students are more likely to engage willingly in activities that are linked to positive affect. Stipek and colleagues (1998) found that the affective climate of the classroom was the most powerful predictor of student motivation. In classrooms that provided a significant positive affective climate, students reported considerable intrinsic motivation, additional help seeking, positive emotions related to content and significant perceptions of task-specific competencies.

According to Stipek and colleagues (1998), teacher strategies that support or convey positive affect include expressing positive emotions toward and enjoyment of chemistry and showing sensitivity and kindness toward students. Teachers also can use humor to enhance the enjoyment and situational interest of students (Zillmann, Williams, Bryant, Boynton, & Wolf, 1980). Use of negative affect, such as threats, sarcasm, directives and imposed goals may result in decreased positive affect and less subsequent intrinsic motivation for the activity (Deci & Ryan, 1985; Turner, Midgley, Meyer, & Patrick, 2003). Many researchers have argued that, especially as students mature, they need positive relationships with peers and teachers. Cooperation, rather than competition, fosters a supportive social context. An emphasis on cooperation, through group work and encouraging students to help one another enhances personal relevance of content, intensifies its interest and increases students' commitment.

Conversely, social comparison and competition tend to decrease positive affect, instances of risk taking after failure, self-evaluation of ability and persistence.

### *Identifying and Correcting Misconceptions*

Misconceptions of the current nature of laboratory work include an over-emphasis on conceptual learning, the predominance of recipe-style laboratory work, a lack of attention to the development of investigation skills and subjecting students to information overload. Hodson (1990) has criticized much laboratory/practical work as being "ill-conceived, confused and unproductive" (p.33). He believes a major cause of this "unsatisfactory nature of much school practical work" (p.33) is because it is used unthinkingly, without any clearly thought-out purpose in mind. Hodson argues for a sharper focus on what students are actually doing in the laboratory and on the purposes of particular practical activities.

Woolnough and Allsop (1985) have warned of the dangers of carelessly mixing the knowledge and methodology aspects of science and of making laboratory work subservient to theory. They argue that the emphasis on developing concepts through laboratory work has had a detrimental effect on the development of science investigation skills. Likewise, Fensham (1988) believes that modern science courses have reduced the role of laboratory work to the enhancement of conceptual learning and have neglected opportunities for students to develop confidence and skills in applying scientific knowledge to solve problems.

Criticism has also been leveled at the predominance of recipe style laboratory work. Reports from the USA all indicate a predominance of recipe style laboratory work that is at the lowest level of openness to student planning. In a review of the

'20th century general chemistry laboratory', Lloyd (1992) indicates that a structured or 'cookbook' approach is still the overwhelming choice in laboratory manuals. These activities provide few opportunities to identify problems or formulate hypotheses and to design experiments or procedures; insufficient discussion of limitations and underlying assumptions; and inadequate provisions for discussion, analysis and consolidation. In a more recent review of the way in which laboratory work is used, Tamir (1990) criticized the low level of inquiry in most laboratory activities. Students are usually provided with the problem and procedures and their role is restricted to the collection of data and, sometimes jointly with their teacher, drawing conclusions. Merritt, Schneider and Darlington (1993) also questioned the nature of many general chemistry laboratory experiments as an 'unrealistic portrayal' of chemistry experimentation. They proposed a change in emphasis with greater involvement of students in planning their experiments. Hodson (1988) has proposed that more attention be placed on affective outcomes and recognition of the role of laboratory work in developing students' self-esteem and confidence in their ability to solve problems (Bennett, 2003).

Johnstone and El-Banna (1986) found that when students had to deal with large amounts of information in a chemistry laboratory session, the reporting of their observations was purely descriptive and lacked evidence of appropriate levels of interpretation and understanding. Johnstone and Letton (1991) claim that a reduction in the amount of new information presented leads to improvements in 'students' learning. They recommend careful matching of laboratory manual descriptions with the actual requirements; improving laboratory manuals by using an open layout and

icons; encouraging students to read the laboratory manual prior to the laboratory session; and structuring laboratory activities so that an open-ended investigation follows earlier sessions which introduce necessary prior knowledge (Dweck, 1988).

Research indicates that many school students perform poorly when faced with a laboratory investigation. A recent study (Hackling & Gamett, 1993) compared the performance of school students, university students and research scientists on a practical, laboratory-based, science investigation task. The study examined the problem solving processes used by year seven, ten and twelve school students, third year undergraduates and research scientists when conducting a laboratory-based science investigation. The performance of subjects was analyzed on four phases of an investigation relating to the design and building of bridges: problem analysis and planning; collecting information; organizing and interpreting information; and concluding.

The features most evident among experts on this investigation were: extensive problem analysis and up-front meta-planning; careful, standardized and repeated measurements; thorough control of variables; active meta-cognitive control over data gathering procedures; extensive data collection and use of recording/graphing procedures to investigate relationships; cautious data interpretation and generalization; and awareness of methodological limitations. While there was a gradual improvement in investigation skills across school and undergraduate levels there appears, even within a developmental framework, to be serious deficiencies in the acquisition of some of the critical skills needed to conduct science investigations. School students generally demonstrated a poor level of performance on skills relating

to problem analysis and planning, carrying out controlled experiments, basing conclusions only on obtained data and recognizing limitations in their methodology.

Roth and Roychoudhury (1993) investigated whether student-centered, open-inquiry laboratory work facilitated the learning of higher order process skills and whether these skills developed holistically within a problem solving context without being taught explicitly. In a study with year eight science and year eleven and twelve physics classes they found that open-ended inquiry laboratories resulted in considerably improved skills of identifying variables, hypothesizing, planning and carrying-out experiments and interpreting data. In this study these cognitive skills seemed to develop gradually and holistically without being taught explicitly.

An elegant study by Toh (1991) investigated the effects of both explicit instruction and practice on students' performance in planning and conducting investigations. The instruction was provided over an eight week period using a Karplus learning cycle. The results of the study indicated that both the explicit instruction and practice were significant factors in improving students' performance on investigation tasks. The effect of explicit instruction was most marked on the students' performance on 'planning' outcomes.

The performance of students on the conducting outcomes of investigations improved both for students who had experienced just practice or instruction plus practice. This was interpreted to mean that students who received no instruction, but experienced practice achieved 'tacit' understanding which the students could not articulate in the formal assessment of planning, but was sufficient to enable them to successfully conduct the investigation.

It is mandatory therefore for the chemistry teacher to clarify the meaning of terms used during teaching. One sure way to doing this is to compare and contrast the meaning of terms in chemistry and how they are used outside chemistry classes. Introductory lesson--involving any difficult terms should highlight and explain their meanings. It is here advised that the use of English dictionary and chemistry or science dictionary should be used side by side.

The teacher should evolve a strategy of ensuring an indiscriminate use of these with a view to clearly expose differences between like-terms in chemistry. Students should be encouraged as well to put such terms into use often within and outside the classroom as a means of bringing out their proper meanings to aid their understanding. Authors of chemistry text books and other teaching materials can help too to improve on the understanding of identified difficult terms. This they can do by explaining these terms rather than the present practice of either just defining or using them only in problem solving. It would be helpful to bring out their meanings or interpretation through illustrations.

Another potent way of helping students to understand these technical terms is through demonstration and experimentation. For instance the term "solution" can be demonstrated easily in the laboratory and references made to another situation needing solutions to problems such that the distinction would be clear. In fact simple demonstrations and experiments can help to illustrate the meanings of technical terms like boiling, burning, oxidation, spirit, alcohol, solution and so on.

In addition, the resourceful teacher can give simple projects with the aim of understanding the meanings of given technical terms. Once these terms are clearly

understood the student would come to realize that chemistry as a field of study enables man to harness all natural resources to his advantage (Bahr, et al. 1993).

