Evaluating the Effects of Medical Explorers a Case Study Curriculum on Critical Thinking, Attitude Toward Life Science, and Motivational Learning Strategies in Rural High School Students

A Dissertation
Presented to
The Faculty of the Graduate School
Ball State University

In Partial Fulfillment
of the Requirement for the Degree
Ed. Doctor of Biology,
Science Education and Physiology

By
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December 2010
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**Evaluating the Effects of Medical Explorers a Case Study Curriculum on Critical
Thinking, Attitude Toward Life Science, and Motivational Learning Strategies in
Rural High School Students**

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ACKNOWLEDGEMENTS

To the graduate faculty at Ball State University, thank you for the exceptional training you have provided over the past three years. Each one of you has been an inspiration and helped guide me in the right academic direction. Dr. Rogers, I consider you not only a mentor but a friend. You have truly demonstrated what it means to be an advocate for quality science education. Thank you for being an example of how to effectively balance my career with family. Dr. Mulvihill, the professional tips you have given me are invaluable. I now feel better prepared to handle all the duties of the professoriate. Dr. Geelhoed, it has been a pleasure working with you. I admire your professional demeanor. I can only hope that I have learned some of these skills and will use them in the future. Dr. Zamlauski-Tucker, I have greatly enjoyed our academic discussions and collaborative support you have provided as I mature in my professorate role. Dr. Desouza, thank you for always being there to answer a question or give advice. I have enjoyed working with you over the past two years and look forward to working with you in some capacity in the future. Dr. Jim Jones and Dr. Kianré Eouanzouï, thank you for your assistance with data analysis and support with gaining a better understanding of statics and interpreting my data. Thank to the entire graduate faculty at Ball State for helping to make my experience here such and enjoyable and fulfilling one. I have learned so much from you and I thank you for that experience.

To the faculty, staff, and students at Delta High School who had a role in this study, thank you for your help. This school has been such an important part of my educational development. As a student, faculty member, and now as a researcher, I say
without pause that my passion for science education was fostered by my experiences at Delta High School. I would like to thank every faculty member, administrator, staff member, student, and parent who I have had the pleasure of working with for your part in my educational development.

Timmy Foundation and Muncie United Methodist Church, thank you for your financial assistance and support. Dr. Frank and Rosemary Martin, you both have been my inspiration to never be afraid to try new things, push myself to be my best, and showed me that I could follow in your footsteps and complete my doctoral degree. Finally to my wife Lisa and my three children Tyler, Katherine, and Riley, thank you for your patience and never ending love and support. You mean the world to me and as I complete my doctorate I look forward to having more time for family.
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Evaluating the Effects of Medical Explorers a Case Study Curriculum on Critical Thinking, Attitude Toward Life Science, and Motivational Learning Strategies in Rural High School Students

Lance G. Brand
Dr. William Rogers, Dissertation Supervisor

ABSTRACT

The purpose of this study was three-fold: to measure the ability of the Medical Explorers case-based curriculum to improve higher order thinking skills; to evaluate the impact of the Medical Explorers case-based curriculum to help students be self directed learners; and to investigate the impact of the Medical Explorers case-based curriculum to improve student attitudes of the life sciences.

The target population for this study was secondary students enrolled in advanced life science programs. The accessible population were students attending Delta High School (DHS) \( (N = 892) \) located in rural Delaware County, Indiana. The resulting sample \( (n = 71) \) consisted of 36 students in the case-based experimental group and 35 students in the control group. Furthermore, this study employed an experimental, pretest-posttest control group research design. The treatment consisted of two instructional strategies: case-based learning and teacher-guided learning.

Analysis of covariance indicated no treatment effect on critical thinking ability or Motivation and Self-regulation of Learning. However, the Medical Explorers case-based curriculum did show a treatment effect on student attitudes toward the life sciences. These results seem to indicate that case-based curriculum has a positive impact on
students’ perspectives and attitudes about the study of life science as well as their interest in life science based careers. Of additional interest was the observation that on average eleventh graders showed consistently stronger gains in critical thinking, motivation and self-regulation of learning strategies, and attitudes toward the life sciences as compared to twelfth grade students. In fact, twelfth grade students showed a pre to post loss on the Watson-Glaser and the MSLQ scores while eleventh grade students showed positive gains on each of these instruments. This decline in twelfth grade performance is an endemic indicator of underlying problems that exists in this transitional year of education and supports the need to strengthen the transitional connections between high schools and institutions of higher learning.

Knowing that the Medical Explorers case based curriculum does have a strong positive impact on students’ attitudes toward life science and careers in life science is a powerful outcome of this study. These results are also a good indicator that students enjoy and perceive the value to use of case studies in science, and because they see value in the work that they do they open up their minds to true learning and integration.
Chapter 1

Introduction

In recent years, a number of National Science Foundation and National Research Council reports have advocated the need to improve science instruction and enhance science literacy for all students (NRC, 2002). Most recently this push for improvement in science education has been enshrined in No Child Left Behind (NCLB) (U.S.C. 20, 2009). Although national assessments of performance of students during the past decade reveal moderate improvement in basic skills, students continue to perform poorly on tests that require critical thinking and problem-solving skills such as forming hypotheses, making inferences, and drawing conclusions (Riley, 1999). During the same period, the rapid expansion of knowledge and sophisticated technology has made greater demands on workers to adapt and learn quickly on the job. The majority of the jobs our students will have in the future do not exist as yet (National Academy of Sciences, 2008) and this situation magnifies the need to be able to problem solve effectively and to think critically which are skills of vital importance. There is a clear need to help students learn to think more effectively and develop critical thinking skills.
The Science for All reform has emerged following a consensus on the need to improve the scientific literacy of students and the vast population (AAAS, 1993). A major goal of science education should be to improve students’ higher order thinking skills and encourage scientific literacy in a society. For all learners to be successful in science it is important to situate instruction in meaningful contexts in order for real learning to take place. Real learning is found in questions, not answers. The most effective questions are ones that are rooted in issues and problems surrounding students. One effort to improve the learning of science is through case study teaching. Teachers use realistic or true narratives to provide opportunities for students to integrate multiple sources of information in an authentic context, and this may engage students with ethical and societal problems related to their discipline.

The project from which this research study emerged is a case-based curriculum called *Medical Explorers* which was developed through the support of the Timmy Foundation. The Timmy Foundation saw a need to engage the next generation of compassionate and caring students and created a pilot education program and curriculum, known as *Medical Explorers*, for students and teachers, which could be taught at grades 7 to 12. The goal of *Medical Explorers* is to transform students and teachers from spectators into participants. The lessons are multi-disciplinary and students participate in case studies, medical evaluations, treatment plans, and service-learning projects. Numerous research studies demonstrate that this approach to science learning, commonly referred to as “case-based” learning, is important because it enables students to develop skills and confidence for solving problems they have not yet encountered these problem-
solving skills are precisely the skills necessary to address today’s global issues (Smith, 1999).

While the Medical Explorers curriculum is instructed through the case method, it is also built on a Science – Technology – Society (STS) framework which enables science to be taught in a more relevant, meaningful, and appealing way. The curriculum is designed to foster knowledge and understanding of key issues in life sciences, to promote socioscientific discourse, and to encourage higher order thinking skills. This STS approach is based on ideas of incorporating social, cultural, environmental, medical, political, and ethical aspects into the curriculum (Aikenhead, 1992). The curriculum is aimed at promoting understanding of socioscientific issues, and making informed, responsible decisions. In Medical Explorers the students are expected to apply moral reasoning and critical thinking while acting towards improving the health of their patient. These students need to be able to make decisions in a highly complex world. Through the integration of STS and the case method of instruction in the Medical Explorers curriculum the Timmy Foundation hopes to foster the development of critical thinking skills, to help students be self directed learners, and to improve student attitudes of the life sciences.

Students of our modern society should be encouraged to examine critically information that requires knowledge of science and technology. If through the Medical Explorers curriculum students can learn to question, express their own arguments based on scientific knowledge, analyze information critically, handle dilemmas, and develop
the skills necessary to be independent learners, the efforts to improve higher order thinking skills will be rewarded.

**Medical Explorers Case-Based Learning**

Each case from *Medical Explorers* engages students to help solve the real-world problems of patients such as Lucia. *Lucia, a 12-year-old girl, lives in a small shack on an exposed landfill in The Dominican Republic. Her diet consists of food found on the landfill. Clean water is scarce. Extreme heat and humidity exacerbate the problem. Lucia has few opportunities to improve her condition. She is poor and uneducated. Lucia traveled 12 miles to Crossroads Clinic to seek medical attention where volunteers from the Timmy Foundation diagnosed her with congestive heart failure.*

Thousands of children and families in developing countries around the world live like Lucia. Today’s medical research and development are not necessarily geared towards the needs of people in poor countries, and finding solutions to global health issues is complex. Socioscientific issues can serve as the organizers for science education and not as core topics of the curriculum. They allow further inquiry, encourage the search for new information, represent excellent examples for interdisciplinary topics, and foster the emergence of continuous discourse (Dori, 2003). To address and help solve the most pressing global health issues, the next generation of medical professionals must develop a global awareness and compassion to help poor and marginalized populations living around the world. The Timmy Foundation can provide today’s youth and medical professionals with both.
Founded in 1997 by Dr. Chuck Dietzen, the mission of the Timmy Foundation is to build healthy futures worldwide, one child at a time. The Timmy Foundation accomplishes this mission through direct outreach to medically underserved populations in developing countries, systemically strengthening community-based health care and education, and empowering youth at home and abroad to share their energy and compassion with other children and families around the world.

After successfully piloting the Medical Explorers project in three Indiana schools, the Timmy Foundation is poised to implement the second phase of the project into more high schools, and work to conduct a comprehensive evaluation of its effectiveness in partnership with Ball State University. Few models exist for case-study use in the secondary-school level, and it is hoped to use the results of this study to develop a case-based model that is replicable and can be modified to fit in various school settings.

Addressing the medical needs of youth and families in developing countries requires science, creativity and compassion. Developing a global awareness among youth at an early age will give them the foundation to examine critically and to help solve global problems that they do not encounter at home. Moreover, research studies demonstrate that students learn better when curriculum relates to real situations and builds on their prior knowledge and experiences (Williams, 1992).

It is believed that the Medical Explorers curriculum is an effective tool to introduce students to case-based learning in the sciences, and it is developed within a global framework that uses real medical situations from developing countries. Students not only develop science inquiry skills, but they also develop an understanding of the
patient’s culture, socioeconomic status and physical living conditions to create a
treatment plan that is effective. It is important for the students to learn how to use their
science skills in a real-life context. Many international organizations and governments
realize that global health is in a crisis. The next generation of medical professionals must
learn how to solve these problems in a global context, and the Medical Explorers
curriculum is one tool that can be utilized to engage students at an early age.

Preparing Youth to Confront Global Health Issues in a Complex, Dynamic Global Economy

As communities confront unprecedented globalization and problems that require
global solutions, it is vital that youth understand the interconnectedness of global
systems. Research from the Goldman Sachs Foundation and the Asia Society states that,
“Preparing today’s students for success and eventual leadership in the new global climate
is the single most important task facing U.S. education at the dawn of the 21st century”
(Sachar, 2004). Today’s youth must develop benevolent attitudes towards the
populations who are affected by the global health crisis, and it is important that youth
learn about all aspects of a culture and understand the complex nature of global issues.

Case-based Approaches to Teaching Prepares Students for Tomorrow’s Challenges

Medical schools and post-secondary schools across the country often use case-
based or problem-based approaches to teach science skills. Nearly a decade of research
has demonstrated that this approach is remarkably effective, and students who are trained
in this manner are: adept at solving complex problems, able to conduct extensive
research, and develop enhanced teamwork skills (Allen, n.d.). When learning is centered on a specific problem, students are more likely to retain the material and are able to apply it to similar situations. While students may never face the exact problems under study, they gain experience using scientific approaches to work out reasonable solutions to situations that exist in their world.

For example, Lucia, the 12-year old Haitian girl who was diagnosed with congestive heart failure, may receive short-term relief from her symptoms, however an effective sustainable treatment plan must account for the socioeconomic and environmental factors that exacerbate her condition with factors that are unique to her situation. Medical professionals addressing global health problems must show compassion, and also must be equipped with the appropriate problem-solving skills.

This experience is potentially transferable to the unique problems they will encounter as professionals in any career (Waterman, 2009). This approach differs from traditional lectures, because it fully engages students, accommodates different learning styles, and develops skills beyond subject matter knowledge. Traditional lectures focus on building knowledge, while case-based learning builds problem-solving and analytical skills. Not all students learn in the same manner, and case-based learning gives students opportunities to direct their own learning. Case instruction allows students to analyze socially relevant information and develop a hypothesis. Students then use a variety of methods and resources to investigate their hypotheses and produce materials that can be used to present their findings to peers (Waterman, 2009).
Most high school science curriculum is passive and teachers use standard lectures and textbook laboratory experiments to teach science. Frequently students are disconnected and do not see any relationship between their lives and the science curriculum. Case instruction focuses on real-world problems and thus students must learn how to utilize real-world resources to solve these problems. Research demonstrates that the case method and problem-based learning can be better than traditional methods in preparing students for a fast-changing world in which they must constantly acquire new skills and knowledge (Waterman, 2009). While research demonstrates that this approach is effective at the collegiate level, little research has been conducted to evaluate its use at the secondary level.

**How Medical Explorers is Bridging the Gap Between Classroom Learning and Real Life**

A science educator for more than a decade, Lance Brand began collaborating with the Timmy Foundation to create the *Medical Explorers* curriculum in 2004, because for the majority of students it was recognized that there was a clear disconnection between high school science curriculum and the applicability to real-life situations. The excitement of science and natural curiosity is often lost in today’s secondary science curriculum, when students were not challenged to think creatively. Educators have the responsibility to ensure that graduates have the skills necessary for life-long learning skills that include how to research and evaluate their findings, and how to apply the new knowledge to a specific situation.
In partnership with the Timmy Foundation, Brand worked with Rick Crosslin of the Indianapolis Children’s Museum and several other colleagues to develop the Medical Explorers curriculum. The pilot program began in 2005 at three different grade 6-12 schools in Indiana. Initial outcomes from the pilot phase were promising but no quantitative data were collected. Informal teacher observations of general student performance, discussions with students about academic interests, classroom discussions, changes in student academic performance, and student enthusiasm for science were used initially to gauge the impact of the Medical Explorers curriculum. The immediate outcomes among the students seemed to indicate increased interest in medical careers, improved self-confidence, professionalism and ethics, improved critical thinking, collaborative skills, increased understanding of the complexity of world issues, and increased engagement and leadership toward service work.

Consistently, students were able to shift their perspectives and understand how their actions can make a difference in the broader context of global health. Because Medical Explorers uses real children and represents real problems, it helps to demystify medicine and focuses on how each individual can make a difference. The students simply love the experience and discover the greater purpose of learning in the sciences, realizing they have the power and potential to save lives. With the pilot phase complete, the Timmy Foundation is poised to introduce the curriculum to a wider audience and extend the scope of its programming.

Jamison is a 10-year-old Haitian boy who came to the clinic at Haitian Academy. He injured his leg in a “tap-tap” bus accident two years earlier. He is unable to walk on the injured leg and noticed that the skin broke open where he fractured his leg. Since the
accident, he has had a lot of purulent drainage from the wound. He spikes fevers on occasion and is often delirious as a result. Now, he is able to bear weight on the leg but it is significantly deformed.

Jamison was an actual patient treated by volunteers from the Timmy Foundation. Their medical assessment revealed that Jamison suffered from osteomyelitis, which was caused injuries received during his tap-tap accident, and they developed a treatment plan that took into account Jamison’s socioeconomic status and living conditions. High school students participating in the Medical Explorers program also will be introduced to Jamison and several other children like him through their real-life medical stories.

**Overview of the Medical Explorers Curriculum**

The *Medical Explorers* curriculum is a 54-page resource for high school science teachers, that is linked to Indiana Academic Standards in science, language arts, and social studies. The curriculum contains eight real case studies and instructions on how to use this resource in the classroom. In the four lesson plans contained in the curriculum students will:

- Model medical inquiry through evaluation, examining medical history, assessment and developing a treatment plan.
- Create consultation teams that learn medical vocabulary, epidemiology, geography, economics and culture.
- Create presentations to outline their treatment plan including recommendations in hygiene, vaccinations, nutrition, medical and surgical treatments.
- Model actual surgical procedures.
Medical Explorers transforms students and teachers from spectators into participants. Students participate in case studies, medical evaluations, treatment plans, presentations and service-learning projects. The case studies are modeled after actual people and real situations. The information that students learn is real and provides tools that they will apply in further studies or service projects. Students will learn skills and have experiences that can reach beyond the walls of their classrooms.

Students begin their work through case studies that represent children in areas of the world without adequate medical services and nutrition. The children’s profiles are based on experiences at international sites served by the Timmy Foundation and are represented through case studies containing clinical narratives for students to use. Students participating in this project will learn to work together on a science service project that has the power to change lives.

The primary goals of the Medical Explorers project include the following:

1. Build students’ confidence and interest in the medical field and other sciences through case-based and inquiry-based learning.

2. Improve students’ problem solving skills, communication, critical thinking and analysis skills to build a foundation of life-long learning and curiosity.

3. Foster global awareness among students, enabling them to understand their interconnectedness to the global community and its issues.

4. Develop a model or best practices to be disseminated to other schools and audiences.
**Research Focus**

The Timmy Foundation and its partners have successfully completed piloting the curriculum with high school students, the Foundation is now ready to broaden the scope of the project and serve more students and teachers. This study will collect data on the effectiveness and impact of the *Medical Explorers* curriculum among high school students by measuring:

- Skills related to critical thinking
- Motivation as a learner and self-directed study skills
- Attitude toward life science

**Research Objectives and Hypotheses:**

The purpose of this study was to evaluate the effectiveness and impact of the *Medical Explorers* case study curriculum among high school students by:

1. Measuring the ability of the *Medical Explorers* case-based to curriculum improve higher order thinking skills of students.
   
   \( \text{H}_1: \) Students taught using *Medical Explorers* case-based to curriculum will demonstrate greater critical thinking development than students taught through teacher guided learning when accounting for prior critical thinking ability.

2. Evaluate the impact of the *Medical Explorers* case-based curriculum to help students be self directed learners, to ensure that high school graduates have the skills necessary for life-long learning.

   \( \text{H}_2: \) Students taught using *Medical Explorers* case-based curriculum will
demonstrate greater improvement in their motivation and self regulation of learning skills than students taught through teacher guided learning when accounting for prior ability.

3. Investigate the impact of the Medical Explorers case-based curriculum to improve student attitudes of the life sciences.

H₃: Students taught using Medical Explorers case-based to curriculum will demonstrate greater improvement of their attitude toward life sciences than students taught through teacher guided learning when accounting for prior attitude toward life science.

Assumptions

The following delimitations are assumed true for this study.

1. The instructor was an appropriate choice to facilitate this study based on sufficient prior experience with both instructional strategies.

2. The instructor facilitated the prescribe treatments as designed and maximized variation between treatments.

3. Students participated in the treatment and completed all instruments to the best of their ability and all responses are accurate.

Limitations

1. The steep learning curve for student understanding of the Case-Based Learning Instructional Strategy.
2. The short treatment time of the study may not have maximized the effect on critical thinking ability.

3. The content was created to be used with both middle and high school students and therefore the material may not be cognitively challenging for older students.

**Project Timeline**

The planning phase of *Medical Explorers* research occurred through the summer and fall of 2009 with project implementation beginning at the start of 2010.

<table>
<thead>
<tr>
<th>Summary of Activity</th>
<th>Completion Dates</th>
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<tbody>
<tr>
<td>- Project planning</td>
<td>July-Oct. 2009</td>
</tr>
<tr>
<td>- Recruit and select the 1-10 participating classes and provide teacher training</td>
<td>Oct.-Dec. 2009</td>
</tr>
<tr>
<td>- Collect pre-impact data via critical thinking test, self-directed study skills</td>
<td>Jan. 2010</td>
</tr>
<tr>
<td>survey, and attitudinal survey of students.</td>
<td></td>
</tr>
<tr>
<td>- Students complete first phase of <em>Medical Explorers</em> project and post their</td>
<td>Jan.-Feb. 2010</td>
</tr>
<tr>
<td>case reports on a shared website for all the partners schools to read</td>
<td></td>
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<tr>
<td>- Teachers provide formative feedback regarding successes, challenges and</td>
<td></td>
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<tr>
<td>additional support needed</td>
<td></td>
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<tr>
<td>- Students complete the second component of the <em>Medical Explorers</em> project and</td>
<td>Feb. 2010</td>
</tr>
<tr>
<td>post their case reports on a shared website.</td>
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<tr>
<td>- Post impact data are collected and teachers and students submit post curriculum</td>
<td>Mar. – April 2010</td>
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<tr>
<td>comments and suggestions for improvement</td>
<td></td>
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<tr>
<td>- Data analysis</td>
<td>May – Aug. 2010</td>
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</table>
The use of problem-solving case studies addresses the need for enhancing critical thinking skills of students. Educators need to provide the spark that ignites students and invite them to seek and create new knowledge. In order for educators to do so, new learning must be meaningful. If educators expect critical thinking to take place, students need to be provided with case-based lessons in meaningful learning contexts.

Organizations like the Timmy Foundation that are working to solve healthcare problems in developing countries need students who can problem-solve, think creatively and apply their knowledge in unique settings. The *Medical Explorers* curriculum is building that foundation among Indiana students. Through this research the impact of the *Medical Explorers* curriculum on high school students will be measured and a strong collaboration with the Timmy Foundation will be established to create a best-practices model for implementing case-based learning at the secondary-school level and disseminate the information regionally and nationally.
Chapter 2
Review of Literature

Learning novel concepts requires the learner to connect new information to a congruent mental model. Mental models represent a person’s analysis of existing knowledge and of new information even though this information may be fragmentary, inaccurate, or inconsistent (Alvarez, 1990). Holt (1989) states that mental models change when people explore the world around them and create knowledge out of their own questions, thoughts, and experiences. In essence, a mental model is comprised of their organization of world knowledge and experiences and represents an individual’s structure of reality. Problem solving lessons and activities can provide learners with situations that aid in schema construction which includes critical thinking.

Prior research suggests the importance of integrating the teaching of thinking skills and content (Jones, 1990). Students often feel that it is not possible to make decisions without complete information, but learning to make decisions on the basis of probability rather than a complete set of facts is part of real-world problem solving. Unlike the creative, unstructured process of hypothesis generation, evaluating hypotheses is a very logical, deductive process (Williams, 1992).
Cognition and Learning Theory

The complexity of the competencies expected of students today is continually increasing. Knowledge is central in building these competencies, but knowledge alone is not enough. Knowledge must be organized and utilized in systematic ways and applied to actual situations (Thomas, 2001). Cognitive psychologists have found that learning is situated (Baker, 2000). For example, just because individuals have the knowledge to pass tests and write papers about teaching children to read, this does not mean they will be able to teach children to read. Research on situated cognition indicates that if students learn knowledge similar to where they will use the knowledge, they are more likely to transfer the knowledge into practice (Baker, 2000). Cognitive psychologists have also found that knowledge is typically inert when learning is passive. In other words, learners do not commonly make connections between knowledge that is dispensed to them and situations where that knowledge can be used. Instead, learners make better connections when they generate knowledge (Baker, 2000).

Further, the organization of knowledge is crucial because, even though students are able to hold a limited number of units or chunks of information in immediate memory, the amount of information can be increased through incorporating information into larger chunks (Thomas, 2001). If students are assisted in learning information in a way that parallels the way in which that information will be used when retrieved, retention of this information is greatly enhanced. This has the advantage of combining the creation of knowledge structure and a search and retrieval strategy into a single operation (Thomas, 2001). Case-based learning provides for structuring of knowledge in a context specific way.
Educational theorists have begun to emphasize the importance of situating instruction in meaningful contexts in order to recreate some of the advantages of apprenticeship learning (Williams, 1992). Cognitive apprenticeship that emphasizes the social context of instruction draws its inspiration from traditional apprenticeships. Case-based instruction is a form of cognitive apprenticeship which has been employed in legal, medical, and business education. Apprenticeship learning is generally thought of as a way to learn a trade that emphasizes not only physical but also cognitive skills (Collins, 1989). It is characterized by learning the job in exactly the same context in which it will later be performed. It is also characterized by a large amount of practice in performing tasks that are authentic. Authentic activities are coherent, meaningful, and purposeful. In contrast, most students in high school are expected to imagine situations in which the skills they learn will be useful. Therefore the skills learned by students must be transferred to unfamiliar settings before they can be used.

Cognitive learning theory indicates that the learning process can be improved via active learning and problem-solving learning (Chen, 2006). Case method teaching is a method of instruction that can improve cognitive learning process. Presenting cases to students has the advantage of bridging the gap between theory and professional practice and promoting active learning so that students have more incentive to learn in greater breadth and depth. The case-based teaching method brings positive effects to learning, because it can improve on two of the cognitive learning processes: active learning and problem solving learning (Adams, 1988). When students learn new information while solving a problem, they are more likely to use it to solve other problems.
Case instruction is active learning which is a goal oriented process. Since there is no single correct answer in a case, information acquisition alone cannot realize this goal. Different learners can reach dissimilar conclusions for each case study. Understanding a case is best accomplished by sharing mental models of learners via information exchange, analysis, manipulation, and structuring (Chen, 2006). Tasks related to case studies can be categorized into five general types: (1) simple tasks, (2) problem tasks, (3) decision tasks, (4) judgment tasks, and (5) fuzzy tasks. These task types vary by four primary attributes that contribute to task complexity: (1) outcome multiplicity, (2) solution scheme multiplicity, (3) conflicting interdependence, and (4) solution scheme outcome uncertainty (Chen, 2006). The case-based teaching approach can take advantage of the interpersonal interactions in a cooperative or competitive context. This practice has been shown to help activate the short- and long-term memories of case study learners (Chen, 2006).

Case-based learning is strongly rooted and supported in a variety of theoretical perspectives from action research to constructivism (Richards, 1997). Piaget (1926) and Vygotsky (1978) consider such interpersonal learning an effective learning approach. Modern educational theorists such as Paris & Newman, Tishman, Perkins & Jay have begun to emphasize the importance of actively involving learners in instruction that is situated in meaningful contexts and as a result the use of case methods is increasingly being recommended (Ertmer, 1998).

Bruner (1990) provided the three principles of constructivistic learning: 1) instruction must be concerned with the experiences and contexts that make the student
willing and able to learn (readiness); 2) instruction must be structured so that it can be easily grasped by the student (spiral organization); and 3) instruction should be designed to facilitate extrapolation and or fill in the gaps (going beyond the information given).

Advocates of constructivism suggest that educators should first consider the knowledge and experiences the students bring to the learning environment and then build the curriculum so that they can connect new information to existing knowledge and experiences (Huit, 2003). Conversely, advocates of behaviorism suggest that educators should decide what knowledge and skills students should know and build the curriculum to provide this knowledge (Huit, 2003). Table 1.1 compares the principles of constructivism to the characteristics of case-based learning (Smith, 1999).

Table 1.1

_A Comparison of the Characteristics of CBL to the Constructivist Instructional Principles_

<table>
<thead>
<tr>
<th>Characteristics of CBL</th>
<th>Constructivist Instructional Principles</th>
</tr>
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<tbody>
<tr>
<td>Cased-based</td>
<td>Anchor all learning activities to a larger task or problem.</td>
</tr>
<tr>
<td></td>
<td>Design the task and learning environment to reflect the complexity of the practice environment.</td>
</tr>
<tr>
<td></td>
<td>Design an authentic task.</td>
</tr>
<tr>
<td>Problem-solving</td>
<td>Encourage testing ideas against alternative views and alternative contexts.</td>
</tr>
<tr>
<td></td>
<td>Design the learning environment to support and challenge the learner’s thinking.</td>
</tr>
<tr>
<td>Student-centered</td>
<td>Support the learner in developing ownership for the overall problem or task.</td>
</tr>
<tr>
<td>Self-directed learning</td>
<td>Give the learner ownership of the process used to develop a solution.</td>
</tr>
<tr>
<td>Reflection</td>
<td>Provide opportunity for reflection on both the content and the learning process.</td>
</tr>
</tbody>
</table>
According to theories of case-based reasoning, cases in memory are organized according to features that describe situations in which the case may be useful (Edelson, 1996). The collection of features that label a particular case is called an index. A case library is only as useful as the indexes that organize the cases. If cases are stored under irrelevant or incorrect features, the person will not be able to retrieve those cases when they might be useful in the future. Because of the need for an appropriately indexed case library, case-based teaching must attend to the issue of how students develop appropriate indexes for the cases in their memories.

In case-based instruction the learning focus shifts from the explicit knowledge and skills that form the traditional academic curriculum to the development of active knowledge (Stepich, 2000). Active knowledge goes beyond simply recalling information to the ability to use that information to select relevant issues and solve identified problems. For example, students in medical school will read a case study and participate in a dialogue designed to elicit the key issues and scientific principles in the case. More than simply recalling information, the students are asked to analyze the situation as a practicing physician would.

**What is Case-Based Instruction?**

A case is a partial, historical, clinical study of a situation presented in narrative form to encourage student involvement (Greenhalgh, 2007). Cases provide data essential to an analysis of a specific situation, for the framing of alternative solutions recognizing the complexity and ambiguity of the practical world, and for their implementation.
Merriam (1998) defines a case study as “an empirical inquiry that investigates a contemporary phenomenon within a real life context, especially when boundaries between phenomenon and context are not clearly evident.” Cases contain authentic problems, genuine questions, and raise issues in enough detail for learners to suggest possible solutions or outcomes. A case is a story, often told as a sequence of events in a particular place or setting. This provides a clear context in which learners can construct meaning and concepts. The context of a case is intended to enable students to put themselves in the role of being an actor in the situation; in this way, they are more likely to be engaged in the learning and try to relate what they are learning to previous experiences.

A case-based approach emphasizes active construction of knowledge gained from simulated experience. The case study focuses on holistic description and explanation (Merriam, 1998). The object of the case-study approach is to help learners develop skills in dealing with real-life situations by analyzing a typical case, or alternatively, to reach a better understanding of the general principles that are evoked by the case (Romiszowski, 1995). Such an approach presents students with a re-creation of a complex situation and asks them to analyze and solve the problems through reflection and discussion. A primary purpose of cases is to relate educative events to real life situations both in and out of school. In this sense new information is linked to existing concepts and becomes incorporated with existing knowledge rather than compartmentalized memorization (Greenhalgh, 2007).
Case-based learning is cooperative and student-directed. For example, today medical students learn basic science knowledge and the process of making a diagnosis by studying the records of an actual patient. The records are presented in a format that allows students to simulate the process of examining and diagnosing the patient. Students learn to monitor their own understanding of problems to determine what topics they need to study. Then they learn how to research these topics with the guidance of their instructor and by trial and error rather than by being given a prepared list of references. This is similar to the type of research everyone must learn to do on a daily basis as each individual encounters new problems in our rapidly changing world.

Merriam (1998) points out that indeed case studies get as close to the subject of interest as they possibly can, partly by means of direct observation in natural settings, partly by their access to subject factors (thoughts, feelings, and desires), whereas experiments and surveys often use convenient derivative data.

How Does Case-Based Learning Differ from Problem-Based Learning?