Most chemistry educators would agree that laboratory work has a crucial role in chemistry education. The development of the National Science Statement and Science Profile provides an impetus for us to review the ways in which we use laboratory work to achieve the objectives of chemistry courses. Previously it was argued that laboratory work has been used extensively to facilitate conceptual learning and that insufficient emphasis has been placed on the development of investigation skills. If high school and undergraduate students are to improve their investigation and problem solving skills they need more laboratory work provided within the context of investigations. Such investigations would provide students with enhanced opportunities to practice the skills of problem analysis and investigation planning, conducting investigations, data analysis and interpretation, concluding and evaluating findings. Opportunities for investigation-style laboratory work can be found in each of the five types of chemistry laboratory work described above, although examination of relationships, synthesis and analysis are probably more suited to the use of an investigation framework (Cannon, 1929).

Clearly, as argued by Hodson (1990), different laboratory experiences are appropriate in different situations and to achieve different objectives. What is proposed here is a greater recognition of the breadth of the potential outcomes of laboratory work to ensure that laboratory experiences do not focus solely on conceptual learning and the acquisition of various laboratory techniques, but also facilitate the development of investigation skills. In other words, laboratory



experiences should not only be planned to 'fit in' with the theoretical work being taught at a particular time, but should also be considered to have a central role in the teachings and learning of investigation and problem solving skills. Greater attention needs to be placed on these objectives, as well as identifying how best to facilitate their acquisition through appropriate learning experiences and indicate their importance to students through appropriate forms of assessment.

Providing explicit instruction in investigation skills combining some of the ideas of Gott and Murphy (1987) and Millar (1991) suggests that to be successful at planning and conducting investigations students need to be able to apply:

- conceptual knowledge;
- general cognitive processes like observing and classifying;
- procedural knowledge, like understanding how to go about an investigation;
- inquiry tactics, like identifying variables, interpreting data; and
- laboratory techniques like measuring temperature or using a burette.

At a level of sophistication appropriate to the investigation task. There is a need to provide students with experience in procedural knowledge and skills associated with the planning, conducting, data processing and evaluating phases of science investigations. The extent to which explicit instruction is beneficial in developing investigation skills remains an open question.

Millar (1991) has argued that the general cognitive processes such as observing, classifying and hypothesizing are largely 'programmed in' and cannot and should not be 'taught' in the sense of being learning outcomes in their own right. However he interprets procedural knowledge as a 'toolkit' of inquiry tactics and

practical techniques which can be taught and learned. The Roth and Roychoudhury (1993) study identifies student experience in appropriate contexts as the crucial ingredient in improving students' performance in planning and conducting investigations, but Toh's (1991) study supports the view that explicit instruction can be beneficial.

While it is important that teachers and students have a clear understanding of objectives within this area it is also important to guard against what Woolhough (1991) has described as "atomistic assessment" patterns which have been adopted in the U.K. This is an attempt to reliably measure highly specific predetermined scientific skills in a manner which Woolnough regards as being both administratively unworkable and educationally invalid. In other words, assessment of this area should be holistic and focus on the student's overall performance on scientific investigations (Cameron, et al. 1994).

Woolnough and Toh (1990) have identified a strategy for assessing investigations holistically which can be reliable, valid and feasible in whole-class situations. This strategy requires students to write a report under six sections which the authors believe outline the stages of a typical investigation; preliminary thesis, planning, performing, interpreting, communicating and feedback. Three forms of report sheets were trialed using instructions with differing levels of specificity; uncued, broadly-cued and fully-cued. The authors concluded that the broadly-cued report sheet had the greatest potential as an instrument for assessing performance on investigations in a holistic manner. Student performance with the broadly-cued report

sheet correlated most strongly ( $r = 0.8$ ) with a one-to-one observational assessment of student performance.

Students need to be provided with opportunities to conduct more investigation-style laboratory work. Woolnough (1991) argues cogently for providing students with investigations rather than focusing on the individual skills which together can be considered to comprise the ability to undertake investigations. Investigations may be of differing levels of complexity, may be short or extended and may be related to the examination of relationships, chemical syntheses or analyses. However, the structure of investigations should involve students converting a 'problem' into a manageable task, planning a scheme of work, executing the scheme, interpreting the data and coming to a conclusion.

The literature reviewed shows that most elementary students begin their academic career with a desire to learn and with an intrinsic approach to achievement (Entwisle, Alexander, Cadigan, and Pallas, 1986). It has been revealed that an intrinsic orientation toward education switches to a more extrinsic orientation as students increase in age (Goldberg, 1994). Often educators complain that students are unmotivated to learn; parents echo this cry and each blame the other for the students' apathetic response to learning. If schools and parents focused on the different parts of academic motivation and developed meaningful programs, across the home and classroom, possible gains could result (Niebuhr, 1995).

According to Hammer (2003) the home environment is as important as what goes on in the school. Important factors include parental involvement in their children's education, how much parents read to young children, how much TV

children are allowed to watch and how often students change schools. Achievement gap is not only about what goes on once students get into the classroom. It's also about what happens to them before and after school. Parents and teachers have a crucial role to play to make sure that every child becomes a high achiever. Parental influence has been identified as an important factor affecting student achievement. Results indicate that parent education and encouragement are strongly related to improved student achievement (Wang, Wildman, & Calhoun, 1996).

Phillips (1998) also found that parental education and social economic status have an impact on student achievement. Students with parents who were both college-educated tended to achieve at the highest levels. Income and family size were modestly related to achievement (Ferguson, 1991). Peng and Wright's (1994) analysis of academic achievement, home environment (including family income) and educational activities, concluded that home environment and educational activities explained the greatest amount of variance. In conclusion denying the role of the impact of a student's home circumstances will not help to endow teachers and schools with the capacity to reduce achievement gaps (Hammer, 2003).

Allen and Kickbusch (1991), found that the higher-achieving students plan to continue their education after graduation from high school, participate extensively in extracurricular activities, have a few absences each school year, more likely to engage in recreational reading and to check books out of the school or public library on a regular basis, watch less television, spend more time each evening doing their homework, have friend who have positive attitudes toward school and who rarely cut classes or skip school, have positive feelings about their teachers and about specific

courses they take and attribute success in school to hard work rather than ability. This study attempted to reveal the relationship between motivation, family environment, student characteristics and academic achievement.

In considering subject-area differences in students' motivation, a fundamental question relates to the degree to which students' perceptions and beliefs vary across those domains. The question reflects a larger set of assumptions about whether student motivation reflects an individual personality, a dispositional difference or a response to given contextual influences (Cassidy, et al. 1991).

Those issues are important not only for the development of theory, but also because of their differing implications for instructional practice. If one assumes that motivation reflects fairly stable individual differences that generalize across contexts, educators are somewhat absolved of any responsibility for trying to improve their students' motivation. At best, teachers might be expected to provide somewhat different educational experiences for high- and low-motivated students, in a manner similar to ability-based academic tracking. In contrast, if one assumes that students' motivation is malleable and influenced by characteristics of the context that are under the control of teachers and administrators, the possibility and responsibility for intervention becomes apparent.

If high-quality motivation programs can identify causal associations between specific instructional practices and students' motivational beliefs in various subject areas, teachers should be able to promote more adaptive beliefs through attention to the design of instruction and assessment activities. Bong's (2001) findings that various motivational beliefs vary in the degree to which they generalize across

domains suggest that at least some important beliefs may be responsive to contextual influence and, thus, provide support for the latter position.

As noted earlier researches have documented consistent mean-level differences in students' motivational beliefs and perceptions in science learning. If, however, one accepts the notion that different school subjects represent various communities with their own histories, pedagogical traditions and status a more complex understanding of students' motivation must include beliefs within a given domain context, rather than just a simple comparison across domains. That is, there is a need to understand the unique nature of motivation for different domains, including cultural norms for how different subjects are taught, what constitutes participation and learning and how progress is evaluated.

This research paper addresses such questions directly in relation to the areas of learning science. The articles also raises important questions about a different aspect of the ability to generalize; that is, whether current theoretical models of motivation hold up across different subject-area contexts and whether the meaning of a particular construct is the same in different domains. For example, researchers suggest that there may be aspects of reading motivation that are unique to reading as a subject because of characteristics of reading instruction and performance, which are not common in other subjects. Thus, the growing focus on motivational and learning processes within subject areas may lead eventually to some revision of the more general theories of motivation presently accepted in the field.

The more complex and contextualized approach to studying motivation within science domains also has methodological implications in that classroom-based

research, often in the form of some kind of intervention and closely linked to curriculum issues, becomes necessary. Such studies often require that researchers work with teachers and in classrooms over time and use multiple methodologies including both quantitative and qualitative approaches in their work. Again, the articles in this Special Issue reflect those patterns. Researchers have reported a set of findings from a large intervention study that they designed to support students' reading motivation through instructional practice. Chen and Ennis describe a program of research examining associations between various motivational beliefs and learning in physical education, framed within the larger call for curriculum reform in that domain. Finally, the research in motivation and education provide rich descriptions of classroom practice, focusing on particular aspects of instruction and their implications for students' motivation. Patrick and Yoon (2004) examine students' motivational beliefs and conceptual understanding in the context of an inquiry-based science curriculum. Other researchers, in contrast, focus on the question of optimal challenge in chemistry instruction and emphasize the delicate balance between academic press and support that is needed to foster and maintain students' motivation.

### *The Relationship between Motivation and Learning*

Intuitively, people know that whether or not they want to do an activity affects their level of success. Within educational research over the years, science interest and motivation have been shown to be some of the most important factors in predicting success in science and chemistry classes (Eccles & Jacobs, 1986; Reynolds & Walberg, 1992). In discussing Flow Theory, Hektner and Csikszentmihalyi (1996) describe how optimal experience occurs when people do intrinsically rewarding

activities in which they feel optimally challenged relative to their level of skills. In other words, students are inwardly motivated regardless of subject area or nationality by situations which are not difficult, but also not simple.

The term motivation is derived from the Latin word meaning to move. It might be argued that motivation involves anything that moves an individual to action and, in the case of schools, what moves an individual to learn. Ames and Ames (1989) describe motivation as the impetus to create and sustain both intentions and goal seeking acts. Despite these insights, the term 'motivation' is incredibly difficult to define. Maslow (1970) considers motivation to relate to a number of basic human needs such as to achieve a goal in his educational and professional career. Oxford and Shearin (1994), in an analysis of 12 motivational theories or models, identify six factors that relate to motivation. These factors are attitudes, beliefs about self, goals, involvement, environmental support and personal attributes. The recent systematic review of the impact of summative assessment and tests on student motivation for learning by Crick & Wilson (2005) acknowledges that "motivation is a complex concept" that "embraces... self efficacy, self regulation, interest, locus of control, self esteem, goal orientation" (p.368). It would seem that motivation cannot be conceived as a single entity. There can be some confusion between the terms 'disaffection' and 'disengagement' since they are so often used synonymously (Boggiano, 1991).

Some of the students may display behavioral difficulties in classes that they see as particularly irrelevant. Others, however, may not show behavioral difficulties. These pupils may even appear to be engaged with the learning process, but this is simply an alternative tactic in 'playing out time'. Such participation, however, is



likely to be minimal – enough to please the teacher and keep people ‘off their back’ . In this instance, such pupils are de-motivated to learn, but motivated to achieve minimum hassle. A disengaged pupil is one who has lost connection with the learning process. Such pupils may well see the point to learning, value their education and, indeed, be motivated to learn. However, they may have, for example, an emotional problem that is acting as a barrier to their learning. In this case, were the emotional difficulty to be alleviated, they would be likely to re-engage with learning. A number of definitions of motivation currently exist. These have varying emphases and have largely emerged from theoretical considerations. There is evidence that the degree of motivation or de-motivation individuals feel affects their levels of engagement with a task, enjoyment of activities, how and what they learn and ultimately their performance. Given that de-motivation can lead to disaffection with, and even disengagement, from learning, what pupils themselves have to say about their motivation to learn or not is an important prerequisite for informing teaching practices in the classroom.

A number of meta-analyses of research in the field have been conducted. For example, Cameron and Pierce (1994), Black and Deci (2000) and Rummel and Feinberg (1988) all highlight the complex nature of the motivational process. While much evidence points to the adverse effects of extrinsic rewards (including praise) on intrinsic interest and creativity, there is also an ongoing debate about whether or not extrinsic motivators are always necessarily bad. When tasks are perceived as boring and incentive is low, there is evidence to suggest that extrinsic rewards may have the effect of increasing the probability of task completion. The majority of studies in the

area have also made use of an experimental design. Much less research has been conducted in the natural setting of classrooms (Cathryn, 2004).

The research, moreover, has traditionally examined the effect of contingent reward on subsequent involvement in a particular activity. There appears to be little research that explores the views of pupils regarding their own motivation and what works for them. Various writers suggest that a positive motivation towards learning is a disposition of all learners. Maslow (1970) suggests a hierarchy of needs that he thought had to be fulfilled and that a need to learn is one such human fundamental. McCombs (1991) cites previous studies and argues that learners of all ages have to be naturally quite adept at being self-motivated and at directing and managing their own learning on tasks they perceive as interesting, fun, personally meaningful or relevant in some way.

A fundamental theme running through a holist/constructivist approach to learning is that integrity is a primary characteristic of the human mind. An argument exists, therefore, that humans are inherently motivated to learn and psychoanalytic psychologists such as Freud, Adler, Jung and Erikson among others, have explored these intrinsic motives within people. However, behaviorist psychologists such as Pavlov, Skinner and Thorndike, were interested only in extrinsic factors that influence motivation. Further dichotomies of this internal and external kind exist. Cannon (1929), for example, refers to homeostatic and non-homeostatic mechanisms. Some actions, such as changes in body temperature, occur automatically (homeostatic), while others require the person to engage in some kind of agentic behavior (Bruner, 1996).

Hunger requires us to act in a conscious manner (non-homeostatic). However, whether it is wise to delineate the debate and discuss the concepts of intrinsic and extrinsic motivation separately is debatable. Intrinsic motivation may be the result of numerous extrinsic requirements. Actions occur when the internal and the external factors work together to engender a particular behavior. It is likely, therefore, that motivation is the result of interplay between the two. The work of Carol Dweck may be of interest with respect to this internal/external relationship in motivation. According to Dweck (1995), learners can hold one of two quite different implicit beliefs related to learning entity and incremental. She suggests that these beliefs have a different impact on how individuals approach learning and teaching. Entity theorists believe that intelligence is fixed and, although they believe that they can learn new information, they also believe that this will not alter their overall intelligence level. Thus learners holding entity beliefs may explain their failure in terms of lack of ability rather than lack of effort.

On the other hand, incremental theorists focus more on behavioral factors as the causes of failure and they believe that intelligence can be cultivated through effort. Setbacks motivate them to continue to work toward mastery of the tasks (Crick, 2005).

Dweck and Leggett (1988) suggest that, when learners are faced with failure, they respond in particular ways depending on the theory of intellect that they hold. Some learners are performance-orientated and perceive failure as a direct result of their lack of ability. Other pupils are mastery-orientated and perceive failure as a direct result of their lack of effort. Learner motivation, therefore, is affected

differently by the experience of failure, depending on the theory of intellect that is held because it shapes attitudes to achievement and explanations of progress. A learner who is mastery-orientated may be highly motivated by failure because they are more likely to believe that if they simply try harder, the task can be achieved. The importance in this work lies in the implication that, despite inherent dispositions towards particular aspects and ways of learning, learners are not born with particular beliefs about intelligence or learning. These beliefs are formed through the experiences of and interaction with the environment in which one finds oneself. McLean (2003) suggests that given that beliefs are created, teachers may be in a position to influence positively the beliefs that learners hold. While intrinsic motivation cannot be coerced, it can be facilitated.

#### *Technology as a Tool for Motivation*

Therefore, if motivation is low, and motivation is needed for success, how then can higher motivation be achieved? As mentioned previously, our world is becoming more and more high-tech. Bauer & Kenton (2005) assert that students today from all walks of life are quite computer-savvy, sometimes more so than give them credit. Why not attack the information age head on and motivate the students with the media with which they are so familiar?