Problem-based learning (PBL) is an instructional method that challenges students to "learn to learn," working cooperatively in groups to seek solutions to real world problems (Duch, 2008). Students are encouraged to take responsibility for their group and organize and direct the learning process with support from their teacher. These problems are used to engage students' curiosity and initiate learning the subject matter. PBL prepares students to think critically and analytically, and to find and use appropriate learning resources (Duch, 2008).
Problem-based learning is an instructional strategy of "active learning" often used in higher education in such fields as nursing, dentistry and agriculture (Boud & Faletti, 1991; Barrows, 1996, 1998; Savery & Duffy, 2001). The modern history of PBL began at the medical school at McMaster University where Howard Barrows pioneered its use in response to the poor knowledge base that medical students accrued during their neurology clinical residencies (Rhem, 1998; Maudsley, 1999). However, its intellectual history can be traced back through inquiry training, John Dewey, and student apprenticeships (Rhem, 1998; Edweb, 2007). Problem-based learning can be described as “an instructional strategy in which students confront contextualized, ill-structured problems and strive to find meaningful solutions” (Rhem, 1998). In response to an ever-evolving number of variations on PBL, Barrows (1998) defined “authentic PBL” as addressing several educational objectives:

1. Acquisition of deeply understood knowledge integrated from a variety of disciplines.
4. Development of team and interpersonal skills.
5. Development of a desire to continually learn.

The case method employs cases to establish the context for a discussion or problem-solving episode. In essence, case-based learning is simply a form of problem-based learning that consists in presenting the students with a problem which is embedded within a case. Because of this relationship, the terms case-based instruction and problem-based instruction are frequently used interchangeably in the literature. For the purposes
of this research, a case is a description of specific incident or observation that can be used to convey one or more lessons.

Case instruction puts students in the role of a decision maker facing a problem. Using a case-based approach engages students in discussion of specific situations, generally utilizing real-world examples. Such a method is learner-centered, and involves intense interaction between the participants. Case-based learning focuses on the building of knowledge and the group works together to examine the case. The instructor's role is that of a facilitator and the students collaboratively address problems from a perspective that requires analysis. Much of case-based learning involves learners striving to resolve questions that have no single right answer.

**Educational Outcomes of Case-based Learning**

One of the attractive points of CBL is its interdisciplinary nature. Solutions developed by students in CBL have multiple outcomes just as they would with problems encountered in the real world. Students learn to overlap skill sets in competency areas often integrating written, verbal, scientific reasoning, social, and math skills into developing solutions. According to Kleinfeld (cited in Richardson, 2010), students have the benefit of “learning to examine problems, reflect on their own values, and weigh the merit of their thinking, a process of problem framing and inquiry, a process of design.” This learning structure places emphasis on metacognitive skills and allows students to think beyond lower-ordered levels of thinking such as knowledge and comprehension (Chen, 2006).
However, according to the literature, the true student outcomes of CBL have not been confirmed. Albanese and Mitchell (1993) conducted an extensive review of literature on CBL and PBL in the medical field. They revealed that although CBL students did not typically do as well on basic objective-type exams (e.g., multiple choice, True / False, Matching), which focused on rote memory, there were some exceptions. The variation in how CBL was used yielded different outcomes in student performance. However, in terms of clinical exams where problem solving and critical thinking skills were utilized, CBL students scored higher in these areas. Furthermore, the meta-analysis revealed that CBL students’ clinical scores tended to cluster in the middle where conventional students’ scores were on extreme ends of the scale. Finally with performance-based assessments, CBL students received higher rating by the clinical supervisor than their counterparts. Vernon and Blake (1993) conducted a similar meta-analysis and discover results that favored CBL and PBL students for performance-based assessments and conventional students for knowledge-based assessments. However, because the studies lack randomization, they would not conclude that these advantages were due solely to the program designs.

**History of Case Instruction**

Learning through cases has long been an instructional method used with graduate business, law, and medical students. It began as an informal system of apprenticeship, became institutionalized in the late 19th Century, and is now used in almost every law school in the country. Credit for the creation of the case method is given to Christopher Lang Dell, who became dean of Harvard Law School in 1870 (Williams, 1992).
Initially, the case method was considered to be controversial for many reasons. First, many advocates of the lecture method felt that the case method presented the law in detached fragments (Williams, 1992). Students needed the overview and explanations that a properly prepared lecture could provide. Second, students just beginning the study of law by the case method went through a much longer initial period of confusion than those learning by lecture. Finally, learning substantive knowledge via the case method was very slow and just was not practical (Williams, 1992).

It is important to note that when case instruction was first implemented at Harvard, students found the method of instruction very stimulating but when used exclusively students frequently became frustrated and confused (Williams, 1992). The students felt that the case method could be improved through the use of a variety of case formats, each representing some skill needed.

The development of instructional methodologies within medical education throughout the rest of the United States came about slowly. Until the 20th Century, the development of medical education in the United States paralleled that of legal education. Those who could afford to travel studied in the universities of London, Paris, and Edinburgh, and those who could not, apprenticed themselves to practicing physicians (Williams, 1992). When medical schools were first established in this country, the quality of education was often very poor. A typical curriculum consisted of four months of lecture. At many schools, there was no opportunity for clinical education and there were often no requirements for apprenticeship (Williams, 1992).
In 1894, Johns Hopkins University adopted what has become the standard for medical education curriculum. Students spend two years in the lecture hall and in the laboratory learning basic science, and then two years in the school’s teaching hospital working with real patient cases. Regardless of these improvements to medical education, the following complaints about the lecture method are still heard. First, students are too passive. They are not being trained to be critical thinkers and problems solvers. Second, the lecture method is ineffective. Students do not remember the facts they memorize, and what they remember, they fail to use in practice (Williams, 1992). Most critics felt that students who had been taught medicine as isolated facts were unprepared to deal with the uncertainty and variation that characterize the problems of real patients. Unfortunately established faculties were slow to implement case instruction during the first two years of medical schools (Heestand, 1989).

Today, in medical schools which have implemented case studies during the first two years of study, medical students work in small tutorial groups to diagnose patients’ problems and to understand their causes. The problems are constructed from actual patient records and are initially presented to students in the same way that they were presented to the patient’s doctor, as an incomplete set of symptoms without an explanation. Each tutorial group, guided by a faculty tutor, applies a standard clinical reasoning process that includes generating hypotheses, collecting data, and solving the problem. As in the case method in law school, students have no formal knowledge of medicine when they attempt to solve their first problem (Williams, 1992).
The use of case-based teaching and learning in the secondary and undergraduate sciences has not been so pronounced, although there are accounts of science teaching using cases dating back to the 1940s (McNaught, 2005). Even though case-based instruction has been accepted as an effective teaching method in business, medical, and law schools for over a century, unfortunately very little work has been done that carefully examines how learners respond or how effective it might be with students at the secondary level (Ertmer, 1998).

The Importance of Case-based Learning as an Instructional Technique

Two pedagogical principles underlie the case-based teaching architecture: (1) active learning and, (2) learning from cases (Edelson, 1996). Effective learning takes place when students are engaged in the active pursuit of tasks that provide them with both motivation and opportunity for learning. The case approach is particularly effective because they provide a context in which learning is taking place and as a result they are better able to apply their new knowledge to real life situations.

Educators are becoming increasingly aware of the need for students to learn facts and concepts in a more relevant and meaningful context than through rote memorization. This entails achieving meaning through social interactions between the teacher and the learner that stress resolving misconceptions through negotiation (Alvarez, 1990). Unfortunately, content teachers still treat their subject areas as discrete and separate entities with little to no connection to the student’s life or community (Alvarez, 1990). This type of school experience tends to be learned as compartmentalized units to be later
accessed in a specific subject area by way of either question answering or examination. In such instances, many students find information presented in a way that is artificial and not meaningful. Learning experiences are artificial because the information that is presented lacks a situational context for students to link new ideas to existing knowledge. This results in students mistakenly believing that success in school is equated with knowing a given body of knowledge of a subject rather than learning how this new knowledge can be related to their experiences and other subject disciplines both in and out of school.

Incorporation of ideas is achieved by assembling different knowledge sources in memory (Spiro, 1987). In order for knowledge assembly and incorporation to occur, the role of knowledge activation and how one modifies or constructs meaning with the new information is an important consideration. In contrast, most students have learned to concentrate on those facts and themes which they believe will be tested by the teacher in a given subject instead of reflecting on how these facts and ideas can be assembled, related to prior knowledge, and linked to other disciplines containing common conceptual networks (Alvarez, 1990).

The principle of active learning demands that a student be actively engaged in a personally meaningful task. A meaningful task provides both a motivation for learning and a context for interpreting and retaining new knowledge (Edelson, 1996). The principle of learning from cases recognizes that reasoning from cases is an important element of human reasoning, and that the acquisition of cases is a prerequisite for effective case-based reasoning. The case-based teaching architecture is based on the
observation that a great deal of learning, both formal and informal, comes from hearing stories and cases. In the case-based teaching architecture, a student’s active learning is augmented by just-in-time teaching in the form of relevant cases (Edelson, 1996). When combined, cases provide a way to supplement the learning that a student can achieve through activity, and active learning provides a meaningful context for learning from cases.

Educators often tell stories to convey lessons. Teaching with stories and learning from them occur naturally and subconsciously. Stories are but one form that cases take in human learning. Case studies allow the learner to weigh alternative interpretations, dismiss others, make a decision to evaluate multiple possibilities, or accept information as being reasonable. This process helps learners to modify or extend their mental model, or existing knowledge base. In most schools, firsthand experience has traditionally been provided by laboratories, demonstrations, role playing, simulations, and other hands-on activities. These experiences are important for helping students develop personal case libraries. However, firsthand experience is not always feasible or even advisable, so cases can be provided secondhand through storytelling or other forms of presentation.

A case study for example might be used for its very uniqueness, for what it can reveal about a phenomenon, and for knowledge which would not otherwise be accessible. Merriam (1998) points out that unique or atypical cases help elucidate the upper and lower boundaries of experience because such data and information are rare. Further, such data can facilitate prediction by documenting infrequent, non-obvious, or counterintuitive occurrences that may be missed by standard statistical approaches. Finally Merriam
points out that atypical cases are essential for understanding the range or variety of human experience, which is essential for understanding and appreciating the human condition.

Cases may also aid in teaching principles or concepts of a theoretical nature by showing the occasions when the theories are applicable, illustrating the precedents for practice, in abstract and context-dependent issues such as morals and ethics. Cases can be used to train students in analytic strategies and skills and increase students’ motivation for learning. Further, teachers likely also benefit from taking a case-approach to their teaching as they have a chance to reflect upon the learning when they write and introduce new cases in their classes.

Case-based instruction offers a number of advantages and is thought to be more effective than traditional teaching methods because it (1) more accurately represent the complexity and ambiguity of real-life problems, (2) provide a framework for making explicit the problem-solving process of both novice and expert, and (3) provide a means for helping students develop the kind of problem-solving strategies that practicing professionals use (Stepich, 2000). More specifically, case-based instruction can help students learn to: focus on the big picture, work forward from what they know, simultaneously consider multiple factors, generate tentative solutions, and consider potential consequences and implications (Stepich, 2000).

Teaching Pedagogy of Case Instruction
Professional educators face a daunting challenge of preparing students to solve the kind of complex, ambiguous problems that they will encounter as practicing professionals. A case-based teaching system supports constructivist and active learning theories through two interdependent components, the task environment and the storyteller which place the learner in simulated environments that they may face as professionals. The task environment provides a student with an engaging, motivating activity. A key component of case instruction is that the problems are real world problems. Knowing they are working on real problems is motivating for students (Edelson, 1996). The storyteller monitors the task environment looking for opportunities to present cases that will help students learn from their interactions with the task environment. An effective task environment exposes students to a variety of situations that provide valuable experience with the subject matter. An effective storyteller is able to recognize opportunities for learning that arise in the course of a student’s interactions with the task environment and to capitalize on those opportunities by presenting cases that will help the student learn from his or her situation. To achieve this goal, a storyteller must have a sufficiently wide range of cases to cover the opportunities for learning that may arise in the task environment.

The role of the teacher is very important when using case-based learning and the instructional strategy. As the facilitator, it is important that the learning process be guided rather than the instructor solely providing knowledge. The learning process begins by asking open-ended questions, encouraging student participation, providing appropriate information to keep students on track, providing constructive feedback, and
assuming the role as a fellow learner (Aspy, Aspy, & Quimby, 1993). This student-centered arrangement reduces the amount of direct instruction allowing students to assume greater responsibility for their own learning. The case-based learning strategy embodies the tenets of the constructivist pedagogy (Burris, 2005). John Dewey, an American philosopher and educator whose writings and teachings have had profound influences on education in the United States, is often cited as the philosophical founder of this approach in which the basic premise is that a learner must actively “build” knowledge and skills and that information exists within the built constructs (Huitt, 2003). Fennimore and Tinzmann suggested a difference exists between a behaviorally-oriented (teacher-centered) curriculum in which knowledge and skills are taught discretely and then inductively connected versus the constructivistically-oriented (student-centered) curriculum in which students acquire content while carrying out tasks requiring higher-order thinking (Huitt, 2003).

In practice, the construction of case-based teaching systems is both an art and a science. Creating engaging task environments that are motivating, challenging, and interesting is in many ways an art, and developing instructional methods that can present cases to help students learn draws on the science. When an instructor teaches with cases and stories they rely on two critical skills: the ability to recognize an opportunity to present a case or a story, and the ability to identify the right one to narrate to suit that opportunity.

Christensen and Hansen (1981) summarized four basic characteristics for the case method: situational analysis, active student involvement, non-traditional instructor role,
and analysis based actions. Traditional instructional methods are based on the transmission of knowledge from teacher to student. The teacher identifies facts and skills that students need to know, and tells the students these facts and demonstrates how to carry out the skills. In contrast, students in the case-based learning are actively involved in: identifying which aspect of cases they do not understand, finding answers to their own questions through library research, and consultation with experts. As long as the proposed solution is supported properly with the evidence and arguments, an instructor confirms that students have learned how to analyze a simulated case. Students are learning to learn in a way that will be useful in solving real problems with real-world resources. Therefore, the case method seems to be better than traditional methods in preparing students for a fast-changing world in which they must constantly acquire new skills and knowledge.

Even though case-based learning has been shown to be effective with post-secondary students, many have been slow to implement this instructional technique into their pedagogy. Because case-based learning is a relatively new and very different form of education, teachers are still skeptical about its ability to prepare students for standardized examinations (Williams, 1992). They view the floundering of unprepared students as very inefficient and the possibility of students’ sharing incorrect and incomplete knowledge as dangerous. Further, most educators today have had little to no training on case-based learning during their education and as a result they are uncomfortable with their role as faculty members in this curriculum (Williams, 1992). Finally, case instruction does not follow the traditional roles with which most faculty
members are comfortable. There are three primary roles for the faculty in case-based learning curriculum: tutoring, serving as a subject-matter consultant for students, and developing curricular materials. In order for case instruction to be successful, instructors must reevaluate their roles within the classroom.

Chen (2006) proposes that normally an instructor follows four general phases to conduct a case. During phase 1, the instructor must begin with an introduction of the concepts to be covered in the case. Based in the instant feedback of students, the instructor immediately can solicit useful information to modify or adjust his or her original teaching plan according to the responses of the students. During phase 2, each student team must analyze the case assignment. Engaging activities, such as information gathering and preparation for individual parts of the case are required in order to prepare an analysis properly. This can advance learners into a higher level of reasoning, because communication centers on structuring information processes and processing acquired information (Chen, 2006). During the third phase of case instruction the teacher guides students through output generation and discussions. Usually the output is a report that presents the results of the case analysis, either oral or written. In this environment, new points can be made, questions can be asked, and counter-reasoning can be presented while the ideas are fresh, thus allowing students to become active in their questions and counter analyses. Both the cooperative spirit of the students and the competitive spirit among the students can blossom. Follow-up and evaluation are the final phase of the process. Here the instructor can provide students immediate feedback. This usually takes place with class discussions about salient points made in the case analysis. Areas
that might have been omitted or overlooked can be explored. Specific points that the instructor wants to cover can be presented and are heard by all students. Individual evaluations then usually take place in the form of written feedback.

Research conducted by Stephich (2000) at Northeastern Illinois University indicates that an instructor’s approach has a strong impact on the effectiveness of case-based learning. It is important to begin the discussion of a new case with a structure, but to avoid rigid adherence to that structure. When the initial set-up is too restrictive, students do not have room to express their views and may feel that they are providing answers rather than discussing ideas. As a facilitator, the instructor has two basic tasks: (1) setting up the discussion to create a dialogue among the students and (2) facilitating the discussion to keep the dialogue going. As the case proceeds it is important for the instructor to help the students find the connections among the points being made and relate their discussion to the big picture issues in the case (Stepich, 2000). To accomplish this, it is important to look continually for opportunity to add questions and comments designed to help students see connections. At the same time, it is important to monitor the possible effects that a teacher’s input may have on students. Stepich points out that students sometimes perceive comments from the instructor as the answer, which may impede rather than support the dialogue. The instructor’s comments and questions can also encourage students to elaborate their thoughts about a point raised in the discussion. Other students can then respond to the elaboration thereby continuing the dialogue.

It is important for case instructors to be aware of students’ responses and approaches to the case method and to provide support for those who are unprepared,
intimidated, or reluctant to engage in this unfamiliar and demanding learning environment (Ertmer, 1998). Ertmer and Newby (1996) emphasize the need for teachers to help students set process goals by emphasizing the strategies underlying successful case analysis and by encouraging risk-taking and mistake-making as ways to improve analysis approaches. By emphasizing group problem solving and strategy-oriented discussions, perhaps teachers can shift students’ emphasis from fact-finding to effective strategy use.

When people learn from experience, they pay attention to the circumstances in which an experience occurs (Edelson, 1996). This context helps individuals store experiences as cases in their memories. The context provides learners with features that they can use to index cases. When they find themselves in situations that have features that match the context of the earlier experiences, they are able to retrieve the earlier cases to help decide how to act in the new situations. When teaching with cases, it is important to convey them to a learner in a context that provides the learner with features with which to index that case. Effective case-based teaching takes advantage of context to help the learner index cases effectively in his or her own memory so that they can be retrieved when they might be useful for dealing with novel situations. The Medical Explorers case based curriculum allows students to experience science in a constructivist setting where students are expected to understand the reasoning that supports the epistemic values and to be capable of questioning and discussing them.
Impact of Case-Based Learning on Students

While case-based instruction has been accepted as an effective teaching method in business and law schools for over a century, almost no research has been conducted on the impact of case-instruction at the secondary level. Most educators would likely agree that case-based instruction might not work for all learners, but little has been written about how students react to a case-based learning curriculum and almost all of the research which has been conducted has been focused on the post secondary level. It is important to understand how this instructional method affects the persons most directly involved in it.

Students may like using cases and perceive that they have learned a lot, but this does not necessarily mean that they have gained new or better problem-solving skills. There is some research to indicate that case-based instruction may not be effective with all learners as they may not be prepared to direct their own learning. Case-based learning requires a great deal of knowledge, effort, persistence, and self regulation on the part of the students who must be able to devise plans, gather information, evaluate both the learning process and its outcomes, and generate and revise solutions to problems (Ertmer, 1998). Results from a study by Ertmer and Newby (1998) point to the potential roles that perceived value, learning focus, and use of reflective monitoring strategies may play in shaping students’ responses and approaches in a case-based course. In general, students with high self-regulation were more successful toward adopting and/or employing a facilitative approach to case-based instruction.
Humans are driven by their curious nature and at first one might assume that all students will be motivated to deepen their understanding when confronted with authentic problems in realistic situations. Unfortunately, not all students are adequately prepared to direct their own learning in a case-based environment. It has been noted that students have initial difficulty with the lack of structure (Williams, 1992). Thomas (2001) was able to demonstrate that students need an understanding of how the problem works as well as direct instruction in the reasoning process that they are supposed to employ during problem solving. Providing students with opportunities to integrate their knowledge through case studies may not be effective if they lack the skills or motivation needed to regulate their learning. Once students understand the structure of how to tackle case-based problems, case-based learning provides experiences that can contribute to student confidence (Thomas, 2001).

For many students, discussing and analyzing a case are unfamiliar. Students are often socialized in the standard lecture format where the instructor lectures, students take notes, and interaction between instructor and student is otherwise confined to question and answer events (Mostert, 2007). Students may have difficulty adjusting their expectations of knowledge acquisition and their response modes to the relatively unfamiliar instructional setting when cases are used. Mostert (2007) notes that such sources of frustration, especially those related to their inability to trust their own judgment and those of their peers to arrive at workable solutions, either due to inexperience or lack of knowledge about theories and research findings, can be lowered, for example, by supplying a conceptual framework used as an advanced organizer.
Heckman conducted a study evaluating the influence of problem-based teaching on the knowledge of 40 students at the end of a neurology elective (Heckmann, 2003). A seventy-eight question multiple choice test was utilized as a pre and post analysis of the change in knowledge base between the problem-based learning group and students who experienced the traditional lecture approach. In addition, all students were asked about their degree of satisfaction with the elective in general. Students of both groups did not differ with regard to age, gender, number of semesters, score of last examination or score of the test at the beginning of the elective. However, students who participated in the problem-based teaching group performed significantly better in the test at the end of the elective (increase 16.3%) than those who were trained according to the conventional teaching program (6.3% increase). Heckman concluded that more problem-based teaching including practical exercises significantly improved students’ performance. Hence, the adaptation of this teaching strategy covering these aspects should be encouraged.

In another study conducted by Hudson and Buckley (2004) a cross-sectional evaluation of case-based teaching revealed that students valued this approach. The initiative not only integrated physiology with related basic sciences and clinical medicine but importantly linked students’ developing knowledge of theory to practice. Here it was clear the case instruction could successfully be used to place learning in the context of a case to give meaning to the tasks and material that students were acquiring, while integrating their theoretical knowledge and understanding of the basic sciences (Hudson, 2004). There is also some evidence that cases may also help learners to develop
problem-solving skills and collaborative skills that are recognized as key outcome skills that students will need in their future professional lives (McNaught, 2005).

Interestingly, when compared with students in a case-based learning curriculum, conventional-track students suffered from more stress, found their education less relevant to their future careers, and had more difficulty in applying what they learned (Williams, 1992). During interviews, case-based learning students received significantly higher scores from a blind rater on problem solving, maturity, and motivation (Williams, 1992). On the other hand, case-based learning students were more likely to feel they lacked knowledge in basic science content areas.

**What is Critical Thinking?**

Although definitions differ, many researchers have defined or characterized critical thinking in terms of cognitive skills (Beyer, 1987; Bryne & Johnstone, 1987; Frye, Alfred, & Campbell, 1999; Burris, 1995). A set of cognitive skills identified by Beyer as necessary for effective critical thinking were the ability to:

1. Distinguish between verifiable facts and value claims.
2. Distinguish relevant from irrelevant information, claims, and reasons.
3. Determine factual accuracy of a statement.
4. Determine credibility of a source.
5. Identify ambiguous claims or arguments.
6. Identify unstated assumptions.
7. Detect bias.
8. Identify logical inconsistencies in a line of reasoning.
9. Recognize logical inconsistencies in a line of reasoning.

10. Determine the strength of an argument or claim.

On the other hand, some researchers have linked critical thinking skills with higher-order thinking and used Bloom’s Taxonomy of Education Objectives as the framework for analyzing this form of cognitive skills (Burden & Byrd, 1994). In Bloom’s Taxonomy of Education Objectives, there are six levels of cognition: Knowledge, Comprehension, Application, Synthesis, Analysis and Evaluation (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956). According to Bloom et al. Knowledge is the recall of specific information, processes, patterns, or structures. Whereas, Comprehension represents the understanding of information by an individual such that one can use the information but does not necessarily relate it to other material or use it to its fullest implications. These two levels are commonly considered forms of lower-order thinking (Miller, 1990).

The upper four levels are generally considered forms of higher-order thinking (Miller, 1990). Bloom et al. (1956) defined Application as the use of abstraction in particular and concrete situations; Analysis as the ability to break down elements into its constituent parts such that the relative hierarchy of ideas is made clear and relationships between the ideas are made explicit; Synthesis as putting together parts so that they form a whole; and Evaluation as the judgments made about the value of material and methods for given purposes. Although there is an evident link between critical thinking and higher-order thinking, some researchers suggest that although critical thinking encompasses aspects of higher-order thinking the two concepts should not be used synonymously (Ennis, 1985; Facione, 1990). Facione (1990) suggested that critical thinking, creative thinking, problem solving and decision-making where all forms of a cognitive process that are closely related to higher-
order thinking. Similarly, Ennis stated that critical thinking encompassed a great deal of higher-ordered thinking.

For many years, a generally accepted way to define critical thinking has eluded researchers. However, in recent years researchers have more clearly defined it and have established a set of characteristics that are more manageable to measure and teach. Learning inherently involves components of inference, judgment, active mental construction, and critical thinking (Dori, 2003). Critical thinking can be defined as being able to examine an issue by breaking it down, and evaluating it in a conscious manner, while providing arguments or evidence to support the evaluation. Instructional techniques which enhance critical thinking provide an avenue for activating existing memories and for constructing new ones (Alvarez, 1990). Critical thinking provides the learner with a strategy for achieving understanding, and can be accomplished by constructing ideas and engaging in reflective thinking. In order for all students to be potentially successful learners, thinking must be applied to all learning and to all learners. This view, namely that teaching for higher order thinking is important for the learning of all students in all academic tracks, is also emphasized by other researchers (Dori, 2003).

**How Does Case Instruction Affect Critical Thinking Skills?**

The promotion of critical thinking skills has long been advocated. In 1983, The National Commission on Excellence in Education (NCEE) conducted a study of the state of the US educational system and concluded that declines in educational performance are in large part the result of disturbing inadequacies in the way the educational process itself
is often conducted. The inadequacies were grouped under four categories: content, the information being taught to the students; expectations, the level of knowledge students should possess by graduation; time, the amount of time and rigor students put into the learning process both in school and at home; and teaching, the qualifications and availability of skilled educators. The report identified the risk to the nation’s welfare and global dominance as “a redistribution of trained capability throughout the globe” to which America is slow to respond (NCEE, 1983). The report went on further to say:

Knowledge, learning, information, and skilled intelligence are the new raw materials of international commerce and are today spreading throughout the world as vigorously as miracle drugs, synthetic fertilizers, and blue jeans did earlier. If only to keep and improve on the slim competitive edge we still retain in world markets, we must dedicate ourselves to the reform of our educational system for the benefit of all--old and young alike, affluent and poor, majority and minority. Learning is the indispensable investment required for success in the "information age" we are entering (NCEE, 1983).

Some years later, a report entitled Learning and Living: A Blueprint for High Performance (1992), the Secretary’s Commission on Achieving Necessary Skills (SCANS) identified critical thinking as a skill needed by all workers. More specifically, workplace competencies were identified as the ability to manage resources, work productively with others, acquire and use information, understand complex systems, and work comfortably with a variety of technologies (The Secretary’s Commission on Achieving Necessary Skills, 1992). These reports demonstrate the importance of critical
thinking to the success of the country on the global market and the role the educational system plays in developing students’ critical thinking skills.

Fostering the thinking quality of students is one of the most ancient goals of education, dating back to the days of Plato in ancient Greece (Dori, 2003). During many generations, this goal was intended only for a small, restricted group of elite students, while the vast majority of students did not have the privilege of enjoying an educational tradition that fostered their thinking (Dori, 2003). Critical thinking is a high priority outcome of education. Critical thinking skills are crucial for independent thinking and problem solving in both our students’ professional and personal lives. Employers need individuals who can think critically and analytically, interpret information and experimental data, tackle unfamiliar open-ended problems, and apply their knowledge. Case studies need to help students to learn how to understand the given information, acquire relevant information, and accomplish stated goals or tasks via a critical thinking process (Chen, 2006).

Case-based learning is one method that can be used to foster critical thinking (Alvarez, 1990). This method also fosters student reflection on preconceived motions and promotes changes in thinking via a constructivist approach to learning (Bolt, 1998). Engaging in debate and dialogue with their peers about a situational problem promotes critical thinking in students (Harrington, 1996; Moje, 1997). Students need to be provided with problem solving lessons in meaningful learning contexts for critical thinking to take place. Analyzing information and data presented in case studies, posing questions, providing scientifically grounded arguments, expressing opinions, making
decisions, and system thinking are higher order thinking skills (Dori, 2003). Case-based instruction and learning provide students with a forum for taking an active role in structuring and creating their own meaning. The case method of teaching and learning provides a forum during which students can develop their own framework to reason and think about problems and situations related to an area of study (Alvarez, 1990).

A study conducted by Driver, Newton, and Osborn (2000) claimed that in order to develop deep understanding and evaluative skills, students must acquire the ability to construct arguments and engage in dialogic thinking. Arguments can be based on scientific claims or on social foundations. Ignoring the social perspectives of science means teaching in a value-free, abstract, and objective approach, which does not reflect our complex modern world (Driver, 2000). The case method has become a means for effective learning that draws the attention of the student audience by portraying real-life scenarios. Studies related to teaching students at various ages, using case studies have indicated that the case study method is effective at improving students’ conceptual understanding, question posing and critical thinking abilities, as well as their motivation (Dori, 2003).

Research conducted by Alvarez (1990) examined the impact of a 6-week interdisciplinary case study with ninth-grade students enrolled at Gallatin High School in Tennessee. In this study, students individually selected one case from an array of cases that appealed to their interests. Their study found that case instruction required students to analyze concepts according to a different perspective or within a different situation (Alvarez, 1990). In this study students were required to apply information to authentic
problem situations that required them to think critically in order to obtain a plausible and defensible resolution. In working through these cases, students were given opportunity to demonstrate the variety of abilities and interests they possessed by revealing in-school as well as out-of-school knowledge. Alvarez found that students were most articulate when they were confronted with meaningful tasks that required thinking and active participation in situations that: incorporated knowledge from other disciplines and contexts, were relevant to the experiences of their community, and allowed them to formulate and pursue their own interests to the related topics (Alvarez, 1990). Equally important was that teachers began and ended this interdisciplinary project with invested interest and ownership.

Alvarez has demonstrated that authentic cases seem to spur curiosity and invite students to initiate critical thinking. Case-based instruction and learning provide students with a forum by which to take an active role in structuring and creating their own meaning (Alvarez, 1990). To begin to solve a new case or problem, students must ask themselves questions such as “What information do you need to establish whether the ideas that the group came up with are correct?” or “How would you determine which is most likely?” This problem solving process is real world but this is not something that is routine at the secondary level and these learned skills are areas in which the students need further study.

A 2003 study conducted by Yehudit Dori at the Israel Institute of Technology evaluated teaching biotechnology through case studies and its impact on higher order thinking skills of nonscience majors. The research population consisted of about 200
nonscience majors in eight classes of grades 10-12 from heterogeneous communities. This study found a significant improvement in students’ knowledge and understanding and higher order thinking skills at all academic levels (Dori, 2003). Interestingly, when case instruction was used the scores that low academic level students achieved in the knowledge and understanding category were higher than their high academic peers’ scores. In the higher order thinking skills such as question posing, argumentation, and system thinking, a significant difference in favor of the higher academic students was found but improvement at all academic levels was observed. The gap in critical thinking skills that had existed between low and high academic level students narrowed. Further most students reported that the biotechnology topics that they had studied were interesting and relevant. In this study the use of case instruction seems to demonstrate clearly its ability to impact the development of scientific and technology literacy along with higher order thinking skills of nonscience majors (Dori, 2003).

**Impact of Case-Based Learning on Self-directed Study**

Creating self-directed learners is one of the major objectives of case-based learning and of society in general. In the information age, new scientific information is discovered at an exponential pace; former information frequently becomes obsolete; and new technologies are introduced daily. Given this, schools have a reasonability to ensure that their graduates have the skills necessary for life-long learning: how and where to obtain information, how to evaluate it, and how to apply the new information to problems. A case-based approach emphasizes both individual self-study and group discussion, with the group discussion building on individuals’ personal work.
Case-based learning empowers the student to make decisions about how to go about solving the problem, what information is needed, and along the way aids students in building their self-directed study skills. In support of this, research has shown that case-based learning students spend more time studying in the library using a wider variety of resources that they selected themselves as compared with the conventional students who primarily rely on the textbook and the instructor (Williams, 1992).