Several studies have already been performed in which technology is used to motivate student learning. In one study, Hsu (2004) set up a web-based learning environment to facilitate and encourage communication between students on a cooperative learning science inquiry. Goldberg, Foster, Maki, Emde, & O'Kelly (2001) demonstrated that cooperative learning itself can increase student motivation

and success rates. This study, which took place in Taiwan, looked at test scores, informal observations and semi-interviews. The internet was reviewed as source of collecting information, along with student communication and cooperation as tools for learning. After four web-based lessons, students of all levels showed a statistically significant increase in motivation and performance. Students categorized as having low science processing skills made the most rapid progress in building their science process skills (Bybee, 1985).

In Louisiana, Magoun, Eaton, & Owens (2002) sought to change the attitudes of young girls regarding information technology by offering a three week, residential computer science program involving mentoring and hands-on activities. A Computer Attitude Questionnaire was employed before, during and after the experience, to discover any changes in attitude, motivation and success. Negative attitudes toward chemistry and science in general were correlated with lower success rates in these areas before the program. Higher levels of motivation and more positive attitude were strongly correlated with better performance in computer science after the program (Deci, 2000).

Many students simply do not seem to find science lessons particularly interesting or see the purpose of their end result. This concern is not new. Researchers dating back to the 1920s cite similar worries. During the last twenty years or so a number of changes in science teaching have occurred. One of the most significant of those changes being the development of a wide range of materials which use contexts and applications as a starting point for developing an understanding of scientific ideas. Such approaches are variously described as context-based, applications-led or

STS (Science-Technology-Society). Examples of curriculum development drawing on such approaches can be found in materials ranging from small teaching units to whole courses, developed on local, national and international scales and for all age ranges from primary through to tertiary. A key aim of these approaches is to stimulate young people's interest in science and to help them see how it relates to their everyday lives. Given the aspirations of these approaches and their widespread use, it is important to examine their effects in a systematic way. This report therefore presents the work undertaken for a systematic review of the effects on pupils of teaching approaches which emphasize placing science in context and promote links between science, technology and society (STS). Students using such materials might find out about the electromagnetic spectrum through learning about medical techniques for seeing inside the body or explore the views of different members of a community on the impact of locating a chemical industry nearby.

Aikenhead (1994) has produced a detailed overview of STS approaches and materials and how they draw on contexts and applications to develop ideas about science, technology and society. The term context-based approach appears to have been applied to some of the activities in school science classrooms for a little under twenty years. From the early 1980s, context-based approaches started to appear in mainstream science courses and these are now in widespread use in a number of countries. Courses using context-based and STS approaches are characterized by one or both of the following aims: to help young people appreciate how science relates to their current and future lives and to stimulate interest in science, possibly with a view to encouraging more young people to continue their study of science beyond the

compulsory period. Additionally, they tend to be characterized by a broader range of teaching strategies than the traditional teacher exposition and practical work associated with science teaching. Research into the effects of context-based and STS approaches falls into three main areas (Bauer, 2005).

The most significant concerns pupils' affective responses. A number of people working in science education, particularly those involved in the development of the associated curriculum materials, have argued that these responses are motivating for pupils. Within this, one area of focus has been to explore their effects in relation to gender, with context-based and STS approaches being seen as a means of encouraging more girls to be interested in science. Barker & Millar's (2000) research has focused on the development of pupils' understanding of scientific ideas as a result of following context-based and STS approaches. The final strand has explored aspects of teachers' responses to and use of, materials incorporating context-based and STS approaches such as with Borgford (1995). Broadly speaking, the claims made by the research are that pupils following context-based and STS courses develop an understanding of scientific ideas which is at least as good as that of pupils following more conventional courses and that such approaches do appear to motivate pupils in lessons.

Will this be time well spent for our students? The answer is a resounding YES. With a growing gap between the technology 'haves' and the 'have-nots', school is the best place to level the playing field. Our students' future careers will depend on the ability to use technology for many purposes, not the least of which is communication. So, just like teachers are encouraged to promote literacy in all

subject areas, researchers such as Huang & Mullinix (2002) assert that teachers should also encourage computer literacy in all subject areas.

### *Summary*

In summary, research motivation and student success suggests that self-efficacy is positively related to a host of positive outcomes of schooling such as choice, persistence, cognitive engagement, use of self-regulatory strategies and actual achievement. This generalization seems to apply to all students, as it is relatively stable across different ages and grades as well as different gender and ethnic groups. From these findings, it seems clear that self-efficacy beliefs are related to several of the other academic enablers reviewed in this miniseries. In particular, self-efficacy has been associated with increased persistence relating it to engagement.

Research has also been reviewed suggesting that self-efficacy promotes adaptive strategy use such as self-regulation suggesting that students with high self-efficacy beliefs will also be likely to use adaptive and appropriate study skills. In terms of social behavior, less is known about the relation between academic self-efficacy and peer relations. However, recent research suggests that both perceived social competence and the endorsement of social responsibility goals (adhering to social norms or rules) are associated with higher reports of academic self-efficacy. Having positive self-efficacy is adaptive for school learning and achievement as well as other academic enablers, suggesting that schools should seek to develop positive self-efficacy beliefs in their students.

The concept of intrinsic versus extrinsic motivation is prevalent within social-cognitive models of motivation and is thus included in this review of motivation as an



academic enabler. Intrinsic motivation is defined as motivation to engage in an activity for its own sake, whereas extrinsic motivation refers to motivation to engage in an activity as a means to an end.

## Chapter Three: Applications and Evaluation

### *Introduction*

Once I had finished my review of the literature regarding motivation and learning and of technology use as a tool for motivation, I was eager to begin my own study. My action research began a few months into a new position as a science teacher in a local school. I selected the most challenging class in which to introduce the use of technology by the students. I had a tough road ahead of me. These students were challenging my strength, my endurance and my classroom management ability. If technology could motivate a group of students to learn science, I might have a chance to reach this difficult group.

### *Participants*

The school at which this study took place is an experimental small school model in an inner city school in Central New York State. The 2006-07 student population consisted of 558 students in seventh through twelfth grades. The school racial breakdown was 75% Black, 18% Hispanic and 7% White. The student body had 61-70% of the students as members of families whose primary means of support is a public welfare program.

This school is located within what is commonly considered one of the roughest school campuses in the city. I started in January as the fifth teacher in one school year. The teacher they had the longest (three months) was certified to teach history. Discipline is a daily issue and apathy is rampant. These students have had no consistency during this school this year and are used to people leaving and giving up on them. In the beginning, my biggest task was establishing trust. Following that,

getting and keeping their attention was my focus. It took a long time to convince most students that the past would not repeat itself. Some were likely never convinced. As a first year teacher, I was struggling to maintain behavior and cover material, but I had come to believe that lack of motivation was probably the largest problem in this class.

In the seventh grade, there were 145 students, 82 male and 63 female. The curriculum for seventh and eighth grade science is a spiral model, of five major areas within science, culminating with the New York State eighth grade science assessment. In the seventh grade science class in this study, there were 27 students registered, 13 male and 14 female. One of the females left to join the young mothers' program and two never attended in the time I was there, so in effect, there were 24 in the class. This class included three students with an IEP, four others who were repeating seventh grade and two others who were repeating seventh grade for the second time. Many of these students had behavior issues, even before being in such a disruptive environment as this school year had been. The class meetings were two out of every three days for 55 minutes. Getting to know my students, I found that e-mail; IM, ipods, MySpace and such were their mode of communication with each other and the world. I thought maybe this could get them into school work, science in particular.

### *Instruments for Study*

Because the parents of my students rarely sign and return any paperwork given to them regarding their children, I had to rely on data that was in existence, (student grade reports and work), with no use of student names or identification of any kind. Any other data was my own reflective writing in a journal which I also do

daily regardless. Because of all this my study falls under the Exempt status according to the US Department of Health and Human Services (See Appendix). The exempt status allowed me to conduct this research as stated above without parental consent forms.

To study changes in motivation, I selected two sources of data. The first source was student work and the second was teacher observation of students. Several assignments were assessed that occurred before significant use of technology in the classroom and several that involved student use of technology. Student work was assessed to find average grades and the percent of students not participating per assignment. Student attitudes were assessed informally by teacher journaling. In my journal I recorded overall attitude in class during the assignment, number of students on task and comments regarding their attitude. Students rarely keep their thoughts to themselves. If they think something is boring, stupid, (or worse adjectives) or cool or fun, it is spoken aloud.

### *Procedures of the Study*

The first two assignments involved individual work followed by teacher lead group discussion. The next three were independent student work. The next assignment was a longer term group project, where students were to do research on one body system per group. This was followed by two days in the computer lab during which the students were shown how to make a web page to share their results. Several assignments followed involving independent and pairs work. Finally, there was a four class period project in the library computer lab on a Web Quest.

This research assessed the assignments in two ways. One important factor was performance. The other important factor was participation. Many students earned a zero on assignments and any zeros were considered a lack of participation. These percentages were recorded per assignment. I felt this would be an accurate way of gauging motivation. I kept a chart each day that recorded the type of assignment, whether it occurred before, during or after a tech-heavy lesson. I also recorded how many students were present and how many received a zero. Figure one shows the tally I kept of student grades and participation for sixteen assignments. There were six assignments before use of the computer lab. There was one computer lab assignment, followed by five assignments that I classified as after tech use. Finally there were the four days of Web Quest activity.

I wrote in my journal each day after lessons with my seventh grade science class. My journal entries focused on general attitude and mood of students. I did note which students tended to not participate, but used a code known only to myself so that they would not be identified should anyone ever read these notes. I wrote about the general tone of the day, were most students on task or in a wild mood. I wrote about whether students seemed to understand their tasks and whether they seemed bored with the topic or method of delivery.

## Chapter Four: Results

I was very excited to see a change in my students as time went on. I was also curious to see whether the use of technology would motivate them to participate more in class. I did see a trend of better behavior and more participation over time. The data that follows includes the students' work in the class and my own observations.

### *Student Work*

Table One is a chart of raw data student work used during this testing period.

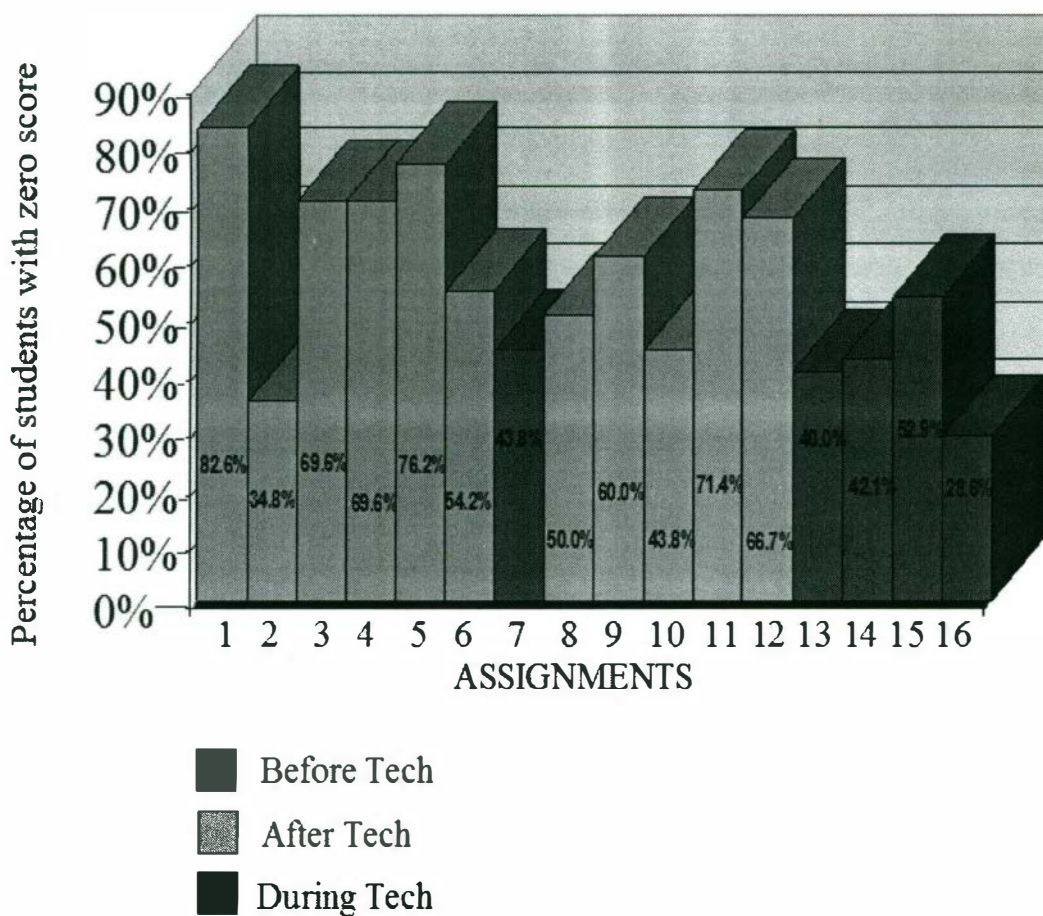
Table One: *Assignment Tally Chart*

#	Assignment Type	Number of students with zero	Number with 50% or better	Number present in class	Before (B), During (D) or After (A)
1	independent work followed by group discussion	19	4	23	B
2	independent work followed by group discussion	8	15	23	B
3	independent work	16	7	23	B
4	independent work	16	7	23	B
5	independent work	16	5	21	B
6	group project	13	11	24	B
7	web pages	7	7	16	D
8	independent work	9	6	18	A
9	independent work followed by group discussion	12	8	20	A
10	independent work followed by group discussion	7	7	16	A
11	independent & pairs work	15	6	21	A
12	independent work	14	5	21	A
13	Web Quest: Project Day 1	8	6	20	D
14	Web Quest: Project Day 2	8	8	19	D
15	Web Quest: Project Day 3	9	8	17	D
16	Web Quest: Project Day 4	6	11	21	D

Table One lists the type of assignments with the number of zero scores (no participation), the number of 50% or better (moderate participation), the number of

students present in class (to help me calculate percentages) and whether the activity occurred before, during or after computer lab work. It is hard to see from a chart such as this any trends in the data. Following are two graphs that I used to analyze the student work data. The first graph charts the percent zero grade per assignment (see Figure One).

Figure One. *Percent Zero Grades by Assignment*



Each assignment is numbered in the sequence in which it occurred and the colors indicate whether the assignment occurred before, after or during a lesson

involving the use of technology (see Figure One). There is clearly a lot of variation from one assignment to another. You can also see that overall, the trend was toward fewer zeros as time went on. It was also apparent that the technology assignments had the fewer zero scores than nearly every non-technology assignment.

My second graph compares the assignments by category (see Figure Two).