**Interdisciplinary Impact of Case-Based Learning**

The *Medical Explorers* curriculum utilizes the case study method of instruction in a multidisciplinary approach. Cases that revolve around defined topics and that allow for cross curricular connections to be made can lead to better comprehension and knowledge transfer and the application of pre-existing knowledge to new situations (Alvarez, 1990). The case-based method of instruction is interdisciplinary in nature in that it contains problem situations that arise from a thematic concept that includes other subject areas. Cases that present learners with single and varied contexts across disciplines provide learners with scenarios that can be discussed and analyzed from multiple perspectives. Students’ collaborative skills, such as the ability to engage in academic conversations and to pay mutual respect to each other, show strong improvement after going through a case-based learning experience (Hazard, 1999).
Need for Research on Case-Based Learning at the Secondary Level

Science education at all levels has focused mainly on the dissemination of science content by disciplinary experts with limited skills in cognition, pedagogy, and active learning. This has led to an overemphasis on the outcomes of scientific work and an under emphasis on true scientific thinking. Often, science is presented to students as a body of established fact in a manner that downplays uncertainty. Allowing students to learn about the diverse methods of science can generate interest and perhaps point more students toward a career path that involves science. The use of cases, particularly at the secondary level, may well provide a much more authentic experience of the process of doing science. Doing science involves investigating open-ended problems where the answer to the problem is uncertain. The true nature of science is violated by passive recipe-based education. The learning of science is related to exploration of ideas, application of theories to particular social and technological contexts, and also consideration of appropriate codes of practice. All these aspects can be handled well in a case-based approach.

Educational literature is filled with claims of the benefits for students who participate in case-based learning: knowledge and skill acquisition, attitude change, and development of judgment and wisdom (Wolfe, 1993); increase in professional reasoning, critical thinking, problem solving, and reflective thinking (Barell, 1995); group cooperation, recognition of multiple viewpoints as well as increased interest and motivation (Wassermann, 1994). However, almost all of this research has been conducted at the post secondary level and provides little information about the effectiveness of case instruction at the secondary level.
Support for teaching with cases comes from the theory of case-based reasoning (Edelson, 1996). This theory argues that many situations are too complex for people to deal with by reasoning from first principles. Instead, they reason using previously stored cases. Researchers have observed evidence of people using case-based reasoning in practical situations in a wide variety of problem-solving domains (Edelson, 1996). Because complex subjects such as science require case-based reasoning, it is important to teach those subjects in a way that will assist the natural process of case-based reasoning.

Although the prevalence of the case method in professional education reflects this recognition, much of grade Kindergarten -12 and undergraduate education does not.

Research on the effectiveness of case-based learning has taken place primarily within medical and law school and because the data have been collected primarily by independent researchers, its legitimacy may be questioned. Unfortunately, even this research is limiting because most of it involves comparative studies, which contrast student perceptions of case-based science teaching with more traditional teaching. Much of the research comparing case-based learning and conventional curricula has been largely reactive; that is, opponents of case-based learning raise a specific objection to the program’s cost or its ability to prepare students, and advocates of case-based learning gather data to support their position. Further, these studies do little to inform educators and researchers about the impact of case-based learning on students at the secondary level.

While questionable, many studies of the case method and problem-based learning provide evidence that case-based approaches to instruction similar to those advocated by
cognitive apprenticeship and anchored instruction can be successful when used in a school setting as the primary method of instruction (Chen, 2006). Post secondary education studies have provided considerable information about faculty and student perceptions of the value of case-based teaching, student attendance in class, and perceptions of changes in student learning and motivation (Lunderberg, 2006). In a recent national survey it was found that faculty believed that students’ critical thinking increased and their understanding deepened when learning via case-based instruction (Yadav, 2006). Faculty reported students in the classes using case studies demonstrated stronger critical thinking skills (89.1%), were able to make connections across multiple content areas (82.6%), and developed a deeper understanding of concepts (90.1%) (Hoag, 2005). Most of the faculty perceived when they used case-based teaching that students were better able to view an issue from multiple perspectives (91.3%), and were more engaged in the class when using cases (93.8%). In addition, research by Hoag (2005) and colleagues has shown that students tend to attend class more on days when cases, rather than lectures, are used. Furthermore, students believed that content is easier to remember and apply and they enjoy it more when using case studies.

According to a recent meta-analysis examining 43 research studies on problem-based and case-based learning, there are significant differences on skills gained (Dochy, 2003). However, there were no significant differences in knowledge on standarized measures of accumulated knowledge gained in medical school. This is not exactly surprising given that the case-based approach focuses on depth of understanding rather than breadth. However, when the assessment task measured critical thinking rather than
basic knowledge, students in case-based learning showed higher gains in performance as compared to traditional instruction (Dochy, 2003).

Unfortunately, little research has been conducted on the effectiveness of case instruction on younger students even though anchored instruction and cognitive apprenticeship advocate the use of case-based instruction with younger students (Williams, 1992). Its effect must also be tested with those who lack motivation and good learning strategies. Initial data suggest that middle-school students who work with video-based cases show gains in problem solving and develop positive attitudes toward the subject matter (Williams, 1992). Clearly there is much to be done to determine how this type of instruction works with younger students. Additional experience and evaluation are necessary to investigate the impact of case-based teaching systems on students understanding and abilities.

If educators want to understand case-based instruction, then there is a clear need to know more about who learns from cases and why. Although case-based learning methods are being used in some university level courses in the field of science, mathematics, business, and education, there has been little implementation of this method within K-12 education. Relatively little empirical research has been examined as to whether and how these case-based teaching approaches have the desired effects of promoting deep understanding, enabling transfer of ideas to new contexts, and making learning more motivating or valuable for certain student populations, especially traditionally underrepresented groups (Lundeberg, 2006).
Chapter 3

Methodology

*Medical Explorers*’ cases vary greatly in content and complexity. The initial problems that were presented to students were relatively short and simple. Each group’s assignment was to evaluate all aspects of the patient’s life and to arrive at a conclusion and treatment plan. The explanation was expected to be more than a diagnosis; it was expected to contain the important history and laboratory information to support the diagnosis. The relationship between data and diagnosis must have been explained in terms of basic biological mechanisms or biochemical disturbances. Students must learn to develop confidence in their ability to reason through a problem, identify what they already know, and what they need to learn. Although this metacognitive ability is often already a part of the reasoning skills of many good students, working under the guidance of their teacher provides practice that is designed to make these skills automatic for all students.
Research Objectives and Hypotheses:

The purpose of this study was to evaluate the effectiveness and impact of the *Medical Explorers* case study curriculum among eleventh and twelfth grade high school students by:

1. Measuring the ability of the *Medical Explorers* case-based to curriculum improve higher order thinking skills of the students.

   **H₁**: Students taught using *Medical Explorers* case-based to curriculum will demonstrate greater critical thinking development than students taught through teacher guided learning when accounting for prior critical thinking ability.

2. Evaluating the impact of the *Medical Explorers* case-based curriculum to help students be self directed learners, to ensure that high school graduates have the skills necessary for life-long learning.

   **H₂**: Students taught using *Medical Explorers* case-based curriculum will demonstrate greater improvement in their motivation and self regulation of learning skills than students taught through teacher guided learning when accounting for prior ability.

3. Investigating the impact of the *Medical Explorers* case-based curriculum to improve students attitudes of the life sciences.

   **H₃**: Students taught using *Medical Explorers* case-based to curriculum will
demonstrate greater improvement of their attitude toward life sciences than students taught through teacher guided learning when accounting for prior attitude toward life science.

**Rationale:**

Science education at all levels has focused mainly on the dissemination of science content by disciplinary experts with limited skills in cognition, pedagogy, and active learning. This has led to an overemphasis on the outcomes of scientific work and an under emphasis on true scientific thinking. The use of cases, particularly at the secondary level, may well provide a much more authentic experience of the process of doing science. Unfortunately, little research has been conducted on the effectiveness of case instruction on younger students even though anchored instruction and cognitive apprenticeship advocate the use of case-based instruction with younger students. Almost all of this research has been conducted at the post-secondary level and provides little information about the effectiveness of case-based instruction at the secondary level. Research on the effectiveness of case-based learning has taken place primarily within medical and law schools. Unfortunately, even this research is limiting because most of it involves comparative studies, which contrast student perceptions of case-based science teaching with more traditional teaching. Further, these studies do little to inform educators and researchers about the impact of case-based learning on students at the secondary level.
Data exists that suggests that middle-school students who work with video-based cases show gains in problem solving and develop positive attitudes toward the subject matter (Williams, 1992). Relatively little empirical research has been examined as to whether and how these case-based teaching approaches have the desired effects of promoting deep understanding, enabling transfer of ideas to new contexts, and making learning more motivating or valuable for certain student populations, especially traditionally underrepresented groups (Lundeberg, 2006). Clearly there is much to be done to determine how this type of instruction works with younger students. Additional experience and evaluation are necessary to investigate the impact of case-based teaching systems on students understanding and abilities at the secondary level.

**Context:**

For this study, Indiana high school students were selected to participate in the *Medical Explorers* case-based curriculum. The test population was to include a minimum of thirty students in advanced life science courses, at the eleventh and twelfth grade level, at Delta High School. In addition a minimum population of fifteen advanced science students at the eleventh and twelfth grade level from Delta High School was used as the control population. Participation in the *Medical Explorers* study was voluntary. Appropriate written permission for use of students in this study was obtained as needed from the local principal, school board, parents or students, the Indiana Department of Education, and the Ball State University Institutional Review Board.
Both the control and experimental groups were asked to complete all pre and post instrumental measures. The experimental test population participated in the five week Medical Explorers case-based learning (CBL) unit in between the pre and post analysis. The control group was involved in more of a traditional teacher guided learning (TGL) instructional approach during the same five week time period. All pre and post instrumental measures were given to both groups in the same order on the same days. A parental consent / student assent form was provided to the instructor prior to the commencement of the study (see appendix G).

**Number of Subjects:**

This study utilized 81 high school students taking a life science course at the eleventh and twelfth grade level to establish a meaningful control and experimental population for this study. Four students in this population chose not participate in the voluntary study; six students were removed from the study due to excessive medical absences and attrition from the school. The final total number of students in the subject population was 71.

**Subject population:**

Research subjects will fell into one of two categories: control, and experimental subjects. The control population was made up of 35 students enrolled in a junior / senior level advanced life science course. The experimental population was made up of 36 students enrolled in a junior / senior level life science course. The subject population
consisted of students 16 - 18 years of age from a variety of socioeconomic backgrounds and who were not be discriminated based on sex, race, or intelligence.

Method of subject recruitment
Students enrolled in an advanced level life science course, at Delta high school in Delaware County, were asked to voluntarily participate in this study. Recruitment was made by verbal and written announcement by the principle investigator and key personnel (assessment administrator) of the study in five junior and senior level advanced life science classes. An overview of the study was explained to the students, discussion was open to questions and answers, and all students were asked to take home student/parent consent form which also contains a description of the study. The scripted announcement of the study and recruitment / consent form for students and parents can be viewed in appendixes G & L.

Medical Explorers’ Instructional Methods
The Medical Explorers curriculum is based on evaluative case studies which involve description, explanation, and judgment. Metacognitive aspects of solving cases are directly taught to students. The instructor must ensure that problem solving always includes steps of generating a hypothesis, gathering data, and coming to a conclusion based on the information gathered. The problem of a case is always encountered first, before students study the related basic science concepts. To begin tackling the problem, the students will first work together to identify the potential problem-solving resources
needed. At first, initial case problems should be simple so that the students become accustomed to the vocabulary and tasks of case-based learning, including problem identification and hypothesis generation (Williams, 1992). In the *Medical Explorers* curriculum, students are first introduced to the format of case-based learning by collectively working through one case as a group. The teacher’s function will be to guide the group, not to solve the problem for them. The goal is to create an open working atmosphere in which students feel free to offer their opinions or admit their ignorance. A decision is made to determine which group members will be in charge of the different aspects of the case. The content in the *Medical Explorers* curriculum book was unaltered; however, the handouts and instructional material were adapted to be used in the secondary classroom.

The *Medical Explorers* curriculum is divided into three phases: whole class guided case study, independent small group case study, and making a difference at the local and global level. During the first phase of the curriculum the whole class is introduced to their patient and begins to discuss the goals for diagnosing and treating the patient. The teacher leads the students in evaluating what is known and what information is needed. Each patient is evaluated holistically by learning about their: religion, culture, environment, socioeconomic conditions, family history, available health care, and any medical evaluation information. The class then discusses the information that is needed from each area and how that information may be vital toward diagnosing and properly treating their patient. The class is then divided into smaller research teams of two to four students who are assigned one of these research categories and will be responsible for
collecting as much information as possible and reporting it back to the whole class. Students are initially given one class hour to collect information using resources in the library and on the Internet. During this time it is essential for the teacher to check for progress and refocus students toward the goal of obtaining information which might be helpful in diagnosing and treating the patient.

Students discuss the initial information provided in the patient’s case, list the important facts, report the initial information from each subgroup, and summarize the problem. At this point they are trying to create a working list of important facts and terms. This becomes a fluid list which will have to be changed as students learn more about their patient. In this phase, the group should have a preliminary discussion of what the problem is and what they believe are the key pieces of information to be pursued.

The next step of problem solving the patient’s condition is a circular process of generating hypothesis with existing knowledge and determining what data should be obtained to establish or rule out each hypothesis. Subgroups will then tackle their newly developed list of questions during a second day of research.

Because one purpose of case-based learning is to learn basic science concepts, the ideas that are generated must be ideas about the basic biological mechanisms that underlie a patient’s problem, not simply the names of diseases. Ultimately the whole class must come back together to discuss the information that was gathered and in what way it is helpful toward diagnosis and treatment. Based on all the information gathered the class narrows the list of hypotheses and the evidence collected is used to arrive at a diagnosis. Once a diagnosis is agreed upon students must discuss a treatment plan and
what questions need to be answered. Each diagnosis is different depending on the patient, but often students need an additional day of research to investigate things such as: appropriate medications, homeopathic medicine, surgery, physical therapy, and dietary changes. Finally the class comes back together and reports what they have discovered about possible modes of treatment based on the patient’s culture, religion, and socioeconomic level. Students must summarize what they have learned about the basic-science concepts and explain how it relates to the problem that they solved and how it adds to what they already know.

From the author’s past experience, it has been found that students often feel that it is not possible to make decisions without complete information, but learning to make decisions on the basis of probability rather than a complete set of facts is part of real-world problem solving. Taking the time to solve the first case as a class is a valuable investment and worthwhile with increased student confidence as they tackle their own cases in small groups. During the second phase of Medical Explorers, the students pick a new patient to investigate and repeat the case-based learning process independently, this time in small groups. The primary role of the instructor is to keep groups actively engaged, asking new questions, stimulating discussion, and guiding the students through the process.

During the second phase of the Medical Explorers curriculum the class is divided into new medical research teams of three to four and given a new patient of their own. Each team is then responsible for going through the entire process of diagnosing and developing a treatment plan for their patient. One of the first tasks is for the group to
decide on the tasks to be completed and questions that need to be answered so that this work can be subdivided among group members. Groups are given three to four days of in-class research time and about ten days of out of class time to work independently. It is important periodically to have groups discuss their goals, questions, and report new information by each group member. Ultimately each group goes through the same initial process that the whole class did to arrive at a diagnosis and treatment plan.

Once medical research teams have arrived at a diagnosis and treatment plan during phase two they are asked to put together a presentation of their work. Student teams report back in a number of creative ways such as: creating a web page, developing a video, singing a rap, or creating a media enhanced PowerPoint presentation. The goal of the presentations is to show others what information they started with about their patient, what information was gathered, how this information was used to arrive at a diagnosis, and what the most appropriate treatment plan would be for their patient. In the past the creativity and professional level of work students have presented to the class during phase two have been amazing.

During the third phase of the Medical Explorers project students are asked to develop an individual or group service plan which will help improve conditions at school, in the community, or at the global level. This phase of the project is designed to get students to reflect on their impact on the world around them and to understand that they can make a difference. The Timmy Foundation can assist students in finding volunteers who have completed service projects, connecting them to local support organizations, or make arrangements for those who wish to participate in international mission trips.
Medical Explorers Case-Based Educational Objectives

In addition to the original education objectives created by the authors of Medical Explorer case-based curriculum, the primary investigator chose to establish additional educational objectives. These educational objectives were then evaluated by the primary investigator informally through student observation and discussion as well as formally utilizing a rubric scored final project which emphasizes these educational objectives.

Educational Objectives:

Students should be able to:

- Understand how scientific knowledge can be used to guide decisions on environmental and social issues.
- Recognize that their explanations must be based both on their data and other known information from investigations of others.
- Understand the characteristics and uses of various sources of scientific information and the evaluation of scientific information, claims, and arguments.
- Recognize the social, cultural, and ethical aspects of science, engineering, and technology.

Instrument Methods and procedures used:

Pre and post analysis was conducted in both the control and experimental groups to evaluate the effectiveness of the Medical Explorers case-based curriculum. All students participated in all pre and post analyses as a regular part of the class so that no one, including the key investigator nor the other students in the classes, knew who was or
wasn’t participating in the study. Through the consent form, students and or parents were able to allow or not allow the data collected from these pre and post analyses to be used in the study. Each student was asked to use a unique identifier code assigned to them by the assessment administrator so that all pre-post analysis was completed in a confidential manner. By considering fluctuations over the case study unit, the primary investigator was able to address questions related to students’ changing responses, approaches to learning, attitude, and critical thinking skills.

All participating students were asked to complete the following:

- The Motivation & Self-regulation of Learning Questionnaire (MSLQ)
- Watson-Glaser Critical Thinking Appraisal
- Relevant Biology CAT: Attitude Survey

Student analyses for the Watson-Glaser, Motivational and Self-regulation of Learning Questionnaire (MSLQ), and CAT Attitude Survey were administered as paper and pencil assessments. Students were asked to use their unique identifier code number and individual names were never used. This unique identifier was used by the researcher to track responses on a pretest/posttest study design only.

**Description of data collected:**

All data collected in this study was confidential. All participants were assigned a unique identifier code so that tracking of the responses was possible. Each student was asked to fill in their unique identifier code for all pre-post analysis. To help eliminate
potential issues of perceived coercion of students in the key investigator’s classes now or in future courses, the assessment specialist within the school acted as the third party key personnel in the study. All consent forms were collected by the assessment specialist (key personnel) and were never seen by the principal investigator. The key investigator provided the assessment specialist with a list of students in each course which were then randomly assigned (non-alphabetical order) a unique identifier code. The list which linked students to the unique identifier code was secured and only seen by the assessment specialist. Once the study was completed this list was shredded so that data can never be linked to a particular student. The principal investigator helped train and support the assessment specialist on proper administration of the analyses instruments. All pre and post assessments were then be administered by the assessment specialist (key personnel) only using the unique identifier code assigned to each student and then all data was immediately handed off to the key investigator. The assessment specialist also filled in two coded tables (see Appendix H & I) for the key investigator which provided the following information for each student: parent/student consent to use data or not, attendance and participation for each pre and post analysis, gender, ethnicity, free or reduced lunch status, and SAT/PSAT data when available. At the end of the study the assessment specialist retained the consent forms for a two year period and then they will be shredded. This investigative procedure was utilized to truly make the key investigator blind to who was or wasn’t participating in the study and secures individual data so that it can never be linked to an individual student.
Table 2.1

Summary of Schedule by Instructional Strategy

<table>
<thead>
<tr>
<th>Day</th>
<th>Control Teacher Guided Learning (TGL) Group</th>
<th>Experimental Case-bases Learning (CBL) Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Assessment administrator and researcher introduce research project and answer questions. Information and consent form sent home.</td>
<td>Assessment administrator and researcher introduce research project and answer questions. Information and consent form sent home.</td>
</tr>
<tr>
<td>2-7</td>
<td>Consent forms collected by assessment administrator and students are assigned a random data code.</td>
<td>Consent forms collected by assessment administrator and students are assigned a random data code.</td>
</tr>
<tr>
<td>8</td>
<td>CAT and MSLQ pretests are given by the assessment administrator.</td>
<td>CAT and MSLQ pretests are given by the assessment administrator.</td>
</tr>
<tr>
<td>9</td>
<td>WGCTA pretest administered.</td>
<td>WGCTA pretest administered.</td>
</tr>
<tr>
<td>10-35</td>
<td>Instruction using lecture and application activities lead by the teacher.</td>
<td>Facilitation of case study using group investigation of Medical Explorers patients.</td>
</tr>
<tr>
<td>36</td>
<td>CAT and MSLQ posttests are given by the assessment administrator.</td>
<td>CAT and MSLQ posttests are given by the assessment administrator.</td>
</tr>
<tr>
<td>37</td>
<td>WGCTA posttest administered.</td>
<td>WGCTA posttest administered.</td>
</tr>
</tbody>
</table>

Description of Instrumental Research Measures:

Motivation and Self-regulation of Learning Questionnaire (MSLQ)

Current research on student classroom learning stresses the importance of considering both motivational and cognitive components of academic performance (Garcia, 1994). Motivational components include students’ perceptions of the classroom environment as well as self-related beliefs such as personal goals, self-efficacy, interest,
and value beliefs. Cognitive components include students’ content knowledge as well as various cognitive learning strategies such as rehearsal elaboration, and organization, as well as metacognitive strategies such as planning, monitoring, and regulating learning (Garcia, 1994). Given that both motivational and cognitive components are important for classroom learning, issues regarding assessment become paramount.

Students have differing levels of personal interest and value for classroom academic tasks. Many laboratory tasks that are used in secondary science classrooms today likely have a low value for the typical student, as they may seem unimportant or not meaningful to real life. Thus being able to measure students’ beliefs regarding classroom work is helpful toward linking them to students’ cognitive and metacognitive learning strategies.

The Motivation and Self-regulation of Learning Questionnaire (MSLQ) is a Likert-style self-report questionnaire designed to access students’ motivational orientation and use of learning strategies for a specific course or unit of study (see Appendix E). This instrumental measure was developed by the National Center for Research on Improving Postsecondary Teaching and Learning at the University of Michigan. Initial MSLQ results were gathered from 380 Midwestern college students over 14 subjects and 5 disciplines. Pintrich et.al. reported internal consistency coefficients between .52 and .93 for each subtest with relatively good reliability and validity (Ertmer P. A., 1996). Because the students participating in this Medical Explorers Case Study will be juniors and seniors at the advanced science level, the
MSLQ seems to be a good measurement of student motivation and learning strategies for this study.

The Motivation and Self-regulation of Learning Questionnaire (MSLQ) consists of fifteen subscales that can be used singly or together. The instrument is designed to be given in class and takes approximately 20-30 minutes to administer. There are two sections to the MSLQ, a motivation section and a learning strategies section. Students respond to items regarding motivation, cognitive and metacognitive strategy use, and management of outside resources, using a seven-point (1-not at all true of me; 7 – very true of me) scale. The motivational section assesses students’ goals and value beliefs for a course or unit, their beliefs about their skills to succeed in a course, and their anxiety about tests in a course. The learning strategy section looks at cognitive and metacognitive strategies concerning student management of different learning resources.

The motivational scales are based on a broad social-cognitive model of motivation that proposes three general motivational constructs: expectancy, value, and effect (Garcia, 1994). Expectancy components refer to students’ beliefs that they can accomplish a task, and two MLSQ subscales are directed toward assessing perceptions of self-efficacy and control beliefs for learning. Control beliefs for learning refer to students’ beliefs that outcomes are contingent upon one’s own effort, rather than external factors such as the teacher or luck. Value components focus on the reasons why students engage in an academic task. Three subscales are included in the MSLQ to measure value beliefs: intrinsic goal orientation, extrinsic goal orientation, and task value beliefs. The
third general motivational construct is effect, which taps into students’ worry and concern over assessment.

The learning strategies section is divided into three general types of scales: cognitive, metacognitive, and resource management. Cognitive strategies include students’ use of basic and complex strategies for the processing of information for texts, projects, and lectures. The uses of more complex strategies are measured by two subscales concerning the use of elaborate strategies and organizational strategies. In addition, a subscale on critical thinking is included, which refers to students’ use of strategies to apply previous knowledge to new situations or make critical evaluation of ideas. The second general category is metacognitive control strategies, which is measured by one large subscale concerning the use of strategies that help students control and regulate their own cognition. This subscale includes planning, monitoring, and regulating. The third general strategy category is resource management, which includes four subscales on students’ regulatory strategies for controlling other resources besides their cognition. These strategies include managing one’s time and study environment, as well as regulation of one’s effort. Finally, the remaining two subscales, peer learning and help-seeking focus on the use of others in learning.

While this instrumental measure was originally designed to measure motivation and use of learning strategies for a specific course, here the author proposes to use the MSLQ to evaluate motivation and use of learning strategies for the Medical Explorers curriculum unit. By having students respond to the MSLQ at the end of the Medical Explorers unit, with medical research materials and models, and having just completed
their case reports, the author hopes that these cues will stimulate the respondents to think about their actual beliefs and behaviors for the Medical Explorers curriculum.

**Analysis of the MSLQ:**

An average MSLQ score was calculated for each student in the control and experimental groups and then a mean MSLQ score was calculated for each of the groups. Average subscale scores for each student were constructed by taking the mean of the items that make up that subscale within the MSLQ. For example, intrinsic goal orientation has four items, thus an individual’s score for intrinsic goals orientation were computed by summing the four items and taking the average. There were some negatively worded items and the ratings were reversed before an individual’s score is computed, so that the statistics reported represent the positive wording of all the items and that higher scores indicate greater levels of construct of interest. This procedure was used to generate average student subscale scores within each of the three general motivational constructs: expectancy, value, and effect, as well as the three subcategories for learning strategies: cognitive, metacognitive, and resource management.

This study examined the relationship between overall change in pre and post MSLQ scores and student project performance within the Medical Explorer unit, change in critical thinking ability based on the Watson-Glaser, as well as change in student attitudinal data obtained through the CAT biology attitude survey. It was predicted that the overall MSLQ scores would show positive correlation with the final project grade. Students who approach the Medical Explorers unit with an intrinsic goal for learning,
who believe that the material is interesting and important, who have high self-efficacy beliefs for accomplishing the tasks, and who rated themselves as in control of their learning are likely to do well in terms of the Medical Explorer unit grade.

More importantly this study determined the impact the Medical Explorer curriculum has on student motivation and self-regulation of learning by comparing MSLQ performance between the pre and post tests of the control and experimental groups. The MSLQ survey further allowed for the evaluation of students’ change in learning strategies based on their participation in the Medical Explorers curriculum by comparing pre and post student performance on the MSLQ. Finally the relationship between average scores on the CAT biology attitudinal survey and pre and post changes on student motivation as measured by the MSLQ were compared to determine if a student’s attitude toward biology has any impact on a student’s motivation or learning strategies.

**Assessment of Critical Thinking Skills**

Critical thinking is the ability to recognize that a problem exists and to look for evidence to solve it. It is the ability to assess this evidence in a logical way in order to determine new knowledge and direction. Performance data, such as standardized objective tests or critical thinking tests would allow one to determine the impact of case-based learning on cognitive development, and to understand more about how and why cases affect student understanding in science.
For this study, critical thinking ability was assessed and operationally defined by the Watson-Glaser Critical Thinking Appraisal®. The instrument measured inference, recognition of assumptions, deduction, interpretation, and evaluation of arguments. Other measurements were collected to account for other forms of critical thinking ability potentially not measured by the WGCTA®.

**Watson-Glaser Critical Thinking Appraisal**

The most widely used and well respected instrument of critical thinking today is the Watson-Glaser Critical Thinking Appraisal. The Critical Thinking Appraisal is based on Dressel & Mayhew’s (1954) definition of critical thinking, and includes five subtests each measuring a different aspect of critical thinking: inference, recognition of assumptions, deduction, interpretation, and evaluation (Watson & Glaser, 1980, p.2). The test is frequently used to measure gains in critical thinking abilities resulting from instruction, to predict success on programs in which the ability to think critically is important, and to explore and determine relationships between critical thinking abilities and other abilities or traits.

The Watson-Glaser Critical Thinking Appraisal, a paper-and-pencil instrument, is a commercial product that assesses various aspects of reasoning ability that align with 21st Century skills of problem solving and critical thinking. It is an instrument for high school and college students to assess inference, recognition of assumptions, deduction, interpretation, and evaluation of arguments. It also can be used to assess critical thinking in the workplace. Performance does not rely on the test taker’s knowledge of course
content or prior knowledge. Instead, it measures the extent to which an individual processes information, can make judgments, and can think through options and consequences. Test takers are asked to evaluate reading passages that contain problems, statements, arguments, and interpretations. Responses are in the form of forced choice.

**Description of the Test**

The WGCTA (Watson-Glaser Critical Thinking Appraisal) (Forms A and B) consists of 80 items that assess the individual’s critical thinking ability. The creators of the instrument viewed critical thinking as a composite of attitudes, knowledge and skills. According to the User’s Manual, this composite includes:

1. Attitudes of inquiry that involve an ability to recognize the existence of problems and an acceptance of the general need for evidence in support of what is asserted to be true;

2. Knowledge of the nature of valid inferences, abstractions, and generalizations in which the weight or accuracy of different kinds of evidence are logically determined;

3. Skills in employing and applying the above attitudes and knowledge. The WGCTA is composed of three subscales: Recognition of Assumptions, Evaluation of Arguments, and Drawing Conclusions.

**Recognize Assumptions**

Assumptions are statements that are implied to be true in the absence of proof.
Identifying assumptions helps in discovery of information gaps and enriches views of issues. Assumptions can be unstated or directly stated. The ability to recognize assumptions in presentations, strategies, plans, and ideas is a key element in critical thinking. Being aware of assumptions and directly assessing their appropriateness to the situation help individuals evaluate the merits of a proposal, policy, or practice.

**Evaluate Arguments**

Arguments are assertions that are intended to persuade someone to believe or act a certain way. Evaluating arguments is the ability to analyze such assertions objectively and accurately. Analyzing arguments helps in determining whether to believe them or act accordingly. It includes the ability to overcome a confirmation bias – the tendency to look for and agree with information that confirms prior beliefs. Emotion plays a key role in evaluating arguments as well. A high level of emotion can cloud objectivity and the ability accurately to evaluate arguments.

**Draw Conclusions**

Drawing conclusions consists of arriving at conclusions that logically follow from the available evidence. It includes evaluating all relevant information before drawing a conclusion, judging the plausibility of different conclusions,
selecting the most appropriate conclusion, and avoiding overgeneralization beyond the evidence.

Watson-Glaser has been extensively validated to provide the most accurate picture available of critical thinkers.

Reliability of the Watson-Glaser Critical Thinking Assessment

- Form A Coefficient Alpha = .83
- Form B Coefficient Alpha = .81

Validity evidence collected on the Watson-Glaser

- The Watson-Glaser Technical Manual fully describes the studies conducted and their results. In summary, expected patterns of correlations were found with:
  - **Cognitive ability** (e.g., $r = .60$ with WAIS-IV fluid reasoning composite; $n = 49$)
  - **Occupational and educational attainment** (e.g., $r = .28$ with job level; $n = 432$; $r = .33$ with education level; $n = 581$)
  - **Job performance** (e.g., $r = .28$ with supervisory ratings of core critical thinking behaviors; $n = 68$)
  - **Attitudes or personality preferences** related to critical thinking performance (e.g., for the correlation between Watson-Glaser II Evaluate Arguments and Myers-Briggs Feeling, $r = -.27$, $n = 60$)

**Analysis of the WGCTA**

One primary goal of this study was to evaluate the change in critical thinking skill through the use of the Medical Explorer case instructional method among high school students. The Watson-Glaser Critical Thinking Appraisal is the best compromise between practicality and the requirement for the least bias. Students were administered the WGCTA before and after the *Medical Explorers* curriculum in both the experimental and control groups. Any pre and post changes in critical thinking ability between the experimental and control group can then be correlated to the *Medical Explorers*
Changes in each of the three primary test areas of the WGCTA; recognizing assumptions, evaluating arguments, and drawing conclusions, were compared for pre and post for each student in both experimental and test population. Pre and post performance changes was then compared between the experimental and control groups. Further student performance on the WGCTA was compared to the MSLQ performance to determine if changes in learning strategies and student motivation have any impact on development of critical thinking skills.

**Relevant CAT: Attitude Survey**

**Discipline:** Biology

**Description:**

The CAT biology attitude scale is a 22-item instrument that is designed to measure students’ attitudes toward biology; in particular, it is designed to measure their feelings of like or dislike about biology. Fourteen of the items use a Likert-type scale (five-point agree-disagree scale) and eight items use a semantic differential scale (five-point bipolar adjective scale). The instrument was developed on the assumption that an important consequence of instruction is a change in the student’s attitude toward the subject, and the authors argue the importance of focusing on attitudes by stating that there usually exists a positive correlation between attitudes and achievement. The authors state that the instrument is not intended to measure absolute attitudes toward biology; rather, it is designed to detect and measure changes in attitude generally from the beginning and end of a course or unit of study. For this study a third section, consisting of 4 questions,
were added to the CAT attitude survey which evaluates student’s perceptions and feelings concerning careers in the medical and life science field. A copy of the CAT survey used in this study can be found in appendix F.

Of a total of 30 Likert-type items initially developed, the authors used fourteen items whose correlations were high ($r \geq .80$, n=54). The eight semantic differential items used were based upon work by Osgood, Suci, and Tannenbaum (1957). To determine the concurrent validity and test-retest reliability, the instrument was administered twice to four undergraduate biology classes. The mean correlation between the Likert-type items and the semantic differential items was about .80, indicating high concurrent validity. The test-retest reliability was also high – correlations were never under .90 for the Likert-type scale, and .80 for the semantic differential scale.

To measure the effectiveness of the Biology Attitude Scale, the authors administered the instrument as a pre- and post-test in three introductory biology courses (n=675) and a group of students who were not taking any biology courses (n=31). Two of the biology courses were for majors, and one was for non-majors. As the authors expected, students in the major courses scored higher on the pre-test, and there was no change in the scores of students who were not taking a biology course.

**Analysis of the Relevant CAT: Attitude Survey**

Average biology attitudinal scores were constructed for each student by first assigning a rating of 1 - 5 (A = 5, B = 4, etc.) for each student response. Negatively worded items then had the ratings reversed for computational purposes. Student
attitudinal responses were then summed and averaged. For example, the Likert attitudinal scale has fourteen survey questions, thus an individual’s score will be computed by summing the fourteen items and taking the average.

Average pre and post difference scores for students on the CAT biology attitude survey were compared for both the experimental and control group to determine if the Medical Explorer curriculum had any significant impact on student attitude. In addition CAT difference averages were compared to Watson-Glaser Critical Thinking II appraisal to determine if student attitude had any measurable impact on changes in critical thinking ability. Finally as mentioned previously the relationship between average difference scores on the CAT biology attitudinal survey and pre and post changes on student motivation as measured by the MSLQ were compared to determine if student attitude toward biology has any impact on student motivation or learning strategies.

**Control Factors**

Internal validity, one of the most important types of research validity, refers to the extent for which error variance (extraneous variables) in an experiment are accounted. It is of the utmost importance that the researcher control model specification error variance in order to conclude that the outcome was due to the independent variable(s) (Parker, 1993). Campbell and Stanley (1963) identified eight extraneous variables that pose threats to internal validity in experimental studies. The threats were: (a) history, which pertains to the environmental events occurring between observations that are extraneous to the independent variable(s); (b) maturation, which refers to the psychological and/or
biological process within the participants that takes place as a function of the passage of time, also extraneous to the independent variable(s); (c) testing, which is sensitization to the posttest as a result of completing the pretest; (d) instrumentation, which refers to changes in the accuracy of instruments, devices or observers used to measure the dependent variable; (e) statistical regression, which occurs when groups are selected based on their extreme scores, because these inconsistent scores tend to regress toward the mean on repeated testing; (f) selection, which refers to the factors involved in placing certain participants in certain groups based on preferences; (g) mortality, which refers to the loss of participants and their data due to various reasons; and (h) interactions of the previous threats with selection (Campbell & Stanley, 1963).

The research design used in this study, (pretest-posttest control group) controlled for many of the threats to internal validity. Random assignment is employed to both groups, and both groups are given a pretest. Differences attributed to history, maturation, testing and instrumentation are equally manifested between the two groups and thus accounted for with use of the pre- and post-test design. Randomization and random assignment of participants protects against statistical regression, selection, mortality and interaction threats (Campbell & Stanley, 1963).

External validity of experimental research asks the question of generalizability. Generalizability requires the research samples to be representative of the population of interest. When effects of differing magnitude exist, the researcher must explain when and where the effect holds, and when and where it does not (Cook & Campbell, 1979). Cook and Campbell identified two threats to external validity: interaction of selection and treatment, which refers to a treatment having effects on a particular groups such as
gender or ethnicity not being generalizable to a differing population; and interaction of setting and treatment, which refers to the participants history (e.g. can data be generalized from one location to another, or one period of time to another). Parker (1993) identified two additional threats to external validity: interaction of treatments with treatments, which refers to the administration of multiple treatment to the same participants potentially leading to cumulative effects; and interaction of testing and treatment, which refers to the increase or decrease in subjects’ responsiveness to treatment due to a pretest. The pretest-posttest control group design presents a threat to external validity because of the pretest. Impact on external validity on the analysis of critical thinking was minimized by utilizing two different forms of WGTA which have high reliability.

What makes this design strong for internal validity makes it weak for external validity reasons. This means that generalizing the results to a different group without a comparative pretest is ill-advised due to the fact that results may vary (Heppner, Kivlighan, & Wampold, 1992). Therefore to account for this threat to external validity, results of this study will be generalized exercising caution to groups with similar pre-treatment measures.

Limitations of the Study

Measuring the impact of case-based instruction is particularly difficult because information obtained is context sensitive, which limits generalizations and theory building. Any teaching situation has many variables that influence the interactions among and between the teachers and students. Such variables include, but are not limited
to: perceived value, students’ motivations to learn, attitude, personal health, nutrition, skill of the instructor, educational level of parent, as well as the student’s socioeconomic level. To increase the internal validity of the research the experimental and control groups be sufficiently large (30 minimum) to detect meaningful effects of the Medical Explorer curriculum.

Given that the Delta High School student population was the only one which was utilized in this study, one issue of concern is the lack of racial and geographic diversity of the student experimental and control populations. While the experimental and control populations at Delta will provide valuable information toward addressing the experimental questions in this study, the populations at Delta will not represent the racial and geographic diversity found throughout the state of Indiana and across the world. However, the experimental and control populations at Delta will represent a wide cross section of socioeconomic levels. Future research would need to broaden the racial and geographic diversity of both the control and experimental populations to see if these variables influence the outcomes of the *Medical Explorers* curriculum as measured by this research.

In addition, because standardized IQ scores were not obtained for each student involved in this research study, no comparison was made between the impact on high, intermediate, and low academic level students. This limits the ability of this study to evaluate the impact of the *Medical Explorers* curriculum on learners at different ability levels. Such future research would allow for the evaluation of critical thinking,
motivational orientation and use of learning strategies, and changes in attitude toward life science among high, intermediate, and low level students.

Future research might also investigate the cumulative, long-term effect of teaching a series of modules that feature case studies which encourage the development of students’ higher order thinking skills. It might also be interesting to study whether and to what extent these acquired skills are transferable to other subject matters.

**Statistical Analysis**

To compare the pre and post impact of the *Medical Explorers* curriculum, comparison was made for each student on: Watson-Glaser critical thinking assessment score, Motivation and Self-regulation of Learning Questionnaire, and the Biology Attitude Scale. To determine the best methods for data analysis a statistician at Ball State University was consulted. Recommended analysis methods were researched, studied, utilized for the pre and post impact data collected from the *Medical Explorers* curriculum.

A standard t-test was utilized to compare pre and post performance among individual students and within student groups. For comparison of changes within the groups (changes between the beginning of the program and the ending of the program) the t-test was utilized for comparing means of dependent samples. Given the relatively small sample size the t-test is one of the most appropriate analysis models to utilize to determine any difference between means. Finally, for comparison of the results of the primary endpoint (percentage increase in the test score) and the secondary endpoint
(attitudinal shift) of the two groups, the t-test was utilized for comparing means of independent samples.

The *t-test* is the most commonly used method to evaluate the differences in means between two groups or two data sets. Theoretically, the *t-test* can be used even if the sample sizes are very small (e.g., as small as 10), as long as the variables are approximately normally distributed and the variation of scores in the two groups is not reliably different. Dependent samples (or "paired") *t-tests* typically consist of a sample of matched pairs of similar units, or one group of units that has been tested twice (a "repeated measures" *t*-test). A typical example of the repeated measures *t*-test would be where subjects are tested prior to an exposure, say for the impact of the *Medical Explorers* curriculum, and the same subjects are tested again after exposure to the *Medical Explorers* curriculum.

Pearson’s chi-square was used to test the hypothesis of no association of columns and rows in the data. Chi square is more likely to establish significance to the extent that the sample size is large. Generally the minimum acceptable sample size is between 20 – 50 and in this case the control and experimental samples will both have about 37 subjects in each population. Applying chi-square to small samples opens up the possibility of Type II errors. Given that the control and experimental populations are relatively small in size chi-square analysis will have limited statistical value in interpretation of the data but will act as an addition measure to determining significance.

Analysis of variance (ANOVA) was utilized to uncover the main and interaction effects of the categorical independent variables on an interval dependent variable. The
purpose is to know if the difference in sample means is enough to conclude the real means do in fact differ among two or more groups. In this case both the experimental and control groups were compared with independent variables: WGCTA, CAT, MSLQ, grade level, gender, and SAT scores. Both main direct effect between an independent and dependent variable (one-way ANOVA) and interaction effect of two independent variables on the dependent variable (two-way ANOVA) were determined.

The key statistic in ANOVA is the F-test of difference group means, testing if the means of the groups formed by values of the independent variable or combinations of values for multiple independent variable. The F-test is an overall test of the null hypothesis that group means on the dependent variable do not differ. It is used to test the significance of each main and interaction effect. A “sig.” or “p” probability value of .05 or less on the F test conventionally leads the researcher to conclude that effect is real and not due to chance of sampling. If the computed F score is greater than 1, then there is more variation between groups than within groups, from which we infer that the grouping variable does make a difference.

Data were analyzed using the Statistical Package for the Social Sciences® (SPSS) computer program, version 18. The alpha level was established a priori at .05 for tests of significance.
Chapter 4
Findings

The primary research purpose of this study was three-fold: to measure the ability of the Medical Explorers case-based to curriculum improve students’ higher order thinking skills; to evaluate the impact of the Medical Explorers case-based curriculum to help students be self directed learners; and to investigate the impact of the Medical Explorers case-based curriculum to improve student attitudes of the life sciences. This chapter includes the results of the procedures used to measure the three research objectives, test the three hypotheses, and the educational objectives of this experiment. The results include statistical significance when appropriate and whether the null hypotheses were accepted or rejected.

Data from 71 juniors and senior advanced life science students were used in the study. The experimental group consisted of students in the Case-based Learning (CBL) treatment group. In experimental group \( (n = 36) \), 18 students (28%) were male and 26 students (72%) were female. The second group consisted of students in the Teacher-guided Learning (TGL) control group. In group two \( (n = 35) \), 11 students (31%) were male and 24 students (69%) were female. For the sample \( (n = 71) \), 29 students (41%) were male and 42 students (59%) were female.
### Table 4.1 Experimental & Control Group Population Analysis

<table>
<thead>
<tr>
<th>Gender</th>
<th>Control (TGL)</th>
<th>Experimental (CBL)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Count</td>
<td>Count</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>24</td>
<td>26</td>
<td>50</td>
</tr>
<tr>
<td>% within group</td>
<td>68.6%</td>
<td>72.2%</td>
<td>70.4%</td>
</tr>
<tr>
<td>M</td>
<td>11</td>
<td>10</td>
<td>21</td>
</tr>
<tr>
<td>% within group</td>
<td>31.4%</td>
<td>27.8%</td>
<td>29.6%</td>
</tr>
<tr>
<td>Total</td>
<td>35</td>
<td>36</td>
<td>71</td>
</tr>
<tr>
<td>% within group</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Groups are nearly equivalent in both experimental and control based on gender distribution. The population of males and females in both groups were relatively equivalent and the assignment of males and females to both groups was completely random based on enrollment in the advanced life science course sections which were used in this study. In the experimental population females made up 72.2% of the population while in control population females made up 68.8% of the population. In
comparison, males made up 27.8% of the experimental population and 31.4% of the control population.

### Table 4.2 Ethnicity to group

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Group</th>
<th>Control (TGL)</th>
<th>Experimental (CBL)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>A</td>
<td>Count</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>% within group</td>
<td>5.7%</td>
<td>.0%</td>
<td>2.8%</td>
</tr>
<tr>
<td>C</td>
<td>Count</td>
<td>33</td>
<td>35</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>% within group</td>
<td>94.3%</td>
<td>97.2%</td>
<td>95.8%</td>
</tr>
<tr>
<td>O</td>
<td>Count</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>% within group</td>
<td>.0%</td>
<td>2.8%</td>
<td>1.4%</td>
</tr>
<tr>
<td>Total</td>
<td>Count</td>
<td>35</td>
<td>36</td>
<td>71</td>
</tr>
<tr>
<td></td>
<td>% within group</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

The ethnicity of both the control and experimental populations were fairly consistent in both groups. Both populations were nearly homogeneous with Caucasian making up over 94% of both populations with less than 6% minority populations. All students were randomly assigned to the experimental and control groups solely on their choice to take one of the advanced life science courses used in this study.
Table 4.3 Grade to group

Experimental & Control Group Grade Level Analysis

<table>
<thead>
<tr>
<th>Group</th>
<th>Control (TGL)</th>
<th>Experimental (CBL)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count</td>
<td>21</td>
<td>14</td>
<td>35</td>
</tr>
<tr>
<td>% within group</td>
<td>60.0%</td>
<td>38.9%</td>
<td>49.3%</td>
</tr>
<tr>
<td>Grade</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Count</td>
<td>14</td>
<td>22</td>
<td>36</td>
</tr>
<tr>
<td>% within group</td>
<td>40.0%</td>
<td>61.1%</td>
<td>50.7%</td>
</tr>
<tr>
<td>Total</td>
<td>Count</td>
<td>35</td>
<td>36</td>
</tr>
<tr>
<td>% within group</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

The distribution of eleventh and twelfth grade students in the experimental and control population was not equivalent because the population sizes were relatively small and students were randomly assigned to each group. As a result the experimental population ended up having 38.9% (n=14) eleventh grade students and 61.1% (n=22) twelfth grade students. In contrast the control population had the almost opposite distribution with
60% (n=21) eleventh grade students and 40% (n=14) twelfth grade students. This was further compounded by the fact that eleventh and twelfth grade students performed quite differently on several off the instrumental measures utilized in this study, which will be discussed in chapter 5.

Table 4.4 Chi-Square Tests: Grade Level and Group

<table>
<thead>
<tr>
<th>Test</th>
<th>Value</th>
<th>df</th>
<th>Asymp. Sig. (2-sided)</th>
<th>Exact Sig. (2-sided)</th>
<th>Exact Sig. (1-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>3.164a</td>
<td>1</td>
<td>.075</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuity Correction</td>
<td>2.376</td>
<td>1</td>
<td>.123</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>3.188</td>
<td>1</td>
<td>.074</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fisher's Exact Test</td>
<td></td>
<td></td>
<td></td>
<td>.098</td>
<td>.061</td>
</tr>
<tr>
<td>Linear-by-Linear Association</td>
<td>3.120</td>
<td>1</td>
<td>.077</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td>71</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 17.25.
b. Computed only for a 2x2 table

While students were randomly assigned to both the experimental and control populations, Chi-square was performed to determine the correlation between grade level and group. Pearson Chi-square was 3.164 (sig.=.075) demonstrating that even though the distribution of eleventh and twelfth grade students was unequal in the control and
There was a relatively low correlation between the grade level and group as assignment to both groups was based on random chance.

**Overview of Mean performance on instrumental measures:**

**Table 4.5 Descriptive Statistics: Experimental CBL group**

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>WG1</td>
<td>51.61</td>
<td>7.67</td>
<td>36</td>
</tr>
<tr>
<td>WG2</td>
<td>51.75</td>
<td>8.42</td>
<td>36</td>
</tr>
<tr>
<td>CAT1</td>
<td>2.29</td>
<td>0.54</td>
<td>36</td>
</tr>
<tr>
<td>CAT2</td>
<td>2.49</td>
<td>0.52</td>
<td>36</td>
</tr>
<tr>
<td>MSLQ1</td>
<td>5.08</td>
<td>0.62</td>
<td>36</td>
</tr>
<tr>
<td>MSLQ2</td>
<td>5.13</td>
<td>0.68</td>
<td>36</td>
</tr>
<tr>
<td>MEPRS</td>
<td>89.51</td>
<td>8.86</td>
<td>36</td>
</tr>
</tbody>
</table>

**Table 4.6 Descriptive Statistics: Control TGL group**

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>WG1</td>
<td>49.14</td>
<td>8.98</td>
<td>35</td>
</tr>
<tr>
<td>WG2</td>
<td>49.91</td>
<td>9.24</td>
<td>35</td>
</tr>
<tr>
<td>CAT1</td>
<td>2.26</td>
<td>0.53</td>
<td>35</td>
</tr>
<tr>
<td>CAT2</td>
<td>2.22</td>
<td>0.53</td>
<td>35</td>
</tr>
<tr>
<td>MSLQ1</td>
<td>4.90</td>
<td>0.62</td>
<td>35</td>
</tr>
<tr>
<td>MSLQ2</td>
<td>4.82</td>
<td>0.65</td>
<td>35</td>
</tr>
</tbody>
</table>
The experimental population had a total of 36 junior and senior high school students. The mean Watson-Glaser Critical Thinking Appraisal pretest score (WG1) was 51.61 with a standard deviation of 7.67 and a posttest score (WG2) of 51.75 with a standard deviation of 8.42. Pretest CAT biology attitude scores (CAT1) had a mean of 2.29 on a four point scale with a standard deviation of 0.54 and posttest scores with a mean of 2.49 and a standard deviation of 0.52. Pretest scores for the Motivated Strategies for Learning Questionnaire (MSLQ1) had a mean of 5.08 on a seven point scale with a standard deviation of 0.62 and posttest scores with a mean of 5.13 and a standard deviation of 0.68. In addition the experimental group had a final Medical Explorers Project, which was evaluated utilizing a rubric to establish an overall score, which was then used to partially measure the educational objectives in this study (MEPRS). Experimental group participants had a MEPRS mean score of 89.51 on a 100 point scale and showed a standard deviation of 8.86.

The control population had a total of 35 junior and senior high school students. The mean Watson-Glaser Critical Thinking Appraisal pretest score (WG1) was 49.14 with a standard deviation of 8.98 and a posttest score (WG2) of 49.91 with a standard deviation of 9.24. Pretest CAT biology attitude scores (CAT1) had a mean of 2.26 on a four point scale with a standard deviation of 0.53 and posttest scores with a mean of 2.22 and a standard deviation of 0.53. Pretest scores for the Motivated Strategies for Learning Questionnaire (MSLQ1) had a mean of 4.90 on a seven point scale with a standard deviation of 0.62 and posttest scores with a mean of 4.82 and a standard deviation of 0.65.
Overview of pre/post difference for: WGCTA, CAT, MSLQ, Medical Explorers
Project Rubric Scores for both the control and experimental groups

In this experiment it is expected that there should be a measurable difference in scores on pre and post instrumental measures for both experimental and control groups. To test this, the T-test was used to analyze the mean pre and post test scores for each of the instrumental measures in both the experimental and control groups.

\[ H_1: \text{mean posttest scores} > \text{mean pretest scores} \]

\[ H_0: \text{mean posttest scores} = \text{mean pretest scores} \]

<p>| Table 4.7  T-Test of pre/post instrumental measures |
|-----------------|-----------------|-----------------|-----------------|-----------------|
|                | Mean | N   | Std. Deviation | Std. Error Mean |
| <strong>Group</strong>     |      |     |                |                 |
| Control (TGL) |      |     |                |                 |
| Pair 1    | WG2  | 49.91 | 34 | 9.24 | 1.58 |
|           | WG1  | 49.09 | 34 | 9.11 | 1.56 |
| Pair 2    | CAT2 | 2.22  | 34 | .53  | .09  |
|           | CAT1 | 2.24  | 34 | .53  | .09  |
| Pair 3    | MSLQ2| 4.82  | 34 | .65  | .11  |
|           | MSLQ1| 4.90  | 34 | .63  | .11  |
| Experimental (CBL) |      |     |                |                 |
| Pair 1    | WG2  | 51.75 | 36 | 8.42 | 1.40 |
|           | WG1  | 51.61 | 36 | 7.67 | 1.28 |
| Pair 2    | CAT2 | 2.49  | 36 | .52  | .09  |
|           | CAT1 | 2.29  | 36 | .54  | .09  |
| Pair 3    | MSLQ2| 5.13  | 36 | .68  | .11  |
|           | MSLQ1| 5.08  | 36 | .62  | .10  |</p>
<table>
<thead>
<tr>
<th>Group</th>
<th>Pair</th>
<th>Measure</th>
<th>N</th>
<th>Correlation</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control(TGL)</td>
<td>Pair 1</td>
<td>WG2 &amp; WG1</td>
<td>34</td>
<td>.495</td>
<td>.003</td>
</tr>
<tr>
<td></td>
<td>Pair 2</td>
<td>CAT2 &amp; CAT1</td>
<td>34</td>
<td>.844</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Pair 3</td>
<td>MSLQ2 &amp; MSLQ1</td>
<td>34</td>
<td>.725</td>
<td>.000</td>
</tr>
<tr>
<td>Experimental(CBL)</td>
<td>Pair 1</td>
<td>WG2 &amp; WG1</td>
<td>36</td>
<td>.746</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Pair 2</td>
<td>CAT2 &amp; CAT1</td>
<td>36</td>
<td>.676</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Pair 3</td>
<td>MSLQ2 &amp; MSLQ1</td>
<td>36</td>
<td>.591</td>
<td>.000</td>
</tr>
</tbody>
</table>

The null hypothesis (H₀) was tested to determine if pre and post performance was equal for each of the instrumental measures in the experimental and control groups. In both the experimental and control groups the significance value was determined to be less than 0.05 on each of the instrumental measures and the null hypothesis was rejected. As expected there was a difference in pre and post performance on each of the instrumental measures within both the experimental and control groups.
Results of Research Objective One:

Research objective 1 sought to measure the ability of the Medical Explorers case-based to curriculum improve students’ higher order thinking skills. The Watson-Glaser Critical Thinking Appraisal® (WGCTA) was used to measure the critical thinking ability of students. The appraisal was comprised of 80 items that were summated resulting in a possible score of 0 to 80.

Here the research hypothesis was that students taught using Medical Explorers case-based to curriculum will demonstrate greater gains in critical thinking ability than students taught through teacher guided learning when accounting for prior critical thinking ability.

\[
H_0: \mu_{CBL} = \mu_{TGL}
\]

\[
H_1: \mu_{CBL} > \mu_{TGL}
\]

The critical thinking ability scores were summarized by instructional strategy and by sample (see table 4.10 & 4.11). The overall mean sample score on the WGCTA® pretest was 50.4 (SD = 8.4). The CBL experimental group (n = 36) mean score for the pretest was 51.6 (SD = 7.7). The mean score for the TGL control group (n = 35) was 49.1 (SD = 9.0). The mean sample score on the WGCTA® posttest was 50.85 (SD = 7.75). The CBL experimental group (n = 36) mean score for the posttest was 51.8 (SD = 8.4). The mean score for the TGL control group (n = 35) was 49.9 (SD = 7.1).
The mean WGCTA pretest score for the experimental CBL group was 51.6 with a standard deviation of 7.7 and a mean posttest score of 51.8 with a standard deviation of 8.4. In the Control TGL group the mean WGCTA pretest score was 49.1 with a standard deviation of 9.0 and a mean posttest score of 49.9 with a standard deviation of 7.1. Next the difference between pre and post WGCTA (WGd) scores were examined for both the experimental and control groups by gender and grade level.
In the control group, female students showed a mean pre/post difference score on the WGCTA of +1.74 with a standard deviation of 9.31 and males had a mean difference score of -1.09 with a standard deviation of 9.17. When eleventh grade students were
analyzed they showed a mean difference score of +1.24 with a standard deviation of 7.42 while twelfth grade students had a mean difference score of +0.15 with a standard deviation of 11.90.

In the experimental population, female students showed a mean difference score of +0.85 with a standard deviation of 5.42 and males had a mean difference score of -1.70 with a standard deviation of 6.55. When eleventh grade students were analyzed they showed a mean difference score of +1.93 with a standard deviation of 5.44 while twelfth grade students had a mean difference score of -1.00 with a standard deviation of 5.81.

Pre and post performance on the WGCTA for both the control and experimental groups did significantly differ based on gender and grade level. Overall female students in both groups had a mean difference score of +1.27 with a standard deviation of 7.43 while males showed a mean difference score of -1.38 with a standard deviation of 7.84. Further there was a clear difference in performance based on grade level with eleventh grade students having a mean difference score of +1.51 with a standard deviation of 6.62 while twelfth grade students had a mean difference score of -0.57 with a standard deviation of 8.43. This grade level difference in performance based on the WGCTA has an influence on the evaluation of the performance of the control TGL and experimental CBL groups due to the fact that the experimental population had a significantly higher percentage of seniors (61.1%) compared to the control group (38.9%) which may have had an effect on the overall evaluation of the pre/post change in critical thinking among both groups and will be discussed further in chapter 5.
Table 4.12  Levene's Test of Equality of Error Variances

<table>
<thead>
<tr>
<th>F</th>
<th>df1</th>
<th>df2</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.216</td>
<td>7</td>
<td>62</td>
<td>.308</td>
</tr>
</tbody>
</table>

Tests the null hypothesis that the error variance of the dependent variable is equal across groups

In this study it was hypothesized that the experimental CBL groups would show greater gains on the WGCTA on pre and post assessments when compared to the control TGL group. To test this hypothesis, the null hypothesis ($H_0$) that the variance in pre and post difference on the WGCTA across the experimental and control groups would be equal was tested using Levene’s Test of Equality of Error Variance. The Levene’s test revealed a significance value of 0.308 for the null hypothesis and thus it could not be rejected. Variance in the mean difference score on the MSLQ for both the control and experimental groups are the same.

To further evaluate the interaction between group, gender, and grade level on the mean difference score for the WGCTA, ANOVA tests of between-subjects effects was utilized. ANOVA of variance was used to examine the main and interactions effects of gender, group, and grade level (independent variables) on the pre/post score difference on the WGCTA (interval dependent variable). The null hypothesis ($H_0$) being tested in each case was that the difference in pre and post WGCTA scores would be the same when tested against group, gender, or grade.
Table 4.13 ANOVA Tests of Between-Subjects Effects

Dependent Variable: WGd

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>284.848a</td>
<td>7</td>
<td>40.693</td>
<td>.683</td>
<td>.686</td>
</tr>
<tr>
<td>Intercept</td>
<td>1.675</td>
<td>1</td>
<td>1.675</td>
<td>.028</td>
<td>.867</td>
</tr>
<tr>
<td>Group</td>
<td>2.896</td>
<td>1</td>
<td>2.896</td>
<td>.049</td>
<td>.826</td>
</tr>
<tr>
<td>Gender</td>
<td>62.563</td>
<td>1</td>
<td>62.563</td>
<td>1.049</td>
<td>.310</td>
</tr>
<tr>
<td>Grade</td>
<td>134.756</td>
<td>1</td>
<td>134.756</td>
<td>2.260</td>
<td>.138</td>
</tr>
<tr>
<td>Group * gender</td>
<td>19.418</td>
<td>1</td>
<td>19.418</td>
<td>.326</td>
<td>.570</td>
</tr>
<tr>
<td>Group * grade</td>
<td>19.721</td>
<td>1</td>
<td>19.721</td>
<td>.331</td>
<td>.567</td>
</tr>
<tr>
<td>Gender * grade</td>
<td>69.264</td>
<td>1</td>
<td>69.264</td>
<td>1.162</td>
<td>.285</td>
</tr>
<tr>
<td>group * gender * grade</td>
<td>20.628</td>
<td>1</td>
<td>20.628</td>
<td>.346</td>
<td>.559</td>
</tr>
<tr>
<td>Error</td>
<td>3696.595</td>
<td>62</td>
<td>59.622</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3997.000</td>
<td>70</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>3981.443</td>
<td>69</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. R Squared = .072 (Adjusted R Squared = -.033)

When the interaction between mean difference score on the Watson-Glaser (WGd) was evaluated between the groups (control and experimental), ANOVA determined a significance value of .826 which is greater than .05 and the null hypothesis cannot be rejected. This indicates that both the control and experimental groups performed the about the same on the WGCTA based on difference scores. When gender
was evaluated by ANOVA for interaction of effects with WGd a significance value of .310 was obtained and the null hypothesis cannot be rejected indicating that males and females did perform about the same on the Watson-Glaser based on difference scores. Finally when the interaction effect for grade level (eleventh / twelfth) and WGd was evaluated by ANOVA a significance value of .138 was obtained and the null hypothesis could not be rejected indicating that students and eleventh and twelfth grade did perform about the same on the Watson-Glaser. While the null hypothesis could not be rejected based on grade level it should be noted that grade level showed the strongest interaction effect with the Watson-Glaser difference score (WGd) with $F=2.26$ and a significance of 0.138. The impact of grade level on performance on the WGCTA is significant because the experimental group had 38.9% eleventh grade students and 61.1% twelfth grade students while in contrast to this the control population had 60% eleventh grade students and 40% twelfth grade students. No clear interaction effect between WGd and the independent variables of significance (.05) was identified and in each case performance on the Watson-Glaser varied by: group (control / experimental), gender (male / female), and grade level (eleventh / twelfth) was about the same.
Comparison of SAT Performance in Control & Experimental Participants

To determine if there was any measurable cognitive difference between the control and experimental groups, SAT scores were utilized because they represent and standardized measure of cognitive ability and were readily available for most of the population. Looking at performance on the mathematics section of the SAT as a potential correlation to performance on the WGCTA there was no significant difference in performance among the control population (mean= 564.76) and the experimental population (mean=546.36). SAT writing scores (SATw) were also compared between the control and experimental groups (mean= 542.27) with the control group (mean=539.05) showing relative consistency between both groups.