Figure Two: *Average Percent Zero Grades by Assignment Type*

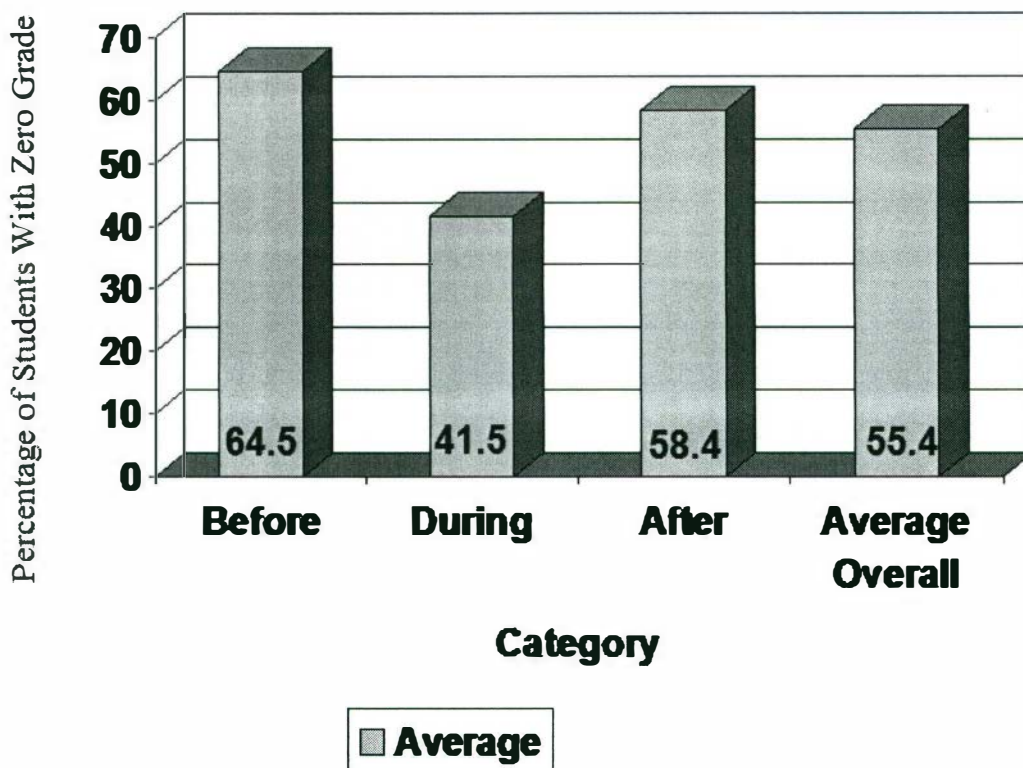


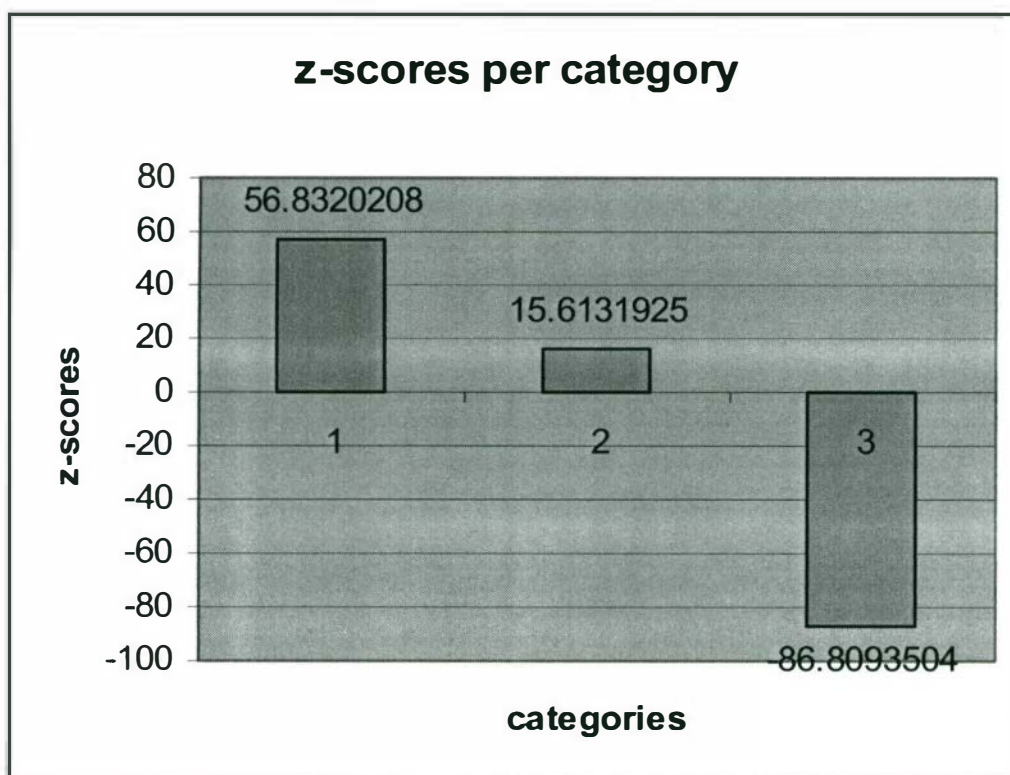
Figure Two combines the percentages from the three different categories (before, after, or during a lesson involving the use of technology) placing them side by side with the overall average zero grade percentage. By simple observation, it appears that the students participated more during technology lessons than before any



such lessons were used. It also appears that student participation increased in the non-technology lessons that followed the first tech lesson.

My next step was to compare the different assignment categories using z-scores, one of the statistical techniques used to determine whether two or more means differ in a statistically significant way. My calculations showed that the three category means did differ significantly from the overall mean (see Figure Three).

Figure Three: Z-Scores by Category



In category 1, the “before” category, the z-score was 56.8320208. This high positive number indicates that there were many more zero scores before the technology assignment. In category 3, the “during” category, the z-score is -86.8093504. This high negative number indicates that there were far fewer zero scores during the technology assignments. In the “after” category, the z-score is

15.6131925. While several students were still getting zeros, fewer were than before technology assignments. The “during” category had the greatest difference from the overall mean.

### *Journaling*

The general trend of my journaling was that this class tended to have a lot of “wild mood” days. The biggest change I saw was that of their general behavior when we entered the computer lab room. When they entered, they were quieter, and noticeably more careful than usual. When we were in the computer lab, they seemed a little more composed and a lot less bored, as evidenced below in an excerpt from my journal.

I saw another side of my kids in the seventh grade science today. I did believe that technology would motivate them to participate more in class but I couldn't believe what I saw! When they walked into the lab it was like they were walking into a church! They were quieter, walked slower, no one pushed or threw anything—it was like they were different kids. Josh (pseudonym) still didn't do any work, but he wasn't jumping all over anyone. Sarah (pseudonym) spent most of her time looking at a website about sneakers but switched back to her work whenever I asked her to. This is great!

As you could see from the excerpt, another positive of the computer lab was that, even if a student was not doing the assignment, he or she was less likely to be disrupting the others' ability to do work. The internet provided a way for them to goof

off without pulling everyone else into it. Still, even with the distraction of chat rooms, games and music a few clicks away, most students completed work when we were in the computer room.

## Chapter Five: Conclusions and Recommendations

In essence, students who utilized technology were more academically on task and performed more consistently as a whole. Across the grade level in the school where the study was done, students performed poorly, and there was a high failure rate. However, beyond the scope of this study, the seventh grade students in this study (currently high school freshmen) not only passed their final exams but also fondly remember using technology to create web pages which revealed their knowledge base.

### *Discussion*

The data suggests that the seventh graders were significantly motivated through the use of technology in the classroom, and I believe it could be an effective motivation tool. Even the students who were not entirely on task for the lessons in the computer lab were less disruptive to others during those class sessions. It is clear that computer and internet use is appealing to students. It will take some work to limit the amount of time students spend during such a lesson on other websites unrelated to the subject. Some teachers have found ways to remedy even this snag. Software exists that blocks use of district unapproved sites. There is also a way that students can be in a room with a class set of computers, where the teacher guides the pages they are on at a given time. Intranet, and internal internet option is also a possibility, but all of these options are a little more computer savvy, and often more costly.

The results of researching student reaction to the use of technology in the sciences proved to be positive and successful. This seventh grade class, who once averaged 30% participation on assignments, now proceeded to increase their

performance rate to 70% completion. Whereas many students in other classes in this inner city school went on to repeat seventh grade, only two of these students failed the class at the end of the year. This shift in work vis-à-vis teaching sciences with technology has often been coined “teachnology” (Kehoe, 2001, p.142) by poststructuralists.

In my journal, I was noting a bit more of the affective aspects of my class. The students are better behaved in the computer lab also because they feel they are being trusted with a responsibility they may not often have. This may have added to the students’ faith in me as someone who was not going to leave them. If I could take the time to reserve the lab and trust them to work well on this expensive equipment, maybe I did care about them, maybe I would not give up on them.

It required a leap of faith on my part to set forth on this path. I needed to trust the students and give them enough room to grow in order for this experiment to work. Many teachers, many people in general, fear change. For this to work on a larger scale, we need to put more trust in these young people. Urban youth require more exposure to technology in order for them to catch up with their suburban counterparts. It is time for us to help bridge the gap.

#### *Action Plan*

The action plan is to continue this study and to expand it to include all of my classes. It is my intention to use the same methods to try to motivate my two high school level Regents Living Environment classes. I think that there is a different level of maturity and a different sense of purpose for many of these students, though not all of them.