<table>
<thead>
<tr>
<th>group</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>SATm</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Control</td>
<td>21</td>
<td>564.76</td>
<td>112.90</td>
<td>24.64</td>
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<tr>
<td>Experimental</td>
<td>22</td>
<td>546.36</td>
<td>89.95</td>
<td>19.18</td>
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<td>SATv</td>
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<td></td>
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<td></td>
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<td>Control</td>
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<td>530.95</td>
<td>119.45</td>
<td>26.07</td>
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<tr>
<td>Experimental</td>
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<td>552.73</td>
<td>64.16</td>
<td>13.68</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
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<td>539.05</td>
<td>97.26</td>
<td>21.22</td>
</tr>
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<td>Experimental</td>
<td>22</td>
<td>542.27</td>
<td>123.02</td>
<td>26.23</td>
</tr>
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<td></td>
<td>Levene's Test for Equality of Variances</td>
<td>t-test for Equality of Means</td>
<td>95% Confidence Interval of the Difference</td>
<td></td>
</tr>
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<td>-------</td>
<td>----------------------------------------</td>
<td>-------------------------------</td>
<td>-----------------------------------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>Sig.</td>
<td>t</td>
<td>Df</td>
</tr>
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<td>.559</td>
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<td></td>
<td>-.74</td>
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<td>-21.775</td>
</tr>
<tr>
<td>SATw</td>
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<td>.55</td>
<td>-.10</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>-.10</td>
<td>39.65</td>
<td>.924</td>
<td>-3.225</td>
</tr>
</tbody>
</table>

Table 4.15  SAT Independent Samples Test
To analyze the equality of variance between each section of the SAT between both the control and experimental groups, Levene's Test for Equality of Variances was used. In this case equal variance was assumed as the null hypothesis for each of the three sections of the SAT. On the math section of the SAT (SATm) significance was determined to be .18 (F=1.86) and the null hypothesis was not rejected and thus the control and experimental groups showed similar performance on the math section of the SAT. On the verbal section of the SAT (SATv) significance was determined to be .00 (F=11.35) and the null hypothesis was accepted, and thus the control and experimental groups performed very differently on the verbal section of the SAT. Finally, on the writing section of the SAT (SATw) significance was determined to be .55 (F=.35) and the null hypotheses was rejected. Given the values determined the performance of both the control and experimental groups on the verbal section of the SAT was very similar. The primary correlation being considered here is the relationship between student performance on the SATm and SATw as related to performance on the WGCTA. Given that this correlation was being established between both the control and experimental groups it was important to establish that both groups performed similarly on the SATm and SATw before the use of case-based instruction with the experimental group. In this case Levene’s test for equality of variance indicated no significant difference found among any of the math or writing sections of the SAT sections for the control and experimental groups. This would seem to indicate that both the control and experimental groups were relatively equivalent based on cognitive ability.
**Results of Research Objective two:**

Research objective 2 sought to evaluate the impact of the *Medical Explorers* case-based curriculum to help students develop self directed learning skills and habits of mind. The Motivation and Self-regulation of Learning Questionnaire (MSLQ) was used to access: value component of education, expectancy component, cognitive and metacognitive strategies, and resource management strategies. The MSLQ utilized a seven-point Likert scale response system where 1—not at all true of me; 7—very true of me) scale. Any MSLQd score of 0.35 or greater is considered statistically significant.

Here the research hypothesis was that students taught using *Medical Explorers* case-based curriculum will demonstrate greater gains in Motivation and Self-regulation of Learning than students taught through teacher guided learning when accounting for prior critical thinking ability.

\[ H_0: \mu_{CBL} = \mu_{TGL} \]

\[ H_1: \mu_{CBL} > \mu_{TGL} \]

The overall difference between pre and post performance on the MSLQ (MSLQd) was examined and compared between the control and experimental groups to determine the impact that the *Medical Explorers* case-based curriculum had on motivational learning strategies. Pre and post difference scores were also correlated to grade level and gender to determine any interaction effect.
In the control population females had a mean MSLQd score of +0.05 with a standard deviation of 0.50 while males had a mean MSLQd score of -0.07 with a standard deviation of 0.52. Again when eleventh and twelfth grade students were examined separately in the control population there was a clear performance difference, eleventh
grader students had a mean MSLQd score of +0.04 with a standard deviation of 0.52 while twelfth grade students had a mean MSLQd score of -0.29 with a standard deviation of 0.31. In the experimental population the results were quite different. Females had a overall MSLQd score of +0.02 with a standard deviation of 0.63 while males had a score of +0.11 with a standard deviation of 0.50. Interestingly enough the performance difference seen between eleventh and twelfth graders in the majority of the other instrumental measures was not seen within the experimental group on the MSLQ.

Eleventh grade students had an overall mean MSLQd score of +0.03 with a standard deviation of 0.41 while twelfth grade students had a mean MSLQd score of +0.05 with a standard deviation of 0.69.

<table>
<thead>
<tr>
<th>Table 4.17  Levene's Test of Equality of Error Variances*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent Variable: MSLQd</td>
</tr>
<tr>
<td>F</td>
</tr>
<tr>
<td>.704</td>
</tr>
</tbody>
</table>

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + group + gender + grade + group * gender + group * grade + gender * grade + group * gender * grade
To test that the equality of variance in MSLQd scores was equal across both the control and experimental groups Levene’s Test of Equality of Error Variance was utilized. Here the null hypothesis being tested was that the error variance of the dependent variable (MSLQd) is equal across groups (control & experimental).

\[ H_0: \text{variance of MSLQd in control} = \text{variance of MSLQd in experimental} \]

\[ H_1: \text{variance of MSLQd in control} \neq \text{variance in MSLQd in experimental} \]

Levene’s Test of Equality revealed a significance of 0.669, which is greater than 0.05 and thus the null hypothesis could not be rejected. Variance of MSLQd scores between the experimental and control groups is the same.
Table 4.18 ANOVA Tests of Between-Subjects Effects

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
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<td>1.516(^a)</td>
<td>7</td>
<td>.217</td>
<td>.730</td>
<td>.648</td>
</tr>
<tr>
<td>Intercept</td>
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<td>.112</td>
<td>.377</td>
<td>.542</td>
</tr>
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<td>.288</td>
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<td>.000</td>
<td>.001</td>
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</tr>
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<td>.139</td>
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<td>.497</td>
</tr>
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<td>.893</td>
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<td>.627</td>
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<td>.151</td>
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<td>.150</td>
<td>.507</td>
<td>.479</td>
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<td>.103</td>
<td>.348</td>
<td>.558</td>
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<td></td>
</tr>
</tbody>
</table>

\(^a\) R Squared = .076 (Adjusted R Squared = -.028)

The pre and post performance on the MSLQ varied little in both the control and experimental groups, but to determine the interaction effect with the MSLQ the ANOVA tests of between subjects effects was utilized. When pre and post MSLQ difference scores were calculated for the control group they were found to vary by only -0.088 (SD= 0.47) and the experimental group showed a difference of 0.043 (SD= 0.59). When pre
and post MSLQ difference was analyzed for interaction between the group, grade level, and gender no significance was found. Specifically, when the null hypothesis for between subject effects of the groups and MSLQd was analyzed by one way ANOVA the significance value was determined to be 0.288 and the null hypothesis could not be rejected. Thus, based on MSLQd scores, the control and experimental groups were the same. When testing the null hypothesis of the interaction between gender (male and female) and MSLQd, ANOVA revealed a significance value of 0.974 and the null hypothesis could not be rejected and thus the performance on the MSLQ was the same between males and females. Finally when testing the null hypothesis of the interaction between grade (11th and 12th grade) and MSLQd, ANOVA revealed a significance of 0.497 and the null hypothesis could not be rejected and thus performance on the MSLQ was determined to be the same between 11th and 12th grade students.

Results of Research Objective Three:

Research objective 3 sought to investigate the impact of the Medical Explorers case-based curriculum to improve student attitudes of the life sciences. Pre and post scores on the CAT and a difference score were calculated for both the control and experimental participants. The CAT was setup using an A-E likert scale which was then converted to a 0-4 scale for analysis purposes. Given that 4 was the top value for the CAT analysis, a change of 0.2 or greater between pre and post performance would be significant.
Here the research hypothesis was that students taught using *Medical Explorers* case-based to curriculum will demonstrate greater gains in attitude toward the life sciences than students taught through teacher guided learning when accounting for prior critical thinking ability.

\[ Ho: \mu_{CBL} = \mu_{TGL} \]

\[ H_1: \mu_{CBL} > \mu_{TGL} \]

The control group saw little deviation in pre and post change in attitude utilizing the CAT instrument with a difference of -0.02 (SD=0.29). While the experimental groups showed a pre and post difference of 0.20 (SD= 0.42). Further analysis of the control group revealed little difference in performance between 11\(^{th}\) and 12\(^{th}\) grade on the CAT, with a mean CATd score of 0.01 and -0.08 respectively. The mean CATd score for males and females in the control population was -0.06 and 0.00 respectively. Slightly different results were found in the experimental population with 11\(^{th}\) grade students having a mean CATd score of 0.03 and 12\(^{th}\) grade students having a mean CATd score of 0.31. When males and females scores on the CAT were analyzed in the experimental population, females had a mean CATs score of 0.23 while males had a mean CATd score of 0.12.
Table 4.19  CATd Descriptive Statistics

<table>
<thead>
<tr>
<th>Group</th>
<th>Gender</th>
<th>Grade</th>
<th>Mean CATd</th>
<th>Std. Deviation</th>
<th>N</th>
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</thead>
<tbody>
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Table 4.20  Levene's Test of Equality of Error Variances

Dependent Variable: CATd

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<th>F</th>
<th>df1</th>
<th>df2</th>
<th>Sig.</th>
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</thead>
<tbody>
<tr>
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<td>.627</td>
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</tbody>
</table>

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + group + gender + grade + group * gender + group * grade + gender * grade + grade + group * gender * grade

Levene’s test of equality of error variance was utilized to determine if the variance in the CATd score was equal across the experimental and control groups. Here the null hypothesis stated that the error variance is equal between both the control and experimental groups. Levene’s test revealed a significance value of 0.627 and thus the null hypothesis could not be rejected. Variance between the control and experimental groups and the difference scores on the CAT were the same.
<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
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<td>.047</td>
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<td>.495</td>
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</tr>
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<td>.006</td>
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<td>.188</td>
<td>1.439</td>
<td>.235</td>
</tr>
<tr>
<td>group * gender * grade</td>
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<td>.032</td>
<td>.248</td>
<td>.620</td>
</tr>
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<td>.131</td>
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<td></td>
</tr>
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<td>69</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. R Squared = .198 (Adjusted R Squared = .107)

Initial analysis revealed no significant difference in pre and post performance on the CAT for either the control and experimental was found. Interaction effects between pre and post difference were compared between both the experimental and control groups by ANOVA. A test of the null hypothesis, that the CATd scores were the same between both the experimental and control group, revealed a significance value of 0.036 and the
null hypothesis was rejected. ANOVA revealed that the performance between the control and experimental groups were different. When the interaction effect between CATd scores and gender (male and female) were analyzed by ANOVA, a test of the null hypothesis revealed a significance value of 0.207 and the null hypothesis could not be rejected. Performance between males and females based on difference scores in the CAT were the same. The test of the null hypothesis on the interaction effect between the CATd scores and grade (11th and 12th grade) revealed a significance of 0.713 and the null hypothesis could not be rejected. Interestingly, when ANOVA was utilized to analyze the interaction between group and gender compared to the CAT difference scores a significance value of .037 was found when testing the null hypothesis. There is a strong correlation group and grade level with respect to CAT difference scores.
Profile Plots

Estimated Marginal Means of CATd

- Estimated Marginal Means
- grade

- Control
- Experimental
Summary of Data

Table 4.22 Summary Descriptive Data

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
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The control group had a final population of 14 junior and senior advanced life science students while the experimental population had a final population of 36 junior and senior advanced life science students. For the Watson-Glaser critical thinking assessment (WG) the maximum score obtainable was 80, the maximum score for the CAT attitudinal survey was 4, and the maximum score for the Motivated Strategies for Learning Questionnaire (MSLQ) was 7.
Table 4.23 Summary Independent Samples Test

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<tr>
<th></th>
<th>Levene's Test for Equality of Variances</th>
<th>t-test for Equality of Means</th>
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To test the equality of variance and equality of means between the control and experimental groups for each of the instruments, Levene’s test for equality of variances and the t-test for equality of means was utilized. For each instruments a comparison or pretest performance, posttest performance, and difference between pre and post performance was analyzed. The null hypothesis of equality of variance will be utilized.
and significance values for the Levene’s test of equality of variance and the t-test will be discussed for each instrument utilized in this study.

In the pretest for the Watson-Glaser (WG1) when equality of variance was assumed, Levene’s test of equality of variance showed a significance value of .13 and the null hypothesis could not be rejected and thus there was equal variance between both the control and experimental groups on the Watson-Glaser pretest. In the t-test the equality of the significance (2-tailed) was determined to be .22 indicating that the equality of the means was the same between the control and experimental groups. For the posttest analysis for the Watson-Glaser (WG2) the performance between the experimental and control groups were very similar, Levene’s test of equality of variances had a significance of .78 and the variance between the experimental and control groups were found to be the same. Similarly, analysis by t-test yielded a significance value of .39 and thus the equality of means between the control and experimental groups was the same. Finally when the difference between pre and post test performance on the Watson-Glaser (WGd) was analyzed, Levene’s test of equality of variance showed a significance of .05 and thus the null hypothesis could be rejected indicating that the equality of variance was different for the control and experimental groups. However, when the t-test was used to test the equality of means for the difference scores on the Watson-Glaser a significance value of .71 was obtained indicating that the mean difference score between the experimental and control groups were the same.

In the pretest for the attitudinal survey (CAT1) when equality of variance was assumed, Levene’s test of equality of variance showed a significance value of .82 and the
null hypothesis could not be rejected and thus there was equal variance between both the control and experimental groups on the CATpretest. In the t-test the equality of the significance (2-tailed) was determined to be .79 indicating that the equality of the means was the same between the control and experimental groups. For the posttest analysis for the attitudinal survey (CAT2) the performance between the experimental and control groups were very similar, Leven’s test of equality of variances had a significance of .85 and the variance between the experimental and control groups were found to be the same. However, analysis by t-test yielded a significance value of .03 and thus the null hypothesis was rejected indicating the equality of means between the control and experimental groups was different. Finally when the difference between pre and post test performance on the CAT (CATd) was analyzed, Levene’s test of equality of variance showed a significance of .28 and thus the null hypothesis could not be rejected indicating that the equality of variance was the same for the control and experimental groups. However, when the t-test was used to test the equality of means for the difference scores on the CAT a significance value of .01 was obtained indicating that the mean difference score between the experimental and control groups were different.

Finally, in the pretest for the Motivated Strategies for Learning Questionnaire (MSLQ1) when equality of variance was assumed, Levene’s test of equality of variance showed a significance value of .88 and the null hypothesis could not be rejected and thus there was equal variance between both the control and experimental groups on the MSLQ pretest. In the t-test the equality of the significance (2-tailed) was determined to be .22 indicating that the equality of the means was the same between the control and
experimental groups. For the posttest analysis for the MSLQ (MSLQ2) the performance between the experimental and control groups were very similar, Leven’s test of equality of variances had a significance of .83 and the variance between the experimental and control groups were found to be the same. Similarly, analysis by t-test yielded a significance value of .06 and thus the equality of means between the control and experimental groups was the same. Finally when the difference between pre and post test performance on the Motivated Strategies for Learning Questionnaire (MSLQd) was analyzed, Levene’s test of equality of variance showed a significance of .65 and thus the null hypothesis could not rejected indicating that the equality of variance was the same for the control and experimental groups. When the t-test was used to test the equality of means for the difference scores on the MSLQ a significance value of .311 was obtained indicating that the mean difference score between the experimental and control groups were the same.
**Table 4.24 Summary Results of Experimental Hypotheses**

<table>
<thead>
<tr>
<th>Experimental Hypotheses</th>
<th>Supported by the data</th>
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<tbody>
<tr>
<td>H1: Students taught using <em>Medical Explorers</em> case-based curriculum will demonstrate greater critical thinking development than students taught through teacher guided learning when accounting for prior critical thinking ability.</td>
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<td>H2: Students taught using <em>Medical Explorers</em> case-based curriculum will demonstrate greater improvement in their motivation and self-regulation of learning skills than students taught through teacher guided learning when accounting for prior ability.</td>
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<td>H3: Students taught using <em>Medical Explorers</em> case-based curriculum will demonstrate greater improvement of their attitude toward life sciences than students taught through teacher guided learning when accounting for prior attitude toward life science.</td>
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Table 4.25  Paired analysis of pre/post performance on research instruments for both the control and experimental groups.

<table>
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<th>Paired Differences</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
<th>95% Confidence Interval of the Difference</th>
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<th>df</th>
<th>Sig. (2-tailed)</th>
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In the control group a mean difference of 0.82 was found between pre and post analysis with the Watson-Glaser (WG2 – WG1), but given that the Watson-Glaser utilized an 80 point scale this difference score was not found to be significant (0.61).

Similarly, in the control group the mean difference between the pre and post CAT was - .02 which was not significant (0.66) and the MSLQ revealed a difference of only -.09 which was not found to be significant (sig. 0.30).

Similar results were found in the experimental group with a pre and post mean difference of .14 for the Watson-Glaser with a significance of .89 and for the MSLQ a mean difference of .04 and a significance of .67. However when the mean difference of the CAT was analyzed it was determined to be .20 and given that the CAT was based on a 4 point scale this was determined to have a strong significance of .01.
### Table 4.26 Correlations among Research Instruments

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<th>SATw</th>
<th>WG1</th>
<th>WG2</th>
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<th>CAT2</th>
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<td>.028</td>
<td>.949</td>
<td>.490</td>
<td>.418</td>
<td>.063</td>
<td>.000</td>
<td>.846</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td><strong>MSLQ2</strong> Pearson Correlation</td>
<td><strong>.623</strong></td>
<td><strong>.204</strong></td>
<td><strong>.472</strong></td>
<td>.084</td>
<td>.222</td>
<td>.095</td>
<td><strong>.445</strong></td>
<td><strong>.591</strong></td>
<td>1</td>
<td>.348</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.002</td>
<td>.362</td>
<td>.026</td>
<td>.624</td>
<td>.192</td>
<td>.583</td>
<td>.006</td>
<td>.000</td>
<td>.038</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td><strong>MEPRS</strong> Pearson Correlation</td>
<td>.528</td>
<td>.359</td>
<td><strong>.608</strong></td>
<td><strong>.326</strong></td>
<td><strong>.395</strong></td>
<td>-.111</td>
<td>.095</td>
<td>.034</td>
<td><strong>.348</strong></td>
<td>1</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.012</td>
<td>.100</td>
<td>.003</td>
<td>.052</td>
<td>.017</td>
<td>.519</td>
<td>.581</td>
<td>.846</td>
<td>.038</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
</tr>
</tbody>
</table>

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).
Here correlations between independent variables for the experimental group were analyzed and the Pearson Correlation and p-value for each was determined. The independent variables being look at were: math SAT (SATm), Critical Reading SAT (SATv), writing SAT (SATw), Watson-Glaser pretest performance (WG1), Watson-Glaser posttest performance (WG2), pretest attitude (CAT1), posttest attitude (CAT2), pretest Motivated Strategies for Learning (MSLQ1), posttest Motivated Strategies for Learning (MSLQ2), and finally student rubric score on the final Medical Explorers project (MEPRS). A Pearson Correlation value of 1.0 would indicates a perfect correlation. The independent variables with a correlation significance at 0.01 are indicated by two asterisks (**) and those with a correlation significance at 0.05 are indicated by one asterisk.

Not surprisingly, there was a very strong correlation relationship found between performance on the Watson-Glaser and performance on the SATm, SATv, and SATw. As an example, just looking at the correlation between the post test performance on the Watson-Glaser (WG2) there was a correlation of .756 for SATm (p= .00), .591 for the SATv (p=.01), and 0.804 for SATw (p=.00). Interestingly student performance on the math and critical reading portions of the SAT (SATm & SATv) were also highly correlated with pre and post student attitude (CAT1 & CAT2). The Pearson Correlation between the SATw and CAT1 was .583 (p=.004) and .668 (p=.001) between SATw and CAT2. Additionally a strong correlation was also found for both the math and writing portions of the SAT with pre and post performance on the Motivated Strategies for Learning Questionnaire (MSLQ1 & MSLQ2). For example, the correlation between
SAT\textsubscript{w} and MSLQ1 was .467 (p=.028) and .472 (p=.026) with MSLQ2. Finally, a very interesting correlation was determined between rubric score performance on the final Medical Explorers project (MEPRS) and both performance on the math and writing portions of the SAT (SAT\textsubscript{m} & SAT\textsubscript{w}). The Pearson correlation between SAT\textsubscript{m} and MEPRS was .528 (p=.012) and the correlation between SAT\textsubscript{w} and MEPRS was .608 (p=.003). In addition there was also a strong correlation of .395 (p=.017) between MEPRS and WG2 as well as between MSLQ2 and MEPRS .348 (p=.038).

Analysis of Medical Explore Educational Objectives:

As a final analysis of the educational objectives for the Medical Explorers curriculum each student participant in the experimental group was asked to create and present a final case report over their patient. Final case reports and presentations were evaluated using a rubric which emphasizes the educational objectives of the Medical Explorers curriculum. The maximum value for the rubric score was 100. Please see appendix D to review the rubric for the Medical Explorers final case-study project.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Minimum Statistic</th>
<th>Maximum Statistic</th>
<th>Mean Statistic</th>
<th>Std. Error Statistic</th>
<th>Std. Deviation Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rubric</td>
<td>36</td>
<td>67.00</td>
<td>100.00</td>
<td>89.39</td>
<td>1.49</td>
<td>8.96</td>
</tr>
<tr>
<td>Valid N (listwise)</td>
<td>36</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The mean score on the Medical Explorers final case-study project (MEPRS) was 89.39 with a standard deviation of 8.96. In the experimental population, females had a mean rubric score of 90.27 with a standard deviation of 8.80 while males had a mean score of 86.62 with a standard deviation of 8.90. Levene’s test of equality of variance between males and females on the MEPRS was found to be .747, thus variance among males and females on the MEPRS was the same. Similarly a t-test of equality of means yielded a significance of .274 and thus the equality of means was the same between both males and females.
Table 4.30  MEPRS Grade Level Statistics

<table>
<thead>
<tr>
<th>grade</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEPRS</td>
<td>11</td>
<td>14</td>
<td>91.32</td>
<td>5.82</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>22</td>
<td>87.94</td>
<td>10.25</td>
</tr>
</tbody>
</table>

Table 4.31 Descriptive Statistics by Grade Level

<table>
<thead>
<tr>
<th>Rubric</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
<td>Upper Bound</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Minimum</td>
<td>Maximum</td>
</tr>
<tr>
<td>11</td>
<td>14</td>
<td>91.3243</td>
<td>87.9639</td>
<td>94.6847</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.82001</td>
<td>80.77</td>
<td>97.69</td>
</tr>
<tr>
<td>12</td>
<td>22</td>
<td>87.9445</td>
<td>83.4002</td>
<td>92.4889</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10.2493</td>
<td>67.00</td>
<td>100.00</td>
</tr>
<tr>
<td>Total</td>
<td>36</td>
<td>89.2589</td>
<td>86.2629</td>
<td>92.2548</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.85457</td>
<td>67.00</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Table 4.32  MEPRS Independent Samples Test: Grade Level

<table>
<thead>
<tr>
<th>Levene's Test for Equality of Variances</th>
<th>t-test for Equality of Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>Sig.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>MEPRS</td>
<td>Equal variances assumed</td>
</tr>
<tr>
<td></td>
<td>Equal variances not assumed</td>
</tr>
</tbody>
</table>

As was seen on several other instruments there was a performance difference on the Medical Explorers rubric score among 11th and 12th grade students. The 11th grade
students had a means rubric score or 91.32 with a standard deviation of 5.82 while 12\textsuperscript{th} grade students had a mean rubric score of 87.94 with a standard deviation of 10.25. Levene’s test of equality of variance between 11\textsuperscript{th} and 12\textsuperscript{th} grade students on the MEPRS was found to be .106, thus variance among 11\textsuperscript{th} and 12\textsuperscript{th} on the MEPRS was the same. Similarly a t-test of equality of means yielded a significance of .270 and thus the equality of means was the same between both 11\textsuperscript{th} and 12\textsuperscript{th} grade students.

**Table 4.33 MEPRS * Gender, Measures of Association**

<table>
<thead>
<tr>
<th></th>
<th>Eta</th>
<th>Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEPRS * gender</td>
<td>.251</td>
<td>.063</td>
</tr>
</tbody>
</table>

The measure of association between gender and the rubric score for the *Medical Explorers* project (MEPRS) was found have an Eta value of .251. Since Eta squared equals the percent of variation in the dependent variable explained by the independent variable this would mean that 6.3 % of the variation in MEPRS is explained by gender.

**Table 4.34 MEPRS * Grade, Measures of Association**

<table>
<thead>
<tr>
<th></th>
<th>Eta</th>
<th>Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEPRS * grade</td>
<td>.189</td>
<td>.036</td>
</tr>
</tbody>
</table>

The measure of association between grade and the rubric score for the *Medical Explorers* project (MEPRS) was found have an Eta value of .189. Since Eta squared
equals the percent of variation in the dependent variable explained by the independent variable this would mean that 3.6 % of the variation in MEPRS is explained by grade.
Chapter 5
Conclusions, Implications, & Recommendations

The primary purpose of this study was three-fold: to measure the ability of the Medical Explorers case-based curriculum to improve higher order thinking skills of students; to evaluate the impact of the Medical Explorers case-based curriculum to help students be self directed learners; and to investigate the impact of the Medical Explorers case-based curriculum to improve student attitudes toward the life sciences. In addition the educational objectives of the Medical Explorers curriculum were evaluated through a final culminating project which was evaluated using a rubric grading system. The following objectives and hypotheses guided this study.

1. Measuring the ability of the Medical Explorers case-based curriculum to improve students’ higher order thinking skills.

\[ H_1: \text{Students taught using Medical Explorers case-based curriculum will demonstrate greater gains in critical thinking ability than students taught through teacher guided learning when accounting for prior critical thinking ability.} \]
2. Evaluate the impact of the Medical Explorers case-based curriculum to help students be self motivated and self regulated learners, to ensure that high school graduates have the skills necessary for life-long learning.

H2: Students taught using Medical Explorers case-based curriculum will demonstrate greater improvement of their self motivation and self regulation of learning than students taught through teacher guided learning when accounting for prior ability.

3. Investigate the impact of the Medical Explorers case-based curriculum to improve student attitudes toward the life sciences.

H3: Students taught using Medical Explorers case-based curriculum will demonstrate greater improvement of their attitude toward life sciences than students taught through teacher guided learning when accounting for prior attitude toward life science.

Review of Research Design

This study employed an experimental, pre and post analysis of both the control and experimental groups to evaluate the effectiveness of the Medical Explorers case-based curriculum. All students participated in all pre and post analyses as a regular part of the class so that no one, including the key investigator nor the students in the classes, were aware who was or wasn’t participating in the study. Through the consent form, students and or parents were able to allow or not allow the data collected from these pre and post analyses to be used in the study. Each student was asked to use a unique
identifier code assigned to them by the assessment administrator so that all pre-post analysis was completed in a confidential manner. By considering fluctuations over the case study unit, the primary investigator was able to address questions related to students’ changing responses, approaches to learning, attitude, and critical thinking skills.

All participating students were asked to complete the following:

- The Motivation and Self-regulation of Learning Questionnaire (MSLQ)
- Watson-Glaser II Critical Thinking Appraisal
- Relevant CAT: Attitude Survey

Student analyses for the Watson-Glaser, Motivational Strategies for Learning Questionnaire (MSLQ), and CAT Attitude Survey were administered as paper and pencil assessments. Students were asked to use their unique identifier code number and individual names were never used. This unique identifier was used by the researcher to track responses on a pretest/posttest study design only. Such research strategies were used to improve the quality and credibility of the data collected in this study.

**Population and Sample**

For this study, rural Indiana high school students were selected to participate in the Medical Explorers curriculum. The target population included advanced life science students at the junior or senior level at Delta High School. Participation in the Medical Explorers study was a normal part of the class but consent to allow individual data to be utilized was voluntary. An administrator consent form, parental consent form, and
student assent form was obtained by the key investigator and assessment administrator prior to the commencement of the study (see Appendix G & L). Participation in the study was voluntary with informed consent obtained from all participants or their parents/guardians (for those under 18); confidentiality and anonymity, of their participation and the data collected from them, were carefully maintained.

Both groups were asked to complete all pre and post instrumental measures. The experimental test population participated in the three week Medical Explorers unit in between the pre and post analysis. The control group was involved in more of a traditional teacher guided learning (TGL) instructional approach during the same three week time period. All pre and post instrumental measures were given to both groups on the same days.

This study utilized 81 high school students taking an advanced life science course at the junior or senior level to establish a meaningful control and experimental population for this study. Four students in this population chose not participate in the voluntary study; six students were removed from the study due to excessive medical absences and attrition. The final number of students in the subject population was 71. The subject population consisted of students 16-18 years of age from a variety of socioeconomic backgrounds and who were not be discriminated based on sex, race, or intelligence. Research subjects fell into one of two categories: control, and experimental subjects. The control population was made up of 35 students enrolled in a junior or senior level life science course. Experimental population was made up of 36 students enrolled in a junior or senior level life science course.
**Review of Instrumentation**

The Motivation and Self-regulation of Learning Questionnaire (MSLQ) is a Likert-style self-report questionnaire designed to access students’ motivational orientation and use of learning strategies for a specific course or unit of study. The MSLQ consists of fifteen subscales that can be used singly or together. There are two sections to the MSLQ, a motivation section and a learning strategies section. Students respond to items regarding motivation, cognitive and metacognitive strategy use, and management of outside resources, using a seven-point (1-not at all true of me; 7 – very true of me) scale. The motivational section assesses students’ goals and value beliefs for a course or unit, their beliefs about their skills to succeed in a course, and their anxiety about tests in a course. The learning strategy section looks at cognitive and metacognitive strategies concerning student management of different learning resources. The motivational scales are based on a broad social-cognitive model of motivation that proposes three general motivational constructs: expectancy, value, and effect (Garcia, 1994). The learning strategies section is divided into three general types of scales: cognitive, metacognitive, and resource management.

Critical thinking ability was assessed and operationally defined by the Watson-Glaser Critical Thinking Appraisal®. The Critical Thinking Appraisal is based on Dressel & Mayhew’s (1954) definition of critical thinking, and includes five subtests each measuring a different aspect of critical thinking: inference, recognition of assumptions, deduction, interpretation, and evaluation (Watson & Glaser, 1980). The
Watson-Glaser Critical Thinking Appraisal, a paper-and-pencil instrument (Forms A and B) consists of 80 items that assess the individual’s critical thinking ability.

The CAT biology attitude scale is a 22-item instrument that is designed to measure students’ attitudes toward biology; in particular, it is designed to measure their feelings of like or dislike about biology. Fourteen of the items use a Likert-type scale (five-point agree-disagree scale) and eight items use a semantic differential scale (five-point bipolar adjective scale). The instrument was developed on the assumption that an important consequence of instruction is a change in the student’s attitude toward the subject, and the authors argue the importance of focusing on attitudes by stating that there usually exists a positive correlation between attitudes and achievement. For this study a third section, consisting of 4 questions, were added to the CAT attitude survey which evaluates student’s perceptions and feelings concerning careers in the medical and life science field. A copy of the CAT survey used in this study can be found in appendix F.

**Research Objective One: Summary of Findings & Discussion**

The first research objective of this study was to measuring the ability of the Medical Explorers case-based curriculum to improve students’ higher order thinking skills. The null hypothesis for critical thinking ability was tested controlling for critical thinking ability prior to treatment. Difference between pre and post performance was used to determine the impact of the Medical Explorers case-based curriculum on the experimental population and then compared to pre and post performance changes in the control population. Here the primary investigator hypothesized that the experimental
group which was exposed to the case-based curriculum would see greater gains in performance than the control group on the WGCTA. Surprisingly little pre and post difference was seen in either the experimental or control groups. Overall the control group has a mean pre and post difference score of +0.82 on the WGCTA and the experimental population had a difference score of +0.14. To test this interaction effect ANOVA was utilized to test the null hypothesis that there was no difference between the control and experimental groups on WGCTA pre and post performance. A significance value of .826 (F=.049) was determined and the null hypothesis was accepted. This seems to clearly indicate that there was no significant difference on mean pre and post difference scores on the WGCTA between the control and experimental group.

When gender effects were looked at in both the control and experimental populations for pre and post performance on the WGCTA, some interesting findings surfaced. Overall females in both populations had a mean WGCTA difference score of +1.27 with an increase of 1.74 in the control population and 0.85 in the experimental population. By comparison, overall males in both populations had a mean WGCTA difference score of -1.38 with a decrease of 1.09 in the control population and decrease of 1.70 in the experimental population. The interaction effect between gender and WGCTA performance was analyzed and the hypothesis that males and females performed differently on the WGCTA was tested. The null hypothesis that males and females performed the same was tested by ANOVA a significance value of .310 was obtained and the null hypothesis was accepted. While a pre and post performance difference on the
MSLQ in males and females was observed it was determined to not be statistically significant.

Initially grade level also seemed to have an influence on pre and post WGCTA performance in both the experimental and control groups. Overall, students in the eleventh grade had a mean difference score of +1.51 while twelfth graders showed a loss of -0.57. Eleventh graders consistently outperformed the twelfth graders in both the control and experimental populations. In the control population eleventh graders showed a gain of +1.24 while the twelfth graders only had a gain of 0.15. Similarly, in the experimental population eleventh graders had a gain of +1.93 while twelfth graders showed a loss of -1.00. Here it was hypothesized that eleventh graders perform better on the WGCTA than twelfth graders. This interaction effect was analyzed by ANOVA and the null hypothesis that there is no difference between eleventh graders and twelfth graders on pre and post difference scores for the WGCTA was tested. A test of the null hypothesis by ANOVA revealed a significance value of .138 (F=2.26) and the null hypothesis could not be rejected. Based on these results the difference observed between the eleventh and twelfth grade student on the WGCTA is not statistically significant.

To determine if there was any measurable cognitive difference between the control and experimental groups, SAT scores were utilized because they represent a standardized measure of cognitive ability and were readily available for most of the population.

There is strong evidence in the literature that case-based pedagogy promotes active, self-directed learning by allowing students to apply their prior experiences in
solving actual or hypothetical problems (Williams, 1992). Additionally, case-based instruction typically includes engaging and energizing student interaction surrounding central questions and themes embodied in a given case narrative. By emphasizing the active and interactive components of the learning process, case-based instruction blends aspects of the cognitive and social constructivist models of teaching and learning. There are direct ties between case-based learning and constructivist pedagogy. Case-study methodology casts the student in the role of knowledge creator and the teacher in the role of facilitator and guide who assists the student in making sense of the course principles. Case-based instruction is a constructivist classroom endeavor in which the teacher must guide students in the direction of inferences and conclusions, in the absence of providing them with ready-made answers.

In line with a cognitive constructivist perspective, case-based learning promotes meaningful learning by permitting students to relate case data to their personal experiences and preexisting knowledge. As students apply theoretical concepts observed in case scenarios to their own life situations, this conceptual information becomes personalized and thereby stimulates introspective analysis (Williams, 1992). Case-based instruction often serves as a springboard for class discussion which promotes active student interaction.

As a means of promoting critical thinking and connections between the theoretical and applied knowledge, case-based instruction has shown to be an effective teaching strategy in science and other disciplines. In a study conducted by Mayo (2004) it was determined that students exposed to case-based instruction outperformed those in the control on comprehension and application of course principles. While critical thinking
was not accessed in this study it is clear that case-based learning has great potential to positively impact comprehension and application of science principles.

**Research Objective One: Conclusions & Implications**

While the Watson-Glaser Critical Thinking Assessment has a high reliability and norms have been established for eleventh and twelfth grade students, it may not have been sensitive enough to fully access critical thinking development in this population of students. Spicer and Hanks (1995) evaluated several standardized critical thinking tests available as well as several performance assessment approaches that can be used as outcome measures within various subjects. Spicer and Hanks determined that standardized tests can provide useful information that is diagnostic and may help to guide instruction, however multiple measures of critical thinking should be used whenever possible since critical thinking is not a general ability but rather a complex set of general and specific factors.

In a study conducted by Richardson (2010), three instructional strategies used in the development and implementation of online discussion questions were examined based on their impact on critical thinking development: case-based discussion, a debate, and open-ended (or topical) discussion. Similarly, this study also utilized the Watson-Glaser and their results showed no significant difference in critical thinking development among any of these instructional method. However based on student interviews, students contended that they were able to learn the material better because it was more relevant and applicable to the real life. In addition, previous descriptive studies (Alexander,
Baldwin, & McDaniel, 1998; DeMarco, Hayward, & Lynch, 2002) indicated an increased satisfaction in the educational experience of students in that it promoted teamwork, creativity, motivation, and critical thinking. Several studies (Amos & White, 1998; Cooke & Moyle, 2002; Williams, Sewell, & Humphrey, 2002) involving nurses in a variety of settings all had outcomes that supported the PBL instructional strategy’s ability to improve critical thinking, creativity, teamwork, research skills, motivation for learning, self-esteem, and professionalism. The reflections submitted by the students and instructor supported these earlier outcomes. PBL may not give students an advantage when acquiring knowledge of new material. However, based on the reflections from this study and past literature, PBL is a good instructional strategy for motivating students to learn, encouraging students to think and problem solve, and helping student to make a connection between what they learn in the classroom and how it can be applied in the real world, which may lead to better retention of the concepts.

The mean change in pre and post critical thinking score between the two instructional strategies was not significant, indicating there was not a statistically significant difference in critical thinking ability when accounting for critical thinking ability prior to treatment. The analysis of covariance of critical thinking ability when accounting for ability prior to treatment yielded no statistically significant difference between the two groups after treatment. The null hypothesis stating that no difference existed between groups on critical thinking ability scores was accepted. In a similar study Burris (2005) reported a statistical difference in critical thinking ability among both the CBL group and teacher guided group. The present results support his findings that no
practical difference existed between the groups when measured using the WGCTA®. In contrast to these findings, in a related study conducted by Choi and Lee (2009) the researchers found that the case-based learning model promoted ill-structured problem solving.

In a related study by Kaberman and Dori (2009), the researchers evaluated the impact of case-based computerized learning environments on question posing skills. This study focused on guided question posing while using a metacognitive strategy by 12th grade honors chemistry students. The participants were 793 experimental and 138 comparison chemistry students. Research instruments included interviews and case-based questionnaires. The questionnaires showed that students utilizing the case-based instructional model significantly improved their question posing skill, as well as complexity level of the questions they posed. While there is no direct correlation to the current study, these results would also seem to indicate that case-based instruction does have a positive impact on higher order thinking skills and likely critical thinking (Kaberman, 2009).

This study did find an interesting pattern in the development of critical thinking among high school juniors and seniors. When the total population was looked at for both the control and experimental populations, the juniors did improve performance on the WGCTA by an average mean of 1.51 (SD= 6.6) and by contrast the seniors declined by an average of -0.57 (SD= 8.4). Given that the experimental and control populations were relatively small this deviation in performance likely impacted the overall analysis of critical thinking development. Further compounding this is the imbalance of junior and
senior in the control and experimental populations with 60% juniors and 40% seniors in the control population, while the experimental population was made up of 38.9% juniors and 61.1% seniors.

**Recommendation One:**

While this study did not reveal any significant change in critical thinking ability due to the use of the *Medical Explorers* case-based curriculum it does have implications for future studies of case method in education. It builds on previous research on the impact of the case method on changes in how students understand the role of teaching and learning. Unfortunately current educational pressures have driven more and more teachers to focus on preparing their students to pass standardized examinations, but by doing so they neglect developing their higher-order thinking skills. In a study conducted by Tsui and Treagust (2007), the majority students who were taught genetics through computer based cases showed evidence of improved conceptual understanding and development of critical thinking skills. Case based instruction should be seen as a tools which can be utilized to address the modern requirements of standards based curriculum in a way that students find relevant.

It is widely recognized that the development of creative and critical thinking can be beneficial for both the individual student and society. Instructors have to understand the fine line between facilitating and instructing. It may be necessary for the instructor to guide them toward helpful resources or clear up misunderstandings without giving students all the answers. An example would be for the instructor to have classroom discussions throughout the learning process to allow students to pose questions to each
other or explain information they have gathered. The primary focus of this is to allow students to share with each other information that will help groups that are off track or having difficulties to refocus their attention. The instructor should also have probing questions prepared to interject if the students are not generating appropriate discussions. Another example would be to employ the use of mini-lessons. This involves the instructor taking key concepts that are difficult and explaining the basic theory behind them in very short 10 minute lessons. This alternative method removes some of the anxiety students have with the difficult concepts so that they can focus more on the problem-solving process, however, it does make the learning process more teacher-centered during the mini-lessons. This method is only encouraged when students are struggling with very difficult material and the mini-lessons are deemed not to take away from the information discovery process.

Analyzing information and data presented in case studies, posing questions, providing scientifically grounded arguments, expressing opinions, making decisions, and system thinking are higher order thinking skills. Studies related to teaching students at various ages, using case studies have indicated that the case study method is effective at improving students’ conceptual understanding, question posing and critical thinking abilities, as well as their motivation (Dori, 2003).

The needs and the interests of students change over time and the effectiveness of the teacher will be determined by one’s ability to adapt to these changes, relate to the students, and develop lessons that will prepare these students to be competitive in a global market. Case-based learning should be incorporated into the curriculum to encourage engagement and relatedness. However, instructors should use classroom
discussions or mini-lessons through the process to mitigate some of the frustrations of using CBL.

Instruction in the facilitation of CBL should be incorporated into teacher education programs at the university level and professional develop provided by school corporations. These training activities should include ample opportunity to the attendees to practice the instructional strategy as a participant and a facilitator. Teachers will not use CBL in the classroom unless they understand and are comfortable with the process. Furthermore, successful outcomes are dependent on the ability of the instructor to facilitate the CBL activity.

**Research Objective Two: Summary of Findings & Discussion**

Research objective two sought to evaluate the impact of the *Medical Explorers* case-based curriculum to help students develop self-directed learning skills and habits of mind. The Motivation and Self-regulation of Learning Questionnaire (MSLQ) was used to access: value component of education, expectancy component, cognitive and metacognitive strategies, and resource management strategies. The MSLQ utilized a seven-point Likert scale response system where 1—not at all true of me; 7—very true of me) scale. The overall difference between pre and post performance on the MSLQ (MSLQd) was examined and compared between the control and experimental groups to determine the impact that the *Medical Explorers* case-based curriculum had on motivational learning strategies.
The control TGL group had a mean MSLQ difference score of -.09 while the experimental group a mean MSLQ difference score of .04. Based on the seven point scale used in this assessment, the mean MSLQ change observed in the control or experimental groups is not statistically significant and shows a change of less than less than 2%. The interaction effects of the groups with the mean MSLQ difference score were analyzed by ANOVA and a significance value of .288 was obtained. The null hypothesis stated that the mean MSLQ difference score was equal in both the control and experimental groups. Given that the significance value was not below the .05 level the null hypothesis had to be accepted.

While there seems to no significant change in the control or experimental population for motivation learning strategies, there still was a recognizable performance difference between eleventh and twelfth grade students. Overall the eleventh grade students showed a mean change in their MSLQ of .03 while twelfth grade students actually showed a decline of -.08. This still represents no significant change, as was revealed by the ANOVA analysis for interaction between grade level and mean MSLQ difference scores. The null hypothesis that there was no difference in MSLQ performance based on grade level was tested. Analysis by ANOVA yielded a significance of .497 and the null hypothesis had to be accepted. Of interest to the MSLQ is the fact that gender seemed to have no real effect on motivation learning strategies. Overall, females had a mean MSLQ difference score of -.04 and males had a mean score of .02. When the interaction effect of gender was compared to MSLQ difference scores
by ANOVA a significance value of .974 was obtained and the null hypothesis that there is no difference between males and females on MSLQ difference scores was accepted.

It was predicted that there would be a strong correlation between performance on the MSLQ and performance on Medical Explorers project rubric score (MEPRS). This was supported by the results obtained in this investigation and correlation analysis between MSLQ2 and MEPRS revealed a correlation value of .348 with a significance value of 0.038. Given that the significance (p value) was below 0.05 the positive correlation MSLQ and rubric performance on the final Medical Explorers project was accepted. Interestingly a strong positive correlation was also obtained between performance on the MEPRS and performance on the math and writing sections of the SAT. Between math section of the SAT and MEPRS the correlation was found to be .528 (p= .012) and the correlation between the writing section of the SAT and MEPRS was .608 (p= .003). Because both the SATm and SATw correlation to MEPRS are below 0.05, the correlation relationships can be accepted. Given that the final project required the application of critical thinking skills and demonstration of effective communication of ideas, correlation to performance on the math and writing sections of the SAT seems rather clear.

**Research Objective Two: Conclusions & Implications**

The Medical Explorers case-based curriculum seemed to have limited impact on students motivation and self-regulation learning strategies. Overall no significant change in MSLQ performance was seen in the control or experimental groups for either the
overall score or subscale scores. This is likely due to the fact that the curriculum was only implemented and analyzed for relatively short period of time of five weeks. Further, while students in the experimental group were engaged in the Medical Explorers during each of these five weeks, instruction was not solely focused on the utilization of case-based instruction. For case-based instruction to have a measurable impact on motivational learning strategies such methods would need to be sustained for longer periods of time and be focused on more intently. A review of the literature did not identify any affective length of time needed for case-based instruction to be affective in high school students. Future studies on the impact of case-based should be conducted over at least a semester and should involve the use of a variety of cases which are integrated into the curriculum.

Of interest though was a positive correlation revealed between post performance on the MSLQ and performance on the final Medical Explorers project rubric score. It seem that students who approach the Medical Explorers unit with an intrinsic goal for learning, who believe that the material is interesting and important, who have high self-efficacy beliefs for accomplishing the tasks, and who rated themselves as in control of their learning are likely to do well in terms of the Medical Explorer unit grade.

Recommendation Two:

Creating self-directed learners is one of the major objectives of case-based learning and of society in general. In the information age, new scientific information is discovered at an exponential pace; former information frequently becomes obsolete; and new technologies are introduced daily. Given this, schools should help to ensure that
their graduates have the skills necessary for life-long learning: how and where to obtain information, how to evaluate it, and how to apply the new information to problems. A case-based approach emphasizes both individual self-study and group discussion, with the group discussion building on individuals’ personal work.

Case-based learning empowers the student to make decisions about how to go about solving the problem, what information is needed, and along the way aids students in building their self-directed study skills. In support of this, research has shown that case-based learning students spend more time studying in the library using a wider variety of resources that they selected themselves as compared with the conventional students who primarily rely on the textbook and the instructor (Williams, 1992).

Teachers should continue to develop the “art” of teaching so that students are motivated to learn. Teachers should focus on creative interest approaches such as case-based instruction, dynamic presentations, application activities to which students can relate, and unique assessments (e.g. portfolios, presentations, case studies, service projects). All schools need to define their philosophy of education as one that promotes critical thinking on important issues such as differentiated instruction, appreciation for diversity, and a belief that the society has a responsibility to educate all students. The case method can be a key ingredient toward that end, and continued research on the case method is necessary to further our understanding of its impact.
Research Objective Three: Summary of Findings & Discussion

Research objective three sought to investigate the impact of the *Medical Explorers* case-based curriculum to improve student attitudes toward the life sciences. Pre and post scores on the CAT and a difference score were calculated for both the control and experimental participants. The CAT was set up using an A-E likert scale which was then converted to a 0-4 scale for analysis purposes. Given that 4 was the top value for the CAT analysis, a change of 0.2 or greater between pre and post performance would be significant. The control group saw little deviation in pre and post change in attitude utilizing the CAT instrument with a difference of -0.02 (SD=0.29). While the experimental groups showed a pre and post difference of 0.20 (SD= 0.42). To determine if the change in CAT scores is significant, ANOVA was utilized to test the null hypothesis of no difference between the groups. Analysis of the null hypothesis by ANOVA revealed a significance value of .036 and the null hypothesis was rejected. As a result the hypothesis that there was a difference in change in attitude between the control and experimental groups was accepted.

Further analysis of the control group revealed little difference in performance between eleventh and twelfth grade on the CAT, with a mean CATd score of 0.01 and -0.08 respectively. The mean CATd score for males and females in the control population was -0.06 and 0.00 respectively. Slightly different results were found in the experimental population with eleventh grade students having a mean CATd score of 0.03 and twelfth grade students having a mean CATd score of 0.31. When males and females scores on
the CAT were analyzed in the experimental population, females had a mean CATs score or 0.23 while males had a mean CATd score of 0.12.

**Research Objective Three: Conclusions & Implications**

This study did reveal significant change in the CAT attitude scores between the experimental case-study and control groups. In rural Indiana high school eleventh and twelfth students, the *Medical Explorers* case-based instruction does seem to positively impact attitudes toward the life sciences. In support of these results a study conducted by Pugh (2002) utilizing the case-based instructional method in teaching a unit on adaption and evolution in a high school zoology class and found that a significantly greater percentage of students in the experimental class (52.9%) than students in the control class (22.7%) engaged in some degree of transformative experience. Further, it was found that students from both classes who engaged in at least some form of transformative experience scored significantly higher than other students on a follow-up assessment of understanding but not on a post intervention assessment of understanding.

At first one might assume that all students will be motivated to deepen their understanding when confronted with authentic problems in realistic situations. Results from a study by Ertmer and Newby (1998) point to the potential roles that perceived value, learning focus, and use of reflective monitoring strategies may play in shaping students’ responses and approaches in a case-based course. In another study conducted by Hudson and Buckley (2004) a cross-sectional evaluation of case-based teaching revealed that students valued this approach. The initiative not only integrated physiology with related basic sciences and clinical medicine but importantly linked students’
developing knowledge of theory to practice. Here it was clear the case instruction could successfully be used to place learning in the context of a case to give meaning to the tasks and material that students were acquiring, while integrating their theoretical knowledge and understanding of the basic sciences (Hudson, 2004).

Interestingly, when compared with students in a case-based learning curriculum, conventional-track students suffered from more stress, found their education less relevant to their future careers, and had more difficulty in applying what they learned (Williams, 1992). During interviews, case-based learning students received significantly higher scores from a blind rater on problem solving, maturity, and motivation (Williams, 1992). However no significant evidence was found that there is any correlation between attitude toward life science and: grade level, MSLQ scores, or WGCTA performance. Although not shown to be significant it can be noted that this study does seem show some correlation between gender and attitude toward life science within the experimental case-study group. When CAT life science attitude scores among females in both the experimental and control group were compared there was a clear increase in post CAT scores among those who had used the experimental case-study method versus the control teacher guided learning method. This would seem to indicate that female students have some preference for the case study method and as a result positively impacts their attitude toward life science. A study by Peplow (1998) seems to confirm these results and revealed that female medical students generally feel that case-based learning develops learning skills to a much greater extent than did male students. In Peplow’s study there was clear evidence that female students responded much more positively to tasks undertaken in the initials discussion sessions and also performed better than the male
students on the case-based problem component of the medical examination process, designed to test deep learning, problem solving, and the application/integration of knowledge.

A study by Canfield and Lafferty (1974) revealed that female students have a higher preference for people-directed content, requiring a close, helping relationship with people (cited in: Peplow, 1998). In addition this study revealed a correlation between females and people-oriented and independent learning styles. Independent learning skills are reflected in such things as problems solving, analysis and conceptualization, written communication, work planning, teamwork, and self-confidence. In contrast a study by Pugh (2002) revealed that there was no significant differences found on measures of class content, interest in class content, interest in learning about life science subjects when case-based instruction was compared to the teacher guided method of instruction.

**Recommendation Three:**

In the age of proliferating educational and video game technologies, a promising direction for case-based instruction might involve the combination of video technology and the case method of teaching. Case-based instruction offers a number of advantages and is thought to be more effective than traditional teaching methods because they (1) more accurately represent the complexity and ambiguity of real-life problems, (2) provide a framework for making explicit the problem-solving process of both novice and expert, and (3) provide a means for helping students develop the kind of problem-solving strategies that practicing professionals use (Stepich, 2000). More specifically, case-based instruction can help students learn to: focus on the big picture, work forward from what
they know, simultaneously consider multiple factors, generate tentative solutions, and consider potential consequences and implications (Stepich, 2000).

Innovative educators, in search of creative avenues for introducing technology into their curricular plans, may turn to selecting video game cases (ex. Real Life) for analysis and discussion in their classroom. However, this approach would call for instructors’ careful planning in the selection process, with respect to the appropriateness and to the degree of complexity, realism, and connection to course concepts. As the creation of video games and simulations becomes increasingly, instructors or even students themselves might create video games based cases that are tailored specifically to fit the needs of a classroom environment. Instructors should continue to evaluate the learning objectives and incorporate a variety of appropriate instructional strategies and assessments into the curriculum in order to achieve the learning objectives.

**Educational Objectives: Summary of Findings & Discussion**

The educational objectives of the *Medical Explorers* curriculum were identified for students to be able to:

- Understand how scientific knowledge can be used to guide decisions on environmental and social issues.
- Recognize that their explanations must be based both on their data and other known information from investigations of others.
- Understand the characteristics and uses of various sources of scientific information and the evaluation of scientific information, claims, and arguments.
- Recognize the social, cultural, and ethical aspects of science, engineering, and technology.

As a final analysis of the educational objectives for the Medical Explorers curriculum each student participant in the experimental group was asked to create and present a final case report over their patient. Final case reports and presentations were evaluated using a rubric which emphasizes the educational objectives being evaluated in the Medical Explorers curriculum. The maximum value for the Medical Explorers final project rubric score was 100. Please see appendix D to review the rubric for the Medical Explorers final case-study project.

The mean score on the Medical Explorers final case-study project (MEPRS) was 89.39 with a standard deviation of 8.96. In the experimental population, females had a mean rubric score of 90.27 with a standard deviation of 8.80 while males had a mean score of 86.62 with a standard deviation of 8.90. Levene’s test of equality of variance between males and females on the MEPRS was found to be .747, thus variance among males and females on the MEPRS was the same. Similarly a t-test of equality of means yielded a significance of .274 and thus the equality of means was the same between both males and females.

As was seen on several other instruments there was a performance difference on the Medical Explorers rubric score among eleventh and twelfth grade students. The eleventh grade students had a means rubric score or 91.32 with a standard deviation of 5.82 while twelfth grade students had a mean rubric score of 87.94 with a standard deviation of 10.25. Levene’s test of equality of variance between eleventh and twelfth
grade students on the MEPRS was found to be .106, thus variance among eleventh and twelfth on the MEPRS was the same. Similarly a t-test of equality of means yielded a significance of .270 and thus the equality of means was the same between both eleventh and twelfth grade students.

A limiting factor in the analysis was that individual educational objectives could not be analyzed independently of each other rather an overall evaluation of the educational objectives was obtained using the final project rubric score. Limitations set forth by the IRB prevented the primary utilizing any documents which could be directly linked to any of the participants in the study. All data had to be first received by a second party and then results obtained transferred to an encoded data sheet which only included students who wished for their data to be used in the study. Given that all the students participating in this study were being instructed by the primary investigator, this data handling procedure ensured anonymity and confidentiality of student data in such a way as to eliminate potential issues of perceived coercion. This approach limited the ability of the primary investigator to directly examine any student papers or data which could be linked to the student participants. In this case only an overall rubric score was obtained to measure the performance on the educational objectives.

In addition to the formal data collected utilizing the Medical Explorers project rubric score, informal observation were made by the primary investigator regarding performance changes as related to the educational objectives. Based on class and small group discussions at the beginning of the study the primary investigator observed that students general did not recognize the complexity of decision making as related to values
and beliefs of a society or culture. Those students who then participated in the Medical Explorers case-based curriculum were then observed to have a greater understanding of the complexities of decision making. In this case students were able to demonstrate the importance of integrating cultural and religious values into medical treatment plans.

Addition information observations were obtained during oral presentations given by each student during final Medical Explorers case reports. During these presentations the vast majority of students utilized scientific research and supporting data to guide their treatment plans. Based on informal observations obtained it seems that the Medical Explorers curriculum did help students to:

- Understand how scientific knowledge can be used to guide decisions on environmental and social issues.
- Recognize that their explanations must be based both on their data and other known information from investigations of others.
- Understand the characteristics and uses of various sources of scientific information and the evaluation of scientific information, claims, and arguments.
- Recognize the social, cultural, and ethical aspects of science, engineering, and technology.

**Educational Objectives: Conclusions & Implications**

After completing the Medical Explorers case-based curriculum all of the eleventh and twelfth grade students who were in the experimental group were able to successfully
demonstrate mastery of the overall educational objectives. Unfortunately due to experimental protocol constraints the primary investigator was not able to analyze subcomponents of each student’s final Medical Explorers project but rather an overall performance score. In future studies it would be recommended that students at other schools across the state or country be utilized to allow for a more detailed analysis of the educational objectives.

Discussion of Correlations between Instruments

Not surprisingly, there was a very strong correlation relationship found between performance on the Watson-Glaser Critical Thinking Assessment and performance on the SATm, SATv, and SATw. An analysis of the P-SAT and SAT by Dinkelman (1990) revealed that 18.5% of questions used showed any critical thinking content. As an example, just looking at the correlation between the post test performance on the Watson-Glaser (WG) there was a high correlation of .756 for SATm (p= .00), .591 for the SATv (p=.01), and 0.804 for SATw (p=.00). These results are supported by a study conducted by Taube (1995) at Purdue University which utilized one-hundred ninety-eight undergraduate students. In this study Taube also found strong correlation performance on the verbal and math sections of the SAT and performance on the Watson-Glaser. These results indicate a clear link between performance on the SAT and critical thinking ability as accessed by the Watson-Glaser Critical Thinking Assessment.

Interestingly student performance on the math and critical reading portions of the SAT (SATm & SATv) were also highly correlated with pre and post student attitude
The Pearson Correlation between the SATw and CAT1 was .583 (p=.004) and .668 (p=.001) between SATw and CAT2. In support of this observation, a study by Devito (1982) also showed a strong positive correlation between student attitudes and performance on the SAT. These findings seem to suggest that student attitudes do indeed seem to have an impact on performance on academic assessment such as the SAT.

Additionally a strong correlation was also found for both the math and writing portions of the SAT with pre and post performance on the Motivated Strategies for Learning Questionnaire (MSLQ1 & MSLQ2). For example, the correlation between SATw and MSLQ1 was .467 (p=.028) and .472 (p=.026) with MSLQ2. Finally, a very interesting correlation was determined between rubric score performance on the final Medical Explorers project (MEPRS) and both performance on the math and writing portions of the SAT (SATm & SATw). The Pearson correlation between SATm and MEPRS was .528 (p=.012) and the correlation between SATw and MEPRS was .608 (p=.003). In addition there was also a strong correlation of .395 (p=.017) between MEPRS and WG2 as well as between MSLQ2 and MEPRS .348 (p=.038). A 1992 study by Payne looked at the effects of learning strategies on a group of black secondary students’ verbal and mathematics SAT scores. Here the learning strategies variables were: (1) rehearsal; (2) elaboration; (3) organization; (4) critical thinking; (5) planning; (6) monitoring; (7) self-regulation; (8) time and study environment; (9) effort; (10) peer help; and (11) help-seeking behavior. Multiple regression equations demonstrated that the self-regulation variable had significant positive effects on verbal and mathematics SAT
scores and that help-seeking behavior had significant positive effects on the verbal score (Payne, 1992). The results obtained in this current research seem to be supported by the literature and it seems clear that there is a positive correlation between learning approaches utilized by students and performance on scholastic aptitude tests such as the SAT.

Summary Conclusion & Discussion:

In this study no significant difference was observed between the control group (teacher guided learning) and the experimental group (case-based learning) for changes in critical thinking, or motivated learning strategies. However there does seem to be a strong correlation between the use of case-based instruction such as Medical Explorers and positive impact on attitude toward life science.

Another interesting observation was the fact the throughout this study, eleventh grade students generally outperformed twelfth grade students on the WGCTA, CAT, and MSLQ. Given that all pre and post analysis was performed in the winter and spring of the school year, there is some evidence that a senior slump or what is commonly referred to as senioritis may have played effect on student performance in post assessments among twelfth grade students in both the control and experimental population. Numerous studies have documented that many high school seniors tend to decline in performance and attitude following receipt of successful admission into a postsecondary institution (Hover, 2001; Kirst, 2001). The U.S. Department of Education formed a National Commission on the High School Senior Year and released a report in 2001 entitled “The Lost Opportunity of Senior Year: Finding a Better Way,” in which the
commission found that for many students, that year “becomes party-time rather than a
time to prepare for one of their most important life transitions” (Hoover, 2001). The
commission also suggested that senioritis may, in fact, be most pervasive among the
“best and the brightest,” given that the savviest students understand that it’s what they
accomplish through the end of their junior year that will determine where they attend
college. Given that all senior participants in this study were college bound it seems
possible that changes in work ethic and attitude toward school may have negatively
impacted the results of this study. This decline in twelfth grade performance is an
endemic indicator of underlying problems that exists in this transitional year of education
and supports the need to stronger transitional connections between high schools and
institutions of higher learning.

Table 5.1 Summary Results of Experimental Hypotheses

<table>
<thead>
<tr>
<th>Experimental Hypotheses</th>
<th>Supported by the data</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1: Students taught using Medical Explorers case-based curriculum will demonstrate greater critical thinking development than students taught through teacher guided learning when accounting for prior critical thinking ability.</td>
<td>NO</td>
</tr>
<tr>
<td>H2: Students taught using Medical Explorers case-based curriculum will demonstrate greater improvement in their motivation and self-regulation of learning skills than students taught through teacher guided learning when accounting for prior ability.</td>
<td>NO</td>
</tr>
<tr>
<td>H3: Students taught using Medical Explorers case-based curriculum will demonstrate greater improvement of their attitude toward life sciences than students taught through teacher guided learning when accounting for prior attitude toward life science.</td>
<td>YES</td>
</tr>
</tbody>
</table>
Limitations of the Study

This study evaluated the effects of Medical Explorers, a case study curriculum on critical thinking, attitude toward life science, and motivational learning strategies in rural high school students. Caution must be taken in transferring the results or application of methodology to other case-based instructional materials or other student populations.

Due to limits in the available target population (n=81), both the experimental (n=36) and control (n=35) populations were rather small. While there is value in the results obtained, the low number of subjects’ decreases the internal validity of the study. To increase the internal validity of the research, the experimental and control groups be sufficiently large (100+) to detect meaningful effects of the Medical Explorer curriculum. In addition, although the content was created for the use in grades 5-12, the content may be too simple and thus not cognitively challenging for the junior and seniors advanced life science students. Further, measuring the impact of case-based instruction is particularly difficult because information obtained is context sensitive, which limits generalizations and theory building. Any teaching situation has many variables that influence the interactions among and between the teachers and students. Such variables include, but are not limited to: perceived value, students’ motivations to learn, attitude, personal health, nutrition, skill of the instructor, educational level of parent, prior student experiences, as well as the student’s socioeconomic level.

Given that the Delta High School student population was the only one which was utilized in this study, one issue of concern is the lack of racial, cultural, and geographic
diversity of the student experimental and control populations. While the experimental and control populations at Delta will provide valuable information toward addressing the experimental questions in this study, the populations at Delta will not represent the racial, cultural, and geographic diversity found across United States and throughout the world. However, the experimental and control populations at Delta did represent a wide cross section of socioeconomic levels. All that can be determined from this study with any degree of confidence is how the Medical Explorers curriculum impacted rural junior and senior high school students in Indiana. Future research would need to broaden the racial, cultural, and geographic diversity of both the control and experimental populations to see if these variables influence the outcomes of the Medical Explorers curriculum and measured by this research.

While individuals were assigned randomly to the two groups in the case, there were distinct differences between the control and experimental populations based on grade level and gender. This opens up the possibility that other variables either mask or enhance any apparent significant difference in means were group difference was examined. If a significant difference is found, it may be due not to group; control variables may be at work.