The plan is to present the findings of this research to fellow teachers at a professional development session. In addition, this research will be presented to administrators, making them aware of the potential benefit from further research. The school in study encourages co-planning and co-curricular work. I plan to work with the other core course teachers and the media teachers to plan some interesting multi-disciplinary lessons that encourage the use of technology by the teachers and the students. We also could expand our study to include all students in our school.

#### *Recommendations for Future Research*

More research is needed that examines additional methods of integrating technology into my classroom and into my students' assignments. It is one thing to utilize Web Quests, but what if students were to create Web Quests? Using PowerPoint for a presentation is nice, but what if students designed web pages to share with each other for studying? Streaming video of experiments could be turned into school news reports. The possibilities are endless.

#### *Conclusion*

This research paper highlights that it is incredibly difficult to motivate my seventh grade class. The mind of a teenager is a difficult nut to crack! What makes them tick, what interests them, what bores them? Does it matter? Should education compete with entertainment? Can today's teachers keep up with the fast pace our children and students are running with? Should they have to? Students can IM, e-mail, use iPods and e-trade. Teachers should discover ways to turn these everyday skills into classroom procedures and methods that better the academics of students. Video game aficionados could become the micro-surgeons of the future. I believe that

technology use should be taught in all subject areas just as we stress literacy in all areas. A student without technology skills will be ill-equipped for tomorrow's workforce.

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## Appendix – 1 Exempt Status

### Exempt Status Regulations, as found on the United States Department of Health and Human Services

One of the six exemptions of research involving human subjects is narrowed in scope by Subpart D's additional protections for research involving children. The other five exemptions apply to research involving children as human subjects in the same way that they apply to research involving adults.

The narrowed exemption is the exemption at 45 CFR 46.101(b)(2), which generally applies to research involving educational tests, interviews or survey procedures or observation of public behavior, if the data are recorded without individual identifiers, or if disclosure of the recorded responses outside the research would not reasonably place the subjects at risk of criminal or civil liability or be damaging to their financial standing, employability, or reputation. Where children will be involved as research subjects, however, the use of survey or interview procedures is eliminated from this exemption, and so is research involving the observation of public behavior if the investigators participate in the activity being observed.

In other words, the only research activities involving children that may fall under this exemption are those involving educational tests or observation of public behavior where the investigators do not participate in the activity being observed. To be exempt, these activities must also meet the condition that the data are recorded without individual identifiers, or the condition that disclosure of the recorded responses would not place the subjects at risk of criminal or civil liability or be damaging to their financial standing, employability, or reputation. Otherwise, all the requirements of the human subjects regulations apply.

45 CFR 46.101(b)(2),

§46.101 To what does this policy apply?

(a) Except as provided in paragraph (b) of this section, this policy applies to all research involving human subjects conducted, supported or otherwise subject to regulation by any federal department or agency which takes appropriate administrative action to make the policy applicable to such research. This includes research conducted by federal civilian employees or military personnel, except that each department or agency head may adopt such procedural modifications as may be appropriate from an administrative

standpoint. It also includes research conducted, supported, or otherwise subject to regulation by the federal government outside the United States.

(1) Research that is conducted or supported by a federal department or agency, whether or not it is regulated as defined in §46.102(e), must comply with all sections of this policy.

(2) Research that is neither conducted nor supported by a federal department or agency but is subject to regulation as defined in §46.102(e) must be reviewed and approved, in compliance with §46.101, §46.102, and §46.107 through §46.117 of this policy, by an institutional review board (IRB) that operates in accordance with the pertinent requirements of this policy.

(b) Unless otherwise required by department or agency heads, research activities in which the only involvement of human subjects will be in one or more of the following categories are exempt from this policy:

(1) Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

(2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless:

(i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

(3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if:

(i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) require(s) without exception that the

confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

(4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.

(5) Research and demonstration projects which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine:

(i) Public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

(6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the Food and Drug Administration or approved by the Environmental Protection Agency or the Food Safety and Inspection Service of the U.S. Department of Agriculture.

(c) Department or agency heads retain final judgment as to whether a particular activity is covered by this policy.

(d) Department or agency heads may require that specific research activities or classes of research activities conducted, supported, or otherwise subject to regulation by the department or agency but not otherwise covered by this policy, comply with some or all of the requirements of this policy.

(e) Compliance with this policy requires compliance with pertinent federal laws or regulations which provide additional protections for human subjects.

(f) This policy does not affect any state or local laws or regulations which may otherwise be applicable and which provide additional protections for human subjects.

(g) This policy does not affect any foreign laws or regulations which may otherwise be applicable and which provide additional protections to human subjects of research.

(h) When research covered by this policy takes place in foreign countries, procedures normally followed in the foreign countries to protect human subjects may differ from those set forth in this policy. [An example is a foreign institution which complies with guidelines consistent with the World Medical Assembly Declaration (Declaration of Helsinki amended 1989) issued either by sovereign states or by an organization whose function for the protection of human research subjects is internationally recognized.] In these circumstances, if a department or agency head determines that the procedures prescribed by the institution afford protections that are at least equivalent to those provided in this policy, the department or agency head may approve the substitution of the foreign procedures in lieu of the procedural requirements provided in this policy. Except when otherwise required by statute, Executive Order, or the department or agency head, notices of these actions as they occur will be published in the FEDERAL REGISTER or will be otherwise published as provided in department or agency procedures.

(i) Unless otherwise required by law, department or agency heads may waive the applicability of some or all of the provisions of this policy to specific research activities or classes or research activities otherwise covered by this policy. Except when otherwise required by statute or Executive Order, the department or agency head shall forward advance notices of these actions to the Office for Human Research Protections, Department of Health and Human Services (HHS), or any successor office, and shall also publish them in the FEDERAL REGISTER or in such other manner as provided in Department or Agency procedures.<sup>1</sup>

<sup>1</sup> Institutions with HHS-approved assurances on file will abide by provisions of Title 45 CFR part 46 subparts A-D. Some of the other departments and agencies have incorporated all provisions of Title 45 CFR Part 46 into their policies and procedures as well. However, the exemptions at 45 CFR 46.101(b) do not apply to research involving prisoners, subpart C. The exemption at 45 CFR 46.101(b)(2), for research involving survey or interview procedures or observation of public behavior, does not apply to research with children, subpart D, except for research involving observations of public behavior when the investigator(s) do not participate in the activities being observed.

## Appendix – 2 Chemistry Concepts Inventory

The Chemistry Concept Inventory (ChCI) is a multiple-choice test designed to assess the effect of curriculum changes. The goal is to make a reliable, easy-to-use instrument that is administered in a short period of time and that can accurately assess student understanding of general chemistry topics. If the ChCI can easily and accurately assess student understanding, then teaching techniques can be evaluated for effectiveness by comparing the group that used the technique to a control group.

Topics covered by the ChCI were selected by a group of chemistry educators in consultation with engineering faculty members. These topics are introduced in general chemistry and reappear in later engineering courses. Topics selected from both semesters of a two-semester chemistry sequence were

Table 1: Topics Covered

Test Topic Subtopics

Chemistry I Thermo-chemistry Heat Concept

Thermal Conductivity

Thermal Equilibrium

Bonding Bond Polarity

Octet Rule

Intermolecular Forces Intermolecular Forces

Chemistry II Equilibrium Rate

Dynamic vs. Static

Le Chatelier's Principle

Equilibrium Constant

Acids and Bases Acid/Base Neutralization

Acid Strength

PH

## Electrochemistry Oxidation/Reduction

### Voltaic Cells

### Electrolytic Cells

Once the topic areas were determined, an extensive literature search was carried out to identify misconceptions associated with the ChCI topics that have already been studied. There is a large body of literature available on chemistry misconceptions. Because of this literature, distracters could be designed to test for known misconceptions. This search also led to natural subtopics within each of the main topics. For each subtopic, at least three questions were written, giving a total of 30 questions for the Chemistry I inventory and 31 questions for the Chemistry II inventory. The questions were intended to be conceptual, not mathematical or algorithmic. These questions were initially given to the students in Chemistry I and II as part of their weekly quizzes. The questions were then compiled into Version A of the ChCI. Because the questions were given after the students had covered the information in lecture, only post-test data were available. Table 2 summarizes these results.