Finally, because standardized IQ scores were not obtained for each student involved in this research study, no comparison could made between the impact on high, intermediate, and low academic level students. This limited the ability of this study to evaluate the impact of the Medical Explorers curriculum on learners at different cognitive ability levels. Such future research would allow for the evaluation of critical thinking,
motivational orientation and use of learning strategies, and changes in attitude toward life science among high, intermediate, and low level learners.

Future Research:

Late in his career, Dewey (1934/1958) turned to the arts because he felt that arts epitomized an optimal type of enriched experience. Dewey (1933) discusses concept formation in relation to the process of reflective thinking (cited in: Pugh, 2002). Individuals start by holding a piece of knowledge as a possibility. Dewey argues that ideas are confirmed by the consequences that they have on everyday experience. In this theory a worthwhile idea allows one to see and experience aspects of the world in a new, meaningful way. As applied to science education, Dewey’s work suggests that science concepts can engage individuals in transformative experiences. Basically, individuals undergo transformative experiences when they actively use a concept, find that it allows them to see aspects of the world in a new way, and personally value this way of seeing. Questions remain about how well such experiences can be fostered and what teaching methods are effective at fostering them.

Many have argued that science education should enrich students’ everyday experience. Indeed, one would likely be hard-pressed to find a teacher, student, parent, or science educator willing to argue that science education should not enrich students’ everyday experience. The case-based method, attempts to bridge the chasm between theory and practice by creating an engaged learning environment where students present their perspectives, hear the perspectives of their peers, and apply the concepts addressed in class.
Much of the research on the case method in education focuses narrowly on how best to teach using cases or studying the impact of case-based instruction on college students’ thinking, reasoning, and in a few cases their practice. One limitation to the current study is that it did not account for individual thinking styles and the development of critical thinking. Pearson correlation analysis reveals that liberal, legislative, judicial, hierarchical, anarchic, external thinking, local, and global thinking styles have a significant correlation with creative thinking. These results are supported by Sternberg and Lubart (1995) that legislative and liberal thinking styles are associated with using creative strategies. In addition there also seems to be some evidence of a relationship between personality types and the development of critical thinking. Unfortunately this current research study did not account for individual thinking styles or personality types and so it is unknown if the distribution of thinking styles or personality types within both the experimental and control populations had any effect on critical thinking development. Future research would need to account for thinking styles and potentially personality types to determine if there is any relationship to critical thinking development when utilizing Medical Explorers case-based instructional materials.

One element of teaching for transformative experiences involves the apprenticeship approach. Case-based instruction is based on the apprenticeship approach. Indeed a goal of case-based instruction is to create a context where particular ways of experiencing the world through concepts are displayed and valued and to help students come to participate more centrally in these experiences.

To address the limitations of this study future research should incorporate multiple methodologies, including interviews, students perception surveys, and student
written products to better understand how high school students view the role of the case method for learning science. Future research might also investigate the cumulative, long-term effect of teaching a series of modules that feature case studies which encourage the development of students’ higher order thinking skills. It might also be interesting to study whether and to what extent these acquired skills are transferable to other subject matters.
References


Appendix

Appendix A:

About the Timmy Foundation

Dr. Charles J. Dietzen’s inspiration for creating the Timmy Foundation was derived from his medical outreach in developing countries, his devotion to improving the lives of all children, and his opportunity to meet Mother Teresa, while completing medical outreach in India.

Since its humble beginnings, the foundation has served thousands of children and the communities in which they live. The Timmy Foundation recognizes that there is an inherent shortfall in the provision of medicine in developing countries. While complex issues contribute to this shortfall, the Timmy Foundation helps to alleviate the shortfall through simply providing physicians and clinic beds where there are few or no other opportunities to seek medical care. On the other hand, the Timmy Foundation also helps to build the infrastructure of many community-based medical practices in developing countries.

The Timmy Foundation works with each of its International Partners Organizations (IPO) to develop the best course of action to build sustainable health practices. Examples of Timmy Foundation projects include:

- Sending volunteer medical brigades to communities in developing countries, such as Ecuador, Columbia, The Dominican Republic, Guatemala, Honduras, Jamaica and Nigeria. The Timmy Foundation works with community-based organizations in each of these countries and helps to build the community’s infrastructure to support sustainable health-care practices. The Timmy Foundation supports the efforts of these organizations year-round.

The Timmy Foundation’s vision is a world in which all children have access to quality healthcare and education. The Foundation believes that quality healthcare not only includes acute treatment but tending to the individual as a whole. Providing resources such as proper nutrition, education, and child care are important components for creating a healthy global community.

The Timmy Foundation’s mission is to build healthy futures worldwide, one child at a time, through strengthening community-based health and education initiatives and by empowering young people to share their energy and compassion.
- Creating a referral system with each of its IPOs to track the long-term progress of its patients and ensure the patients with the most critical need receive medical support and discounted treatment and surgeries.

- Building a network of volunteers at colleges and universities around the country. The ten chapters help to raise money, donate equipment and create greater awareness for global health issues.

- Completing research and epidemiological studies in the communities in which they work.

- Partnering with community-based organizations and non-governmental organizations (NGO) to build and sustain schools and other resources that contribute to the healthy development of youth.

- Providing grant money to community-based organizations and NGO to establish programs that support the needs of their community.

The Timmy Foundation is governed by a 15-member Board of Trustees. The Trustees are diverse and represent professionals in the business, medical, educational and nonprofit community and includes three high school students. Originally founded in Indiana, the Timmy Foundation has several chapters at universities across the country. Most of the work of the Timmy Foundation is carried out by its hundreds of volunteers with the only full-time staff being project coordinators.
Appendix B:

Medical Explorer

We were not all born to be doctors and nurses, but we were all born to be healers,

– Charles J. Dietzen, MD

The Big Idea

Through medical science investigation, international case studies and service projects we hope to inspire our young people to change the world.

We can do no great things, only simple things with great love. – Mother Teresa
Acknowledgments

The Timmy Foundation wishes to acknowledge the assistance of the following people in the preparation of this project:

Rick Crosslin, Writer and Science Educator

Lance Brand, Pilot reviewer and Science Educator

Patty Zeck, Reviewer and Science Educator

The Timmy Foundation is a 501(c)(3) nonprofit organization based in Indianapolis and dedicated to supporting health care and education initiatives in developing countries. Charles J. Dietzen, M.D., founded the organization in 1997. Dr. Chuck, as he is called, named the foundation after his brother Timmy, who lived only four days. Because of volunteer support and donated warehouse and office space, 97 percent of charitable contributions to the foundation go to its programs. There are only three full-time employees at the foundation because of substantial help from its volunteers. Numerous volunteer opportunities for all ages are available. Contact The Timmy Foundation World Headquarters at 22 e. 22nd Street, Indianapolis, IN 46202; (317) 920-1822; fax 317-920-1821; www.timmyfoundation.org.

What’s Ahead

The goal of the Medical Explorer curriculum is to transform students and teachers from spectators into participants. The lessons are designed so that students participate in case studies, medical evaluations, treatment plans, and service projects. The case studies provided are modeled after real people in real places. The information that science students learn is real and provides tools that they will apply in further studies or service projects. Students will learn skills and have experiences that can reach beyond the walls of their classrooms or the borders of their states and nations. Students begin their work through case studies that represent children in areas of the world without adequate medical services and nutrition. The children’s profiles are based on experiences at international sites served by The Timmy Foundation and are represented through case studies containing clinical narratives for students to use. Clinical medicine is hands-on medicine. Students participating in this project will learn to work together on a science service project that has the power to change lives. The Timmy Foundation hopes to provide opportunities for students to make positive differences that improve the lives of others around the world and in their own backyard. This project helps students achieve
academic standards in Language Arts, Science (Biology) and Social Studies (World Geography). Specific academic standards are listed with each lesson. A complete listing of the Indiana Academic Standards is located at http://ideanet.doe.state.in.us/standards/welcome.html.

The Timmy Foundation

The Timmy Foundation was founded in 1997 to channel resources to sustainable health projects in developing countries.

Our Vision: A world in which basic health care and education are available to all children.

Our Mission: Building healthy futures worldwide, one child at a time. We accomplish this by strengthening community-based health and education initiatives and by empowering young people to share their energy and compassion. The Foundation’s work is dedicated as a living legacy to all of Dr. Chuck’s pediatric hospice patients.

Since its humble beginnings, the foundation has served thousands of children and the communities in which they live in Central and South and North America, the Caribbean, Africa, and Asia. The mission is achieved through collaborative partnerships that provide healthcare and deliver relevant medical and educational resources. The work does not duplicate the efforts of other individuals and organizations but instead supports them by matching resources to the needs.

While working in India in 1997, Dr. Chuck had the great blessing of meeting Mother Teresa. She stressed the importance of giving hope to the people we could not cure. She said, “We can do no great things, only small things with great love.” The Foundation invites you to be a part of the efforts to extend this philosophy by reaching out to those in need. Help the Foundation provide services that are small but mean the world to others. Join the volunteer family and experience the heartfelt joy and love that comes from serving others.

More information about The Timmy Foundation is located in Lesson 3: People Like You Making a Difference! and at the foundation Web site: http://www.timmyfoundation.org.
Medical Explorer

The Timmy Foundation

Introduction

When I was a child my mother encouraged me to eat the food I had left on my plate by telling me that there were starving children in India and China. My response to that comment was, “Great! Let’s mail it to them.” As I got older, I realized this was not a practical solution to the problem. Mashed potatoes and sauerkraut do not fit neatly into envelopes. In elementary school I heard more and more about people in need and I wanted to help. I wanted to be offered the opportunity to make a difference in the world. When those opportunities presented themselves, they needed to be as real as possible in order to touch my heart and move me to action. That motivation is central to the work of The Timmy Foundation. We hope to inspire young people to change the world for the better, and they are certainly meeting our expectations. Our young volunteers have made great contributions to help others in many locations within the United States and abroad. Their compassion is inspirational to all of us. We also have a great group of adults who mentor our young people and encourage their social outreach. We at The Timmy Foundation are fully aware that we cannot reach all of the children who are in need throughout the world, but we know, too, as Mother Teresa said, “It is not my job to be successful, it is my job to be faithful.” We hope to create a ripple effect, setting off a wave of compassion that will sweep across the planet and touch everyone in such a way that they, too, begin to do good works to help others in need and discover that, in fact, healing is a mutual experience.


Charles J. Dietzen, M.D. — Founder & President, The Timmy Foundation
Lesson 1: Case Study - Jamison - Haiti

Model Medical Inquiry: Evaluation, Assessment, and Treatment Plan

Guided Medical Science Inquiry:

Medical Evaluation:

History and Physical Exam

Student Consultation Teams:

Medical Vocabulary, Epidemiology, Geography, Economics, and Culture

Medical Assessment & Confirmation

Consultation Teams: Research Disease and/or Condition

Student Consultation Teams Treatment Plan: Hygiene, Vaccinations, Nutrition, Medical Treatment, Surgical Treatment

Model Surgical Procedures

Lesson 2: Small Group Case Studies

Model Medical Inquiry: Evaluation, Assessment, and Treatment Plan

Medical Evaluation

History and Physical Exam

Medical Vocabulary, Epidemiology, Geography, Economics, and Culture

Medical Assessment & Confirmation

Consultation Teams: Research Disease and/or Condition

Student Consultation Teams Treatment Plan: Hygiene, Vaccinations, Nutrition, Medical Treatment, Surgical Treatment

Lesson 3: People Like You Making a Difference!

Student Service Project
Unit objectives:

Students will

- Explain how scientific knowledge can be used to guide decisions on environmental and social issues.
- Recognize that their explanations must be based both on their data and other known information from investigations of others.
- Understand the characteristics and uses of various sources of scientific information and the evaluation of scientific information, claims, and arguments.
- Recognize the social, cultural, and ethical aspects of science, engineering, and technology.
- Understand and use medical vocabulary and terminology.
- Extract important medical history from a provided clinical narrative.
- Determine significant information from a narrative of a physical exam.
- Analyze and put into their own words information from a medical Evaluation.
- Work in small Consultation Teams to learn information and share it with the class.
- Research the climate and diseases endemic to the region.
- Research the cultural and socioeconomic factors of the region.
- Investigate long-term and public health issues of the region.
- Report to the class information collected during research.
- Come to a consensus on a medical assessment of the child’s condition.
- Outline a treatment plan for the child.
- Clearly present case findings to the class.
Indiana Academic Standards

Science — Biology: B.1.17, B.1.20

Language Arts: 9.1.3, 9.2.3, 9.4.4, 9.4.6, 9.7.16, 10.1.3, 10.4.4, 10.5.6, 10.7.15, 11.1.2, 11.4.7, 11.5.7, 11.7.16, 12.1.2, 12.4.7, 12.5.7

Social Studies — World Geography: WG.2.2, WG.4.7

Vocabulary Important to Project

<table>
<thead>
<tr>
<th>Abdomen</th>
<th>Allergy</th>
<th>Respiratory rate</th>
</tr>
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<tr>
<td>Bladder</td>
<td>Blood pressure</td>
<td>Scoliosis</td>
</tr>
<tr>
<td>Bowel sounds</td>
<td>Breech presentation</td>
<td>Retraction</td>
</tr>
<tr>
<td>Cardiovascular accident (CVA)</td>
<td>Caries</td>
<td>Spastic gait</td>
</tr>
<tr>
<td>Clear to auscultation (CTA)</td>
<td>Clinic</td>
<td>Systolic ejection murmur</td>
</tr>
<tr>
<td>Clubbing</td>
<td>Contracture</td>
<td>System</td>
</tr>
<tr>
<td>Cyanosis</td>
<td>Dentition</td>
<td>Tachycardia</td>
</tr>
<tr>
<td>Disability</td>
<td>Edema</td>
<td>Temperature</td>
</tr>
<tr>
<td>Erythema</td>
<td>Flocculant</td>
<td>Vertebral</td>
</tr>
<tr>
<td>Heart rate</td>
<td>Hemiparesis</td>
<td>Trauma</td>
</tr>
<tr>
<td>Infection</td>
<td>Lymphadenopathy</td>
<td>Vitals</td>
</tr>
<tr>
<td>Lymphatic</td>
<td>Malnourished</td>
<td></td>
</tr>
<tr>
<td>Mass</td>
<td>Midwife</td>
<td></td>
</tr>
<tr>
<td>Muscle stretch reflex</td>
<td>Neurological</td>
<td></td>
</tr>
<tr>
<td>Palpate</td>
<td>Paravertebral</td>
<td></td>
</tr>
<tr>
<td>Perfusion</td>
<td>Potable</td>
<td></td>
</tr>
</tbody>
</table>
Lesson 1

In this lesson students meet a young girl named Maria who lives in the mountains of Guatemala. Students will work in consultation teams to investigate her history and environment, assess her medical condition, and recommend a possible treatment plan. The case study includes clinical information. Clinical medicine is the hands-on encounter between a patient and a health care provider. The case study narratives do not contain X-rays, laboratory reports, or follow-up tests like those that are typically ordered in the United States. In this lesson the students are modeling a health care worker solving a medical problem. This lesson is intended to provide students with experiences and skills to use in future case studies in Medical Explorer and in the real world. The best science is that which we experience and put to use in our daily lives.

Investigation Questions

- Where does Maria live?
- What is her culture? Language? Customs?
- What is the environment and climate of the Guatemalan highlands?
- What types of diseases are found in her area?
- What factors impact Maria’s hygiene and diet?
- Is potable water available in the area?
- How does her family make a living?
- What factors have shaped the history of Guatemala?

Student Case Study Narrative – Maria

Maria is a 12-year-old girl from a village in the highlands of Guatemala. She came to the clinic today with weakness in the left side of her body. She walks with a limp. Her left foot points in. On occasion she will trip. It appears that her left arm is affected more than her leg. Her mother also reports that Maria has trouble seeing things placed to her left and that she has been like this since birth. Mother reports that the delivery was very difficult. The midwife told her she had a “breech presentation.”
**History**
Allergies: peanuts — rash, breathing difficulty one time
Surgeries: none
Illnesses: history of upper respiratory infections. She was treated with herbs. Traditional remedies are used by most of the villagers.
Medications: none

**Family Medical History**
Father is blind in his left eye due to trauma. Maria’s 5-year-old brother, Juan, is also weak on the left side of his body. He reportedly does not have any visual problems. Mother often feels very weak as she is still nursing her youngest child. The rest of the family is malnourished but otherwise healthy.

**Social History**
Maria does not attend school due to her disability. Her parents are interested in having her attend a special education school but they cannot afford it. Her father is a general laborer in the village and makes $2 or $3 on a good day. Her mother is busy caring for the family’s seven children. The children range in age from 1 to 12. It is unlikely that Maria will get married and leave home because of her disability.

**Review of Systems (ROS)**
Maria is often short of breath while running. She has pain in her left lower back. She denies any bladder infections. On occasion she has slurred speech.

**Physical Exam**
Vitals: Respiratory rate 20, heart rate 110, blood pressure 110/70, temperature 98.6
General: Maria is small for her age.
Skin and Lymphatic: There is a patch on the scalp where there is no hair. It measures 1 centimeter in diameter. No flocculants, discharge, or erythema. No lymphadenopathy palpated.
HEENT (Head, eyes, ears, nose, throat): poor dentition, multiple caries, left visual field cut.
Neck: Normal
Chest: Symmetrical, CTA (clear to auscultation), no retractions
Cardiovascular (CV): Tachycardia with 1/6 systolic ejection murmur. Good perfusion of extremities.
Abdomen: Soft and nontender with positive bowel sounds, no mass.
Back and Extremities: No vertebral or paravertebral tenderness, slight scoliosis.
   Contractures of left shoulder, elbow, hip and knee. No clubbing, cyanosis or edema of extremities.
Neurological: Left hemiparesis with increased muscle stretch reflexes on left. Left visual field cut. Normal sensation throughout the body. Spastic gait noted.

**Procedure (Whole class activity)**

Students follow specific steps to investigate and evaluate Maria’s condition. The steps lead toward determining a diagnosis and treatment plan for Maria utilizing aspects such as Maria’s medical history and physical examination. Students read and study the provided medical evaluation narrative that describes Maria and her condition. Consultation Teams will be formed to complete the investigation.

The project includes:
- A medical evaluation,
- Research project of selected topics about the subject’s region and epidemiology,
- A medical assessment,
- Outlined treatment plan.

**Project Steps**

A. Case Study Narrative

B. Consultation Team – Research Tasks

C. Consultation Team – Present Research

D. Medical Assessment

E. Additional Consultation Team Research

F. Outline Treatment

**Medical Evaluation: History and Physical Examination**

A medical evaluation includes four components; History, Physical Examination, Assessment and Treatment Plan. This medical evaluation follows a traditional approach that health practitioners use to evaluate a patient. In this section of the lesson students review the history and physical exam of the case study.

**History** – The goal of taking the patient’s history is to list all past factors of illness, family members, diseases and the general background of the subject. In addition, information about the current condition of body systems such as musculoskeletal, circulatory, neurological, pulmonary, digestive, lymphatic, etc should be noted. Read aloud the history of the subject. Discuss with the class what is known or significant. Record notes in the science journal.
Physical Examination – Trained health care providers follow a specific path when examining a patient. The material in the physical exam is presented in the actual medical vocabulary and recording protocols used in medicine. Students will work together to decipher and understand the physical exam. Much of the information used in the physical examination refers to Latin and Greek medical and anatomical vocabulary. Work with the class to underline, highlight, or list on the chalkboard or dry erase board all medical vocabulary or phrases that are unknown.

Part B. Consultation Team – Research Tasks (Divided among class members)

Geography – Determine the location of the country where Maria lives. Prepare an audio-visual presentation or poster of the geography and climate of the area.

History – research the history of Maria’s country and prepare a report, audio-visual presentation, or poster that identifies political and historical factors that impact the area. Construct a timeline that identifies important events.

Socioeconomic Factors – Research the socioeconomic factors of Maria’s country. Prepare a report, audio-visual presentation, or poster that identifies political and economical factors that impact the area. Students construct a timeline that identifies important events.

Culture, Religion and Language – Research the culture, language and religion of the area. Use posters, audio-visual presentation, dioramas or other products to illustrate their research. Determine if there are subcultures or dialects that are unique to Maria’s village.

Epidemiology – The last Consultation Team researches known diseases found in the region. This is an important task because it will define the direction of the remainder of the investigation. Focus on listing as many diseases as possible. Students prepare a report, audio-visual presentation, or a poster to list and explain diseases found in the area. Also, students should investigate possible trauma, prenatal infections and difficulty in delivery.

Topics should include the following: Malaria, Tetanus, Human Immunodeficiency Virus (HIV), Tuberculosis (TB), Difficult Delivery, Trauma, Prenatal Infections – Cytomegalovirus (CMV), rubella, and meningitis,
The World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC) are two resources that provide information about international diseases.

**Part C. Consultation Team – Present Findings**

Once students have completed their research, they should prepare for a class presentation. Each group should present its materials and take questions from the class. Direct the discussion. Focus on any areas or facts that are related among the teams such as: geography, climate, epidemiology, and information found in the physical exam. Students may need to redirect their research to cover new areas presented. The goal of this section of the lesson is to find information to make an accurate assessment of the case study.

**Part D. Medical Evaluation: Assessment**

Assessing the correct disease or condition of the patient is critical. Students use the information gathered in parts A, B and C to make a diagnosis of the possible disease or condition affecting Maria. Students should suggest two or three different diagnoses for Maria. The class must come to consensus on Maria’s assessment.

**Part E. Medical Evaluation: Treatment Plan**

Students need to revisit the disease with which Maria has been diagnosed. You should aim to become "mini-experts" in order to provide an effective treatment plan. Students are expected to provide a treatment plan that fosters improvement and healing for Maria. The following is a list of the general treatment areas that can be addressed.

**Treatment Plans**

**Education and Public Health** – Students can outline and suggest preventative measures that can be taken to remove, reduce, or eliminate risk factors. It is important that educational treatment plans take into consideration cultural factors, customs, and local resources. In addition, most successful educational plans contain retraining opportunities and on-going assessment. Areas that may be included in any general education treatment are diet, hygiene, safe living conditions, effective sanitation, and clean water.

**Nutrition** – A treatment plan that focuses on good nutrition may be overlooked or ignored. It can be the most productive treatment plan. All other treatments depend upon good nutrition to allow the body to heal. Without good nutrition and clean water, a patient can easily relapse. Students research the sources of food and clean water available to the subject. A
A good nutrition plan must take into account accepted customs and cultural factors. Students consult with dieticians on-line or locally to develop a nutrition plan to fit the needs of the patient. This part of the treatment plan must be coordinated with “Education and Public Health” because of the overlapping issues of clean water and effective sanitation.

**Medicine** – Many diseases found outside of the United States can be eradicated with medicines easily obtainable from our local hospitals. Students should investigate the types of medicines used to combat the disease. They should learn the treatment protocols, dosages, side effects, and other factors of the medicine. The costs and availability of drugs vary considerably from country to country. Students must research what these costs would be in the home country and abroad. They should also learn what factors are needed to insure that the drug will be most effective in treating the disease. In addition, students should be aware of health literacy in regards to adherence over time and actual consumption of the drug.

**Equipment** – Many injuries or diseases cause drastic changes in the quality of life of the patient. In the United States medical equipment is used to compensate for an injury or condition. Wheelchairs, crutches, eye glasses, prosthetic limbs and other equipment are common place in our communities. This same equipment may be an integral part of a treatment plan. Students should research various types of equipment that would help with the disease. A complete report includes the cost, care, maintenance, and availability of the medical equipment. Students should research the cost of equipment both in the United States and the country studied. In addition, students will need to have a outline or lesson plan on how to teach patients how to use the equipment.

**Surgery** – Injuries and diseases often result in the need for surgery or a variety of surgeries. Students research any surgical procedures that are needed to stop, slow or reduce the spread of the disease. Often multiple surgeries are needed to make corrective repairs to tissues, organs or systems damaged by the initial disease. Research surgical procedures needed for the disease. Review these with trained medical staff either on-line or from local sources. The Timmy Foundation is a resource to locate medical staff.
Once the class has reviewed the different types of treatments they should suggest a
treatment plan(s) for Maria. Again, students research the specific treatments that are
needed for the assessment made. A multi-treatment plan may be suggested.

On-line Resources

- CalTech Precollege Science Initiative: Human Body Under Attack
  http://www.capsi.caltech.edu/
- Centers for Disease Control and Prevention http://www.cdc.gov/
- Children’s Museum of Indianapolis — Agricultural Biotechnology Unit of Study, Genetics and
  Cell Biology
- Global Polio Eradication http://www.polioeradication.org
- Indiana AHEC Program — Student Resources on Health Careers
  http://www.ahec.iupui.edu/studentresources/default.htm
- MedLine Plus: Health Topics
- MedLine Plus: Medical Encyclopedia
- MedLine Plus: Medical Dictionary
- Museum of Science & Industry: Live . . . From the Heart
  http://www.msichicago.org/ed/educ_liveheart.html
- National Academies Press  www.nap.edu
- National Institutes of Health Curriculum Supplements — High School
  http://science.education.nih.gov/customers.nsf/highschool.htm
- National Institutes of Health Curriculum Supplements — Middle School
  http://science.education.nih.gov/customers.nsf/middleschool.htm
- National Heart, Lung, and Blood Institute — Diseases and Conditions Index
- Science, Medicine, and Animals: Teacher’s Guide
  http://orsted.nap.edu/books/0309101174/html
- The Timmy Foundation  http://www.timmyfoundation.org
- United States Department of State — International Travel Information
- WISE: Web-Based Inquiry Science Environment  http://wise.berkeley.edu/
- World Health Organization  http://www.who.int/en/
Student Case Study

Physical Exam Translation Form – Maria

Write an explanation in your own words of what is covered in the Physical Exam. Use this form to write an assessment and treatment plan for the case study.

Person Completing Form: _____________________________
Date: _______________ School: ___________________ Grade: _______
______________________ (patient’s name) ________________ (patient’s residence)

Physical Examination (use more space if needed)
General

Skin and Lymphatics

Head, Eyes, Ears, Nose and Throat

Neck

Chest

Cardiovascular

Abdomen

Back & Extremities

Neurological

Assessment
“Maria is a ____ year old girl who has _____________________________.”

Treatment Plan (use more space if needed)

Education

Medicine

Equipment

Surgery

Nutrition

Socioeconomical Issues
**Note for the teacher:**
Jamison’s condition is an open fracture with osteomyelitis. Jamison had trauma from a motor vehicle accident that caused his tibia to break through the skin. This had never been treated over a 2 1/2 year period, resulting in osteomyelitis, infection within the bone.

Allow enough time for all Consultation Teams to research and complete their tasks as well as for teacher review of their work. Student materials are presented in written reports, audiovisual presentations, posters, and/or oral presentations to the class.

**Consultation Team — Present Findings**

Once students have completed their research, they should prepare a class presentation. Each group should present its materials and take questions from the class. Direct the discussion. Focus on any areas or facts that are related among the teams such as: geography, climate, epidemiology, and help students to connect that information to details found in the physical exam. Students may need to redirect their research to address aspects of the physical exam. The goal of this part of the lesson is to find information and correlate details to make an accurate assessment of the case study.
Lesson 2

Case Study Narratives (Small Group Project)

In Lesson 1 students participated in a guided medical investigation of Maria and Juan to determine their medical conditions and treatment plans. In this lesson, students follow the same medical investigation steps to complete new case studies. The case studies are based on experiences from The Timmy Foundation’s international partners. Each case study represents a specific disease or condition endemic to the region. The clinical information in each case study narrative represents a typical patient. Students work in Consultation Teams to complete the investigations.

*This is Science. Don’t take my word for it. Try it yourself!* — Rick Crosslin, Teacher

Case Study Narratives

Six different medical cases are presented. Each one starts with a Student Case Study Narrative containing the clinical history and physical exam of the patient. The second handout is the Student Case Study Physical Exam Translation Form that students use to complete the medical evaluation, assessment, and treatment on selected patients. The third handout is the Teacher Key Physical Exam Translation Form that contains the assessments for all six of the case study patients.
<table>
<thead>
<tr>
<th>Medical Vocabulary Important to Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdomen</td>
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<tr>
<td>Allergy</td>
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<tr>
<td>Bladder</td>
</tr>
<tr>
<td>Bounding</td>
</tr>
<tr>
<td>Breech presentation</td>
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<tr>
<td>Cachectic (CVA)</td>
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<tr>
<td>Caries</td>
</tr>
<tr>
<td>Clinical</td>
</tr>
<tr>
<td>Contracture</td>
</tr>
<tr>
<td>Cyanosis</td>
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<tr>
<td>Disability</td>
</tr>
<tr>
<td>Distress</td>
</tr>
<tr>
<td>Edema</td>
</tr>
<tr>
<td>Excoriation</td>
</tr>
<tr>
<td>Fever</td>
</tr>
<tr>
<td>Flex</td>
</tr>
<tr>
<td>Gastrocnemius</td>
</tr>
<tr>
<td>Hamstring</td>
</tr>
<tr>
<td>Heart rate</td>
</tr>
<tr>
<td>Holosystolic murmur</td>
</tr>
<tr>
<td>Human immunodeficiency virus (HIV)</td>
</tr>
<tr>
<td>Immunization</td>
</tr>
<tr>
<td>Jugular vein</td>
</tr>
</tbody>
</table>
Liver        Lymph node
Lymphadenopathy        Lymphatic
Malaria        Malnourished
Mass        Midwife
Muscle stretch reflex        Neurological
Normocephalic        Organomegaly
Palpate        Paravertebral
Penicillin        Percussion
Perfusion        Pitting edema
Planter        Potable
Purulent        Rales
Rehabilitation        Respiratory rate
Retraction        Rhinorrhea
Scoliosis        Sickle-cell anemia
Spastic gait        Sputum
Sternal        Suprapubic
System        Systolic ejection murmur
Tachycardia        Temperature
Trauma        Tuberculosis
Upper respiratory infection        Urinary tract infection (UTI)
Vaccination        Vertebral
Vitals
**Student Note**

The following abbreviations are often used by health care givers. They are used in prescribing medicines. You may benefit from understanding the following:

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Latin</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q. D.</td>
<td></td>
<td>Every day</td>
</tr>
<tr>
<td>Q. O. D.</td>
<td></td>
<td>Every other day</td>
</tr>
<tr>
<td>B. I. D.</td>
<td></td>
<td>Twice a day</td>
</tr>
<tr>
<td>T. I. D.</td>
<td></td>
<td>Three times a day</td>
</tr>
<tr>
<td>Q. I. D.</td>
<td></td>
<td>Four times a day</td>
</tr>
<tr>
<td>Q. 8 hrs.</td>
<td></td>
<td>Every 8 hours</td>
</tr>
<tr>
<td>P. O.</td>
<td>per ous</td>
<td>By mouth</td>
</tr>
<tr>
<td>I. V.</td>
<td>inter venues</td>
<td>In vein</td>
</tr>
<tr>
<td>I. M.</td>
<td>inter muscular</td>
<td>In muscle</td>
</tr>
<tr>
<td></td>
<td>per</td>
<td>Through</td>
</tr>
<tr>
<td>A. M.</td>
<td>ante meridian</td>
<td>Before middle</td>
</tr>
<tr>
<td>P. M.</td>
<td>post meridian</td>
<td>After middle</td>
</tr>
<tr>
<td>A.</td>
<td>ante</td>
<td>Before</td>
</tr>
<tr>
<td>P.</td>
<td>post</td>
<td>Past</td>
</tr>
</tbody>
</table>
For each case students groups will:

A. Analyze a case study narrative
   a. History
   b. Physical Exam

B. Research
   a. Medical Vocabulary
   b. Geography
   c. Socioeconomic History
   d. Epidemiology

C. Medical Assessment
   a. Confirm with “Teacher Key Physical Exam Translation Form”
   b. Group consensus for assessment

D. Additional Consultation Team Research
   a. Research disease or condition from assessment
   b. Consult local health care providers

E. Outline Treatment
   a. Presents treatment options: Hygiene, Vaccination, Nutrition, Medical Treatment, Surgical Treatment
   b. Confirm plan with “Teacher Key Physical Exam Translation Form”
   c. Consult local health care providers

Present Findings – Case Report

Once groups complete the research they should word process a case report using the outline format utilized in lesson 1. Your report (group or individual) should address the information concerning your patient in each area outlined above. These reports will be considered part of your regular nine weeks grade.
Time
Five to 10 class periods

Investigation Questions

• Where does the child live?
• What are the customs of his or her culture? What language does he or she speak?
• Describe the geography and climate of the area where the child lives.
• What types of diseases are found in this area?
• What factors affect the child’s hygiene and diet?
• Is potable water available in the area?
• How does the child’s family make a living?
• What factors have shaped the history of the area where the child lives?