Table 2: Results from Chemistry Concept Inventory (Version A)

### Chemistry I Chemistry II

N = 326 Students N = 158 Students

Alpha = 0.7883 Alpha = 0.7855

Post-test Mean =  $14.73/30 = 49.1\%$  Post-test Mean =  $18.53/31 = 59.8\%$

The tests were analyzed and descriptive data were gathered. The coefficient alpha, discrimination index, and difficulty index were used to evaluate this first version of the ChCI. The coefficient alpha is a measure of the internal reliability of the test, the ability of the test to evaluate an individual consistently. Alpha ranges from 0 to 1, with 0.7 or higher indicating the test is reasonably reliable. The Chemistry I and Chemistry II inventories both scored above 0.7 (a pleasant surprise). An alpha is calculated for the whole test.

In contrast, discrimination and difficulty indices are calculated for each question. The discrimination index is a measure of how well the question discriminates between the students. To calculate a discrimination index, first the students are ranked by performance on the exam. A top portion of the class is compared to the bottom portion. If every student in the top portion answered the question correctly and every student in the bottom portion answered the question incorrectly, then the question perfectly discriminates between good students and poor students. The discrimination index would be 1. The discrimination index ranges from -1 to 1.

Along with the discrimination index, consider the difficulty index. The difficulty index is the percentage of students who answered the question correctly. Since a question can receive a low discrimination index because the majority of the class answers the question correctly or the majority of the class answers it incorrectly, combining these two indices when evaluating a question is important. Another way of evaluating questions is to see what effect eliminating a question will have on the coefficient alpha. One of the goals of the ChCI is for it to be administered in a short period of time. In order to do so, the test had to be shortened. Questions were eliminated so that the Chemistry I and Chemistry II inventories were 20 questions long. Three questions were written on each subtopic so that one question could be eliminated, leaving two questions on that subtopic. But eliminating questions also has a converse affect on the alpha, thus lowering the reliability of the ChCI. Therefore, after a question was eliminated, the alpha was calculated to see what effect that elimination had. Eliminated questions were those that would have the least negative affect on the alpha. These data, as well as expert judgment, were combined to eliminate weak questions to leave two 20-question tests. Also, a number of questions were modified to make them clearer. The Chemistry I and II Version B were then piloted during the summer of 2003.

The Chemistry I Version B of ChCI was given to university students at the beginning of the semester for a pre-test and again at the end for a post-test. The Chemistry II Version B was given at a community college at the beginning of the semester as a pre-test. Then the questions were spread out over several weekly quizzes. Results from the weekly quizzes were combined to use as the post-test. Results from Version B of the ChCI are summarized in Table 3.

Table 3: Results from Chemistry Concept Inventory (Version B)

Chemistry I      Chemistry II

N = 42 University Students      N = 42 Community College Students

Alpha = 0.7135      Alpha = 0.4188

Pre-test Mean = 5.48/20 = 27.4%      Pre-test Mean = 7.17/20 = 35.9%

Post-test Mean = 10.60/20 = 53.0%      Post-test Mean = 10.93/20 = 54.7%

During the summer of 2003, eleven students were interviewed in depth on seven questions on molecular shape from the ChCI Chemistry I Version B. Student interviews gave helpful insight into how students solve problems. For example, a question might be written to test one aspect of the topic, but students might solve it differently. They might use different reasoning that would lead to a correct answer. The item is therefore testing something other than the intended topic. Student interviews are useful for all of these reasons. For these interviews using Version B,

students were chosen from those students currently taking the first semester of general chemistry. They were interviewed just after covering the relevant information in lecture. These interviews led to some unique findings in spatial understanding and misconceptions held by these students. They helped to validate the test, too.

The student interviews also helped modify some questions to make them clearer. In one question students had to determine the polarity of a molecule for which they were given a description. It reads:

Consider a molecule with the formula  $ZA_2$  where  $Z$  is the central atom and  $A$  and  $Z$  have different electro-negativities. In which of the following cases would this molecule always be nonpolar?

- A. If  $A$  has 2 lone pairs and  $Z$  has no lone pairs.
- B. If  $Z$  has 2 lone pairs and  $A$  has no lone pairs.
- C. If  $Z$  has 1 lone pair and  $A$  has 3 lone pairs.
- D. If  $A$  is drastically more electronegative than  $Z$ .
- E. If  $Z$  is drastically more electronegative than  $A$ .

During the interviews it became obvious that the students were misinterpreting the statements that led to incorrect molecular drawings. The main confusion came from the number of lone pairs of electrons that should be on each of the  $A$  atoms. The purpose of the question is not to test whether or not students can draw a molecule from a written description, but whether they can determine the polarity of the molecule. It is not the intent to cause the students to miss the question because they cannot draw the molecule correctly. To clarify the question, the word "each" was inserted into three distracters so that the question now reads:

Consider a molecule with the formula  $ZA_2$ , where  $Z$  is the central atom and  $A$  and  $Z$  have different electro-negativities. In which of the following cases would this molecule always be nonpolar?

- A. If each  $A$  has 2 lone pairs and  $Z$  has no lone pairs.
- B. If  $Z$  has 2 lone pairs and each  $A$  has no lone pairs.
- C. If  $Z$  has 1 lone pair and each  $A$  has 3 lone pairs.
- D. If  $A$  is drastically more electronegative than  $Z$ .
- E. If  $Z$  is drastically more electronegative than  $A$ .



This new wording was tested on a group of incoming teaching assistants. They were asked to draw the molecule that distracters A, B, and C represented. In nearly every case the drawings that the TAs produced were the intended ones. From student interviews, questions were modified to make them clearer and to ensure that the inventory was testing what was intended.

Results from Version B were evaluated, and a C version of the ChCI was developed. During fall 2003, the Chemistry I and II ChCIs were administered to a large number of students. Available information from this version is in Table 4.

Table 4 Results of Chemistry Concept Inventory (Version C).

Chemistry I Chemistry II

N = 845 Students N = 845 Students

Alpha = .5541 Alpha = .4761

Pre-test Mean =  $4.94/20 = 24.7\%$  Pre-test Mean =  $6.51/20 = 33.6\%$

Two things should be noted about these results. First, the alphas for each test are low. This is expected because the information on the ChCI has not been covered. Once the post-test has been given, the alpha will be calculated with that data. This will give a more true reliability measure. Second, the results show that each group's Pre-test Mean is consistent with guessing, which is also expected, given that the students are at the beginning of the semester. At the end of the fall semester, the ChCIs will be administered again as a post-test. The difference between the pre- and post-test scores will represent what was gained by being in the class. Results will be analyzed and used to explore the effect of teaching style on student learning. Results will be shared with faculty members to shape future curriculum modifications. Student beliefs will be further explored with additional interviews. The final table, Table 5, summarizes the steps taken to develop the Chemistry Concept Inventory.

Table 5 Steps of the development of the Chemistry Concept Inventory

1. Pick topic areas to be covered.
2. Search the literature for research on misconceptions in those topic areas.
3. Determine subtopic areas.
4. Write at least three questions in each subtopic.
5. Administer these questions to students. (Version A)

6. Eliminate weak questions based on the discrimination index, difficulty index, and the coefficient alpha.
7. Administer the remaining questions to students. (Version B)
8. Interview students.
9. Modify questions based on results from test and student interviews.
10. Administer the modified questions. (Version C)
11. Repeat steps 8 through 10 until acceptable results are attained.

## Appendix – 3 Station Lab

### Lab Stations Include:

Xplorer GLX PS-2002

USB Mouse PS-2539

High Precision pH/Temperature Sensor with ISE/ORP Amplifier PS-147

Drop Counter (High Accuracy) PS-2117

Colorimeter PS-2121

Pressure/Temperature Sensor PS-2146

Oxidation Reduction Potential Electrode CI-6716

Stainless Steel Temperature Probe PS-2153

Ideal Gas Law Syringe TD-8596

Conductivity Sensor PS-2116

Voltage/Current Sensor PS-2115

Type K Temperature Sensor with Thermocouple PS-2134

USB Keyboard PS-2540

Explorers GLX Lab Stand PS-2526

DataStudio Lite Data and Collection Analysis Software