Indiana’s Academic Standards

Science — Biology: B.1.17, B.1.20

Language Arts: 9.1.3, 9.2.3, 9.4.4, 9.4.6, 9.7.16, 10.1.3, 10.4.4, 10.5.6, 10.7.15, 11.1.2, 11.4.7, 11.5.7, 11.7.16, 12.1.2, 12.4.7, 12.5.7,

Social Studies — World Geography: WG.2.2, WG.4.7
Student Form

Physical Exam Translation Form
Students write in their own words an explanation of what is covered in the Physical Exam. Students will use this form to write their Assessment and Treatment plan for the case study.

Person Completing Form: ______________________________________
Date: _______________ School: _____________________ Grade: _______
Case Study Patient’s Name: __________________________________
Patient’s Residence: __________________________________________

Physical Examination
General

Skin and Lymphatic

Head, Eyes, Ears and Throat

Neck

Chest

Cardiovascular

Abdomen

Back & Extremities

Neurological

Assessment “__________ is a ___ year old ____ who has __________________________.”

Treatment Plan (use more space if needed)
Education

Medicine

Equipment

Surgery

Nutrition

Socioeconomical Issues
Medical Explorer  
Assessment and Scoring Rubric

This rubric provides a framework for evaluating student’s performance in completing medical evaluations from the case studies. The lessons will be evaluated on the student’s ability to research, create reports, investigate and present finding on subjects presented in case studies. The following criteria will be used.

Students demonstrate the ability to:
- read and study the case history of a child,
- understand medical vocabulary and terminology,
- determine a child’s medical history from a provided narrative,
- determine a child’s physical exam from a provided narrative,
- complete a Medical Evaluation form on the child,
- work in small Consultation Teams to learn information and share with the class,
- provide detailed reports about the region where the child lives,
- research the climate and diseases endemic to the region,
- research culture and socioeconomic characteristics of the region,
- report to the class information collected during research,
- come to a consensus on a medical assessment of child’s condition,
- research selected diseases or medical conditions,
- research selected treatment plans for the child,
- come to consensus on a treatment plan for the child.

Scoring Rubric  
Teachers work with students and Consultation Teams to evaluate and score their ability to complete medical evaluations in this project. Teachers can create or modify the following rubric as needed. Several student products are created in this project – posters, reports, oral presentations, medical evaluation forms, timelines, articles and real service projects. Student progress can be identified at three distinct levels: partial, essential and exceptional.

Partial:
- Completes medical evaluation for Maria and Juan,
- Records minimal observations in science journal,
- Does not demonstrate understanding of the medical evaluation process,
- Contributes little to the Consultation Team process,
- Little or no detailed information provided in Consultation Team presentations,
- Incomplete or missing information on additional case study medical evaluations,
Essential:
- Generates completed medical evaluations for Maria and Juan,
- Makes good observations, records and notes in science journal,
- Demonstrates a good understanding of the medical evaluation process,
- Makes many contributions to the Consultation Team process,
- Provided detailed information in Consultation Team presentations,

Exceptional:
- Completed and added information in the medical evaluations for Maria and Juan,
- Generated numerous observations, records and discoveries in science journal,
- Demonstrated exceptional understanding of the medical evaluation process,
- Demonstrated leadership and provided essential materials to Consultation Team,
- Informative and creative Consultation Team presentations,
Student Case Study Narrative
Jamison: A Young Haitian Man

History: Jamison is a 6-year-old Haitian boy who came to the clinic at Haitian Academy. He reports that he had injured his leg in a “tap-tap” bus accident 2 1/2 years earlier. He had been unable to walk on the injured leg for several months and noticed that the skin broke open where he presumed he had fractured his leg. Since that time he has had a lot of purulent drainage from the wound. He spikes fevers on occasion and at times is delirious with these fevers. He reports that he is very ill during these times but usually recovers. He is now able to bear weight on the leg but it is significantly deformed.

Past Medical History:
• Allergies: No known allergies.
• Surgeries: No history of surgery.
• Medical: Jamison reports that he has had no immunizations. He does have a fever on occasion but reports no headaches.
• Medications: None.

Family History: None provided.

Social History: Jamison lives in a rural area. His family members are subsistence farmers. They live in the lowlands of Haiti. Jamison had worked in the past as a sugar cane cutter. He reports they have no water within the home. They typically buy filtered water. He has limited ability to bathe.

Review of Systems (ROS): Jamison has never attended school. He had no developmental problems as a child. He has been healthy other than the leg.
**Physical Examination**

**General:** Jamison is cachectic. He presently is in no acute distress. He answers questions appropriately.

**Skin and lymphatics:** Skin is clear with the exception of a large lesion over the right tibia. There presently is no drainage of pus. He has swollen lymph nodes in the right groin area and some in the left.

**HEENT:** Normocephalic without lesions. Eyes — pupils equally round and reactive to light with extraocular muscles intact. Ears, nose, throat — clear. He has multiple dental caries.

**Neck:** Supple without mass or goiter. No lymphadenopathy or jugular vein distention. No bruit auscultated.

**Chest:** Symmetrical without retraction. Clear to auscultation bilaterally.

**Cardiovascular:** Tachycardia without murmur or gallop. Pulses are full and bounding bilaterally.

**Abdomen:** Soft, nontender, with positive bowel sounds. No mass or organomegaly appreciated.

**Back and extremities:** No vertebral or paravertebral tenderness on palpation. No CVA tenderness on percussion. No clubbing, cyanosis, or edema of extremities with the exception of the right foot, which has a moderate amount of swelling at this time. He had a negative Homans’ sign bilaterally. He reports normal sensation in the right foot. Presently the leg is not tender. There is no significant erythema.

**Neurological:** Jamison is alert and oriented. Cranial nerve examination revealed no abnormality. Muscle stretch reflexes were normal with the exception of the right lower extremity. He had limited muscle stretch reflex at the knee. He reports decreased sensation over the foot at this time, particularly between the large toe and second toe. He had limited ability to plantar flex and dorsiflex the foot. He has difficulty also with extension of the right knee. Otherwise, Jamison has normal strength and sensation throughout.
Student Case Study Narrative
Lucia: A Haitian Girl in the Dominican Republic

**History:** Lucia is a 12-year-old Haitian girl who lives in the Dominican Republic. She was seen at the Crossroads Clinic. She came from approximately 12 miles away to be evaluated. She had to be carried part of the time due to shortness of breath. Lucia indicates that she often has swelling of her ankles and will cough with difficulty breathing. She cannot keep up with her peers.

**Past Medical History:**
- **Allergies:** No known allergies.
- **Surgeries:** No history of surgery.
- **Medical:** Lucia has had difficulty with breathing and swelling of the legs. She reports that she has had upper respiratory infections in the past. She does not believe she has malaria.
- **Medications:** None.

**Family History:** Lucia’s mother has malaria. Her grandfather reportedly is being treated for HIV and tuberculosis.

**Social History:** Lucia lives in a shack on an exposed landfill. She typically gets her food from items that have been thrown into the waste by people from the nearby city. Lucia and her family live in the lowlands. There is significant heat and humidity in the area. She has very poor hygiene and little or no water. In fact, often they try to catch rain water as delivery of water by truck is often unreliable. She has had no access to education. Her brother works as an indentured servant for a sugar cane plantation owner. His is the only income for the family. He makes less than one U.S. dollar a day.

**Review of Systems:** Lucia reports she often gets short of breath when walking up the mountain. She has had a cough but no sputum. She does note swelling of her ankles on occasion. She does not recall any time as a child when her joints caused her problems.
Physical Examination:
General: Lucia is very small for her age. She is short in stature and extremely thin.

Skin and lymphatics: Skin is clear without evidence of breakdown. No lymphadenopathy palpated.

HEENT: Normocephalic without lesions. Eyes — pupils equally round and reactive to light with extraocular muscles intact. Ears, nose, throat — there is discharge from the left ear. She also has rhinorrhea.

Neck: Supple without mass or goiter. No lymphadenopathy or jugular vein distention. No bruit auscultated.

Chest: Symmetrical without retraction. She does have rales at the bases bilaterally.

Cardiovascular: Extreme tachycardia with a 3/6 systolic ejection murmur heard best at the upper left sternal border radiating up to the neck.

Abdomen: Soft, nontender, with positive bowel sounds. The liver is 3 cm below the right costal margin.

Back and extremities: No vertebral or paravertebral tenderness on palpation. No CVA tenderness on percussion. No cyanosis of extremities at this time. She does have pitting edema of the lower extremities and clubbing of the fingers.

Neurological: Lucia is alert and oriented. Cranial nerve examination revealed no abnormality. Muscle stretch reflexes were normal. Lucia has normal strength and sensation throughout.
Student Case Study Narrative
Luis: A Little Boy Living in Urban Ecuador

History: Luis is 5 years old. He came to the Tierra Nueva Clinic at a local elementary school. Luis’s father asked if we had any medicine for leg pain and cough. He reports that Luis cannot keep up with the other children and often is coughing. He is unable to run for long before he has to squat down. He has had no history of infection. His father indicates that he has been told that Luis has heart disease, but he cannot afford the surgery as it costs five times what he makes in a year and he has four other children to feed.

Past Medical History:
- Allergies: No history of allergies.
- Surgeries: No history of surgery.
- Medical: As above.
- Medications: None.

Family History: No history of heart disease in the rest of the family. No one has malaria although there is an aunt who lives in the lowlands in the forest who has a history of malaria. Luis has visited here in the past.

Social History: Luis lives in an apartment in the city in South Quito. His parents work in the market. They make only $900 a year. Luis seldom goes out of the home as he is not able to keep up with the other children and will get in distress. Quito is at 9600 feet above sea level. There is a significant amount of pollution in the city. Luis does attend school when he is feeling well. They are able to get limited bottled water from the local shop although this is very limited. Luis’s nutrition is significantly limited also.

Review of Systems: Luis has had problems eating. He has always been much smaller than other children his age. His older brother and sister look after him as he will often have to be carried up steep cliffs as this causes a significant amount of leg pain and shortness of breath. He has had a fever recently but has only minimal upper respiratory infection symptoms at this point.
Physical Examination:
General: Luis is very small for his age. He appears to be only 2 years old although he is 5 years old.

Skin/Lymphatics: Skin is clear without evidence of breakdown. No lymphadenopathy palpated.

HEENT: Normocephalic without lesion. Eyes – pupils equally round and reactive to light with extraocular muscles intact. Ears, nose, throat – normal.

Neck: Supple without mass or thyromegaly. No lymphadenopathy or jugular vein distention. No bruit auscultated.

Chest: Symmetrical without retraction. He does have some coarse upper respiratory breath sounds and decreased aeration in the bases of the lungs.

Cardiovascular: Tachycardic with a 3/6 holosystolic murmur. A thrill was appreciated over the chest. Pulses are bounding bilaterally.
Abdomen: Soft, nontender, with positive bowel sounds. The liver was 2 cm below the right costal margin.

Back/Extremities: No vertebral or paravertebral tenderness on palpation. No CVA tenderness on percussion. No clubbing, cyanosis, or edema of the extremities.

Neurological: Luis is alert and oriented x3. Cranial nerve examination revealed no abnormality. Muscle stretch reflexes were normal. Luis has normal strength and sensation throughout.
Student Case Study Narrative
Juanita: A Girl from Honduras

History: Juanita is a 12-year-old girl who came to the clinic at the Sociedad Amigos De Los Niños. She lives in a hut near the sugar cane fields. She has a history of shortness of breath, particularly when they are burning the sugar cane. She reports that she often has coughing episodes and on occasion coughs up a lot of mucus. On occasion she has fevers. She typically cannot keep up with the other children in the village because she gets very short of breath. She has not been seen by a doctor in the past.

Past Medical History:
- Allergies: No history of allergies.
- Surgeries: No history of surgery.
- Medical: As above.
- Medications: None.

Family History: None provided.

Social History: Juanita lives in a mountainous region but her home is located in a valley near some sugar cane fields. She drinks bottled water from the nearby mission. There is limited air pollution with the exception of the burning of the sugar cane fields. Although Juanita is 12 years old she is in Grade 3. She is behind in school because she has taken care of her younger sister since the death of their mother.

Review of Systems: Juanita reports no pain in the joints. She experiences shortness of breath only during the rainy season. She is able to climb the mountains on occasion but is sometimes limited by her shortness of breath.
**Physical Examination:**

**General:** Juanita is very small for her age. She is very thin.

**Skin and lymphatics:** There is a circular hyperpigmented lesion over the right cheek. This measures approximately 2.5 cm in diameter. No lymphadenopathy was palpated.

**HEENT:** Normocephalic without lesions. Eyes — pupils equally round and reactive to light with extraocular muscles intact. Ears, nose, throat — the tonsils are enlarged.

**Neck:** Supple without mass or goiter. Lymphadenopathy is present. There is no jugular vein distention. No bruit auscultated.

**Chest:** Symmetrical retractions at this time. There is an end expiratory wheeze.

**Cardiovascular:** Tachycardia without murmur or gallop. Pulses equal bilaterally.

**Abdomen:** Soft, nontender, with positive bowel sounds.

**Back/Extremities:** No vertebral or paravertebral tenderness on palpation. No CVA tenderness on percussion. No clubbing, cyanosis, or edema of the extremities.

**Neurological:** Juanita is alert and oriented. Cranial nerve examination revealed no abnormality. Muscle stretch reflexes were normal. Juanita has normal strength and sensation throughout.
Student Case Study Narrative
Roberto: a Jamaican Toddler

**History:** Roberto is a 2-year-old Jamaican boy. He has been rather healthy. He recently was weaned and is now eating some solid foods. Roberto has been able to maintain his weight. His mother’s only concern today is the fact that he has an abnormal patch on his chest. He has been scratching this and it is now open and seems to be both painful and itchy.

**Past Medical History:**
- Allergies: No history of allergies.
- Surgeries: No history of surgery.
- Medical: Roberto had a difficult birth. He seems to be a bit weak on the right side, according to his mother.
- Medications: None.

**Family History:** Roberto’s brother also has a similar lesion but it is smaller and on his face.

**Social History:** Roberto lives with his extended family of 10 in a shack in a rural village. His brothers and father are subsistence farmers. They live in the highlands. It is a very humid area and there is limited opportunity to bathe. Roberto’s siblings are attending school.

**Review of Systems:** Roberto did not bear weight on the right arm initially. In recent months he has begun to bear weight on this arm. He had difficulty crawling and now is able to walk but his mother reports that he tends to turn the right leg in and does fall often.
Physical Examination:
General: Roberto is well developed, well nourished, and in no acute distress. He is very interactive and smiles often.

Skin and lymphatics: Skin is clear with the exception of the patch over the chest. This measures approximately 5 cm in diameter. There is significant erythema and a purulent discharge with some excoriations. No lymphadenopathy was palpated.

HEENT: Normocephalic without lesions. Eyes — Normal with the exception of a dysconjugate gaze. There is right exotropia. Ears, nose, throat — normal.

Neck: Supple without mass or goiter. There is no lymphadenopathy palpated. There is no jugular vein distention. No bruit auscultated.

Chest: Symmetrical without retraction. Clear to auscultation bilaterally. He does have the patch as mentioned above.

Cardiovascular: Normal without murmur or gallop. Pulses equal bilaterally.

Abdomen: Soft, nontender, with positive bowel sounds.

Back and extremities: Roberto has a minimal amount of scoliosis. He has a slight contracture of the right hamstring and gastroc. Roberto tends to internally rotate the right lower extremity when ambulating. The right arm pulls up into flexion.

Neurological: Roberto is alert and interactive. He is very pleasant. He is able to respond appropriately to questions and uses single word answers. Muscle stretch reflexes were increased throughout. He seems to have difficulty with the use of the right arm and leg but mobilizes rather well. He does not appear to have any word-finding problems nor does he have any evidence of a right visual field cut.
Student Case Study Narrative
Kirsten: An African American

History: Kirsten is a 12-year-old African American girl who has a history of sickle-cell anemia. She has had multiple crises in the past with a lot of abdominal pain, for which she has received treatment. Most recently her mother reports that she seemed to be having a crisis and was given some pain medicine after going to bed. The next morning she was noted to have weakness on the right side of the body. She also had difficulty with her speech. She was stabilized and then was to begin rehabilitation.

Past Medical History:
- Allergies: Penicillin — causing a rash.
- Surgeries: None.
- Medical: As above. She has had multiple crises in the past.
- Medications: Baby aspirin 1 per day. She is also on Bactrim b.i.d. for a urinary tract infection.

Family History: None provided. Her other siblings are reportedly healthy.

Social History: Kirsten lives at home with her mother, father, and maternal grandmother. Her brother and sister, ages 14 and 15, also live at home. Kirsten attends a local middle school and performs well academically. She is unable to participate in sports. She enjoys playing video games as well as playing the drums.

Review of Systems: Kirsten has a history of upper respiratory infections in the past. She has been healthy until this most recent event.
Physical Examination:
General: Kirsten is well developed and well nourished although she is a bit thin. She is in no acute distress.

Skin and lymphatics: Skin is clear without evidence of breakdown. No lymphadenopathy was palpated.

HEENT: Normocephalic without lesions. Eyes — she appears to have a right visual field cut. Ears, nose, throat — normal.

Neck: Supple without mass or goiter. There is no lymphadenopathy palpated. There is no jugular vein distention. No bruit auscultated.

Chest: Symmetrical without retraction. Clear to auscultation bilaterally.

Cardiovascular: Normal without murmur or gallop. Pulses equal bilaterally.

Abdomen: Soft, nontender, with positive bowel sounds. She has a bit of tenderness over the suprapubic area on palpation.

Back/Extremities: No vertebral or paravertebral tenderness on palpation. No CVA tenderness on percussion. No clubbing, cyanosis, or edema of the extremities.

Neurological: Kirsten is alert but has questionable orientation. She does not seem to understand our questions nor is she able to produce verbalizations. She appears to have a right visual field cut as mentioned above. The right arm and leg are flaccid with decreased muscle stretch reflexes. She has limited movement of the right arm and leg. She has some ability to abduct the right arm and to flex the right leg. Otherwise, she has a very dense right hemiparesis.
Student Case Study Narrative – Juan

Juan is a 7 year old boy from a village in the highlands of Guatemala. He came to the clinic today with weakness in the left side of his body. He walks with a limp. His left toe points in. It appears that the left leg is more affected than the arm. Juan’s mother first noted weakness on the left side when he was beginning to walk.

History
Past Medical History: History of upper respiratory infections in the past. He was treated with herbs.
Surgeries: none
Medical: none
Medications: none

Family History (Medical History of the family): Father is blind in eye left from trauma. Maria, Juan’s older sister, is also weak on the left side of her body. Mother often feels very weak as she is still nursing her youngest child. The rest of the family is malnourished, but otherwise healthy.

Social History: Juan does not attend school due to his disability. His parents are interested in his attending a special education school, but they cannot afford it. His father is a general laborer in the village and makes $2-3 on a good day. Juan’s mother is busy caring for the seven children in her family. The children range in age from one to twelve years. Juan lived in the rain forest with his mother as she cared for her mother for three months. Juan was a toddler at the time.

Review of Systems (ROS)
Juan is often short of breath while running. He has pain in left lower back. He also has a history of recurrent fevers.
Physical Exam
Vitals: Respiratory rate 16, heart rate 80, blood pressure 116/68, temperature 98.6
General: Juan is small for his age
Skin and Lymphatics: There is a patch on the face with excoriations. It measures 2 centimeters in diameter. No fluctuance, discharge or Arythema. no lymphadenopathy palpated.
HEENT (Head, eyes, ears, nose, throat): poor dentician, multiple caries. Eyes are icteric.
Neck: Normal
Chest: Symmetrical, CTA (clear to auscultation), no retractions
Cardiovascular (CV): Normal heart rate and rhythm. Good perfusion of extremities.
Abdomen: Soft non-tender with positive bowel sounds, no mass.
Back and Extremities: No vertebral or paravertebral tenderness. Contractures of left shoulder, elbow, hip and knee. No clubbing, cyanosis or edema of extremities.
Neurological: Left hemi paresis with increased muscle stretch reflexes on left. Normal sensation throughout the body. Spastic gait noted.
Lesson 3
People Like You Making a Difference!

The Timmy Foundation can assist students in finding volunteers that have completed service projects or those that have participated on international mission trips. Visit: www.timmyfoundation.org

International Service Trips
We enable volunteers to travel with us to strengthen the health and education initiatives of our international partners, such as Fundacion Tierra Nueva in Ecuador and the Clinic of the Haitian Academy in Haiti. These service trips are typically one week in length and are paid for by the volunteers themselves. Trip expenses (typically around $1,200 per person, everything included) are kept to a minimum by living in community with the people we serve. While most of our trips are centered on primary healthcare outreach, some trips include public health education, dental, construction, medical equipment maintenance, and child development projects. Non-medical volunteers can serve in our clinics in a variety of capacities: translation, triage, pharmacy assistance, fluoride station and by assisting health care providers.

Medical Ministry Details
Our ministry compound is located near the village of Sosua, on the north coast of the Dominican Republic, just east of Puerto Plata.
http://www.dominicancrossroads.com

What We Do: As a part of its mission to serve the poorest of the poor, Crossroads provides basic primary care and medical care referrals to the public hospital and public and private clinics in Montellano and Puerto Plata. As a result of the generosity of persons from throughout the world, Crossroads has established a one-room clinic in the village of Ascension. The clinic serves persons from Ascension and nearby bateyes and is the base for outreach missions to more distant poor barrios and bateyes on the North
Coast. Care is also provided to persons who seek help from Dr. Bob at his clinic in Sosua. These two sites allow Dr. Bob and Crossroads volunteers to provide follow-up care to acutely ill persons and those with serious chronic conditions.

**Why We Do It:** Haitians who live in the bateyes live on the edge of survival. Most are under nourished and vulnerable to infectious diseases and the premature onset of disabling chronic conditions. Although free care is provided at the public clinic and hospital, this care is extremely limited due to the poverty of the country and minimal resources allocated to the public health system. As a result, patients must pay for diagnostic tests, medicine and food. These costs, plus the cost of transportation to a clinic or the hospital, are impossible for Haitians who struggle just to provide a small daily ration of rice and beans for their families. Crossroads intercedes by providing basic primary care, filling prescriptions and covering the costs of diagnostic tests, surgeries and other treatments when financially possible to do so.

**How You Can Help:** Crossroad’s Medical Mission is exclusively a volunteer effort. We rely on contributions of medicine and monetary donations to support the Mission. Our most critical need is for financial support to pay for diagnostic tests, treatments and surgeries. We work closely with the public clinic and hospital to assure that needed treatments and medicine are provided. We also refer critical and complex cases to a private clinic in Puerto Plata. Physicians at both the public hospital and public and private clinics have been extremely supportive. However, the need and cost of surgeries and medicines always exceeds the limited funds contributed to the Medical Mission. As a result, much prayer and thought are given to the costs and benefits of the care needed by those whose seek our help.

**How You Can Serve:** Crossroads welcomes health professional and student volunteers to assist in its primary care clinic at Ascension and its medical care outreach missions. The Medical Mission is based on the principle of action in the context of prayerful reflection. Our desire is to treat those in the greatest need, recognizing that care decisions must take into account cultural factors and lack of access to the “high tech” medical resources that most volunteers are used to. For these reasons, we ask that groups with physicians and other licensed health care professionals work in close collaboration with a Crossroads staff member. This caring for the sickest individuals first is to assure that clinics are organized in such a way that appropriate triage be undertaken and that follow-up care can be provided. Medical, dental and nursing and other health professional students are required to work under the direct supervision of a Crossroads staff member.

**People Like You Making a Difference! – Student Tasks**
People like you make significant contributions around the world. There are many things young people can do to help others. Contact the volunteer coordinator at The Timmy Foundation for ideas, guidance or resources to make the projects real. Review the mission objectives and opportunities available with The Timmy Foundation – medical supply warehouse, funding outreach growth and international service trips. The following list contains suggestions for student service projects. The most important, and exciting endeavor are those they create. Share the list with your class. Students may want to work together or the class may want to participate in a joint project.

**Service Project  (Your project must involve 6+ hours of documented service)**

- Start a local Timmy Foundation Chapter
- Organize and run a fund raiser for non for profit charity
- Monitor and sustain a patient through the Timmy Foundation
- Create new “Case Study Narratives”
- Log volunteer hours at: Muncie Mission, A Better Way…. (with approval)
- Create your own service project  (Must submit and discuss with teacher ahead of time)
- Organize and run a community cleanup or restoration project

**Find your passion! People of all ages can make a difference and change the world. Lessons like these are lifelong. Your task is to take action a make a difference in the lives of others in need at the local or international level.**

Young people need to understand how powerful they are. – Charles Dietzen, MD

**In the space below concept map your ideas of how you are going to make a difference.**
Lesson 3
People Like You Making a Difference!

This objective of this lesson is to provide role models and inspiration to students to make a difference in the world. The lesson is divided into three parts. The first two sections provide background information about The Timmy Foundation and selected international partners. Students learn about the international partner organizations that the foundation supports. All of these organizations have two things in common: they seek to help others, and they exist because of committed volunteers. The last part of the lesson gives examples of ways students can get involved to make a difference. Students are presented with a list of service projects to support.

Never doubt that a small group of thoughtful, committed citizens can change the world. Indeed, it's the only thing that ever has. — Margaret Mead

Student Tasks

Direct students to find information about The Timmy Foundation at the Web site: http://www.timmyfoundation.org. Share the following excerpts from the foundation’s Web site. Assign each student or group a section of the material to present to the class. The Timmy Foundation can assist students in finding volunteers who have completed service projects or those who have participated on international mission trips.
The Timmy Foundation

Our Vision: A world in which basic health care and education are available to all children.

Our Mission: Building healthy futures worldwide, one child at a time. We accomplish this mission by strengthening community-based health and education initiatives and empowering young people to share their energy and compassion.

The Timmy Foundation partners include international nongovernmental organizations (NGO) that provide medical care to the underserved. The Timmy Foundation has established chapters in universities and high schools throughout the United States. In addition, The Timmy Foundation works with churches and other nonprofit organizations in the United States to improve the health of children at home and abroad.

The Timmy Foundation Mission Objectives:

• Strengthen community-based health and education initiatives
• Organize international service trips
• Collect and distribute appropriate medicines, medical equipment/supplies, and educational materials
• Provide funds for outreach opportunities
• Advocate for these initiatives and the people they serve
• Empower young people to share their energy and compassion
• Promote global awareness and involvement at schools and universities
• Create meaningful international service opportunities for student volunteers
• Encourage life-long commitments to service
Medical Supply Warehouse

Another way in which we support our international partners is by delivering important medicines and appropriate medical equipment and supplies. We coordinate with our partners to determine their material needs, then collect, organize, and ship accordingly. Some items are hand-carried by our volunteers, while larger items are shipped in crates or containers. Many of the durable goods (wheelchairs, shower chairs, etc.) we collect are distributed in the Indianapolis area to children and seniors in need. Other medical outreach organizations are welcome to shop our warehouse free of charge.

Funding for Outreach Growth

We seek funds to distribute to our international partners for the structural improvement of existing clinics and hospitals, for the general support of child development and education projects, and for the medical needs of impoverished children. For example, we provide monthly support to Quito’s Tierra Nueva hospital, enabling them to offer high-quality health care to those without the ability to pay. We also support the monthly salary of a medical doctor in the Haitian Academy’s clinic. That doctor cares for impoverished patients and mentors Haitian medical students.

International Service Trips

We enable volunteers to travel with us to strengthen the health and education initiatives of our international partners, such as Fundación Tierra Nueva in Ecuador and the Clinic of the Haitian Academy in Haiti. These service trips are typically one week in length and are paid for by the volunteers themselves. Trip expenses (typically around $1,200 per person, everything included) are kept to a minimum by living in community with the people we serve. While most of our trips are centered on primary health care outreach, some trips include public health education, dental, construction, medical equipment maintenance, and child development projects. Nonmedical volunteers can serve in our clinics in a variety of capacities: translation, triage, pharmacy assistance, fluoride station, and assistance to health care providers.
**International Partners**

The following organizations are international partners of The Timmy Foundation. Many students and adult volunteers from Indiana support and participate in medical mission to these sites. Each year The Timmy Foundation provides opportunities for young people to help others around the world.

Rather than duplicate efforts, The Timmy Foundation chooses to accomplish its mission by partnering with domestic and international organizations already battling to increase the accessibility of high-quality health care and education to the children in their communities. To empower these initiatives, the foundation serves as a resource clearinghouse, seeking financial, material, and volunteer support for their benefit. Below is a selected list of international partners. The partners below represent five countries The Timmy Foundation visits on medical missions. These five organizations present unique opportunities for learning and service. The five partners represent different cultures, languages, and geographic environments. They all share our mission to increase high-quality health care and education.

Haitian Academy — Port-au-Prince, Haiti

Dominican Crossroads — Sosua, Dominican Republic

Fundación Tierra Nueva — Quito Sur, Ecuador

Sociedad Amigos de Los Niños — Nuevo Paraiso, Honduras

St. Vincent Strambi Clinic — Bull Savannah, Jamaica

**Endemic Diseases and Conditions**

Information about some of the general challenges facing the children is included with each organization. Each of these countries has organizations and foundations working to improve the daily living conditions. This is not meant to be a total picture of the country’s resources. It is intended to illustrate some of the problems and conditions that are present in the country.
Haitian Academy

Port-au-Prince, Haiti

http://www.haitianacademy.net

School Details

The Haitian Academy teaches people of all ages, starting with a classical school for Grades K–5 followed by the Haitian equivalents to U.S. middle school and high school, and then higher education through a technical school and a university. The university offers a diverse range of subjects from medicine to business management. Dr. Marie-Pologne Rene founded the academy after visiting her native Haiti.

Endemic Diseases and Conditions

Typical disease or injury: untreated open fractures; malaria; congenital heart disease; polio

Urban or rural — shacks; exposed landfills; sugar cane fields

Mountainous, lowlands or beach

Heat, humidity

Poverty, poor hygiene

Limited nutrition

Little or no potable water

Severely limited education

High crime rate
Dominican Crossroads
Sosua, Dominican Republic

http://www.dominicancrossroads.com

Medical Ministry Details

The Dominican Crossroads ministry compound is located near the village of Sosua, on the north coast of the Dominican Republic, just east of Puerto Plata.

As a part of its mission to serve the poorest of the poor, Crossroads provides basic primary care and medical care referrals to the public hospital and public and private clinics in Montellano and Puerto Plata. As a result of the generosity of persons from throughout the world, Crossroads has established a one-room clinic in the village of Ascension. The clinic serves persons from Ascension and nearby bateyes (shantytowns) and is the base for outreach missions to more distant poor barrios and bateyes on the North Coast. Care is also provided to persons who seek help from Dr. Bob at his clinic in Sosua. These two sites allow Dr. Bob and Crossroads volunteers to provide follow-up care to acutely ill persons and those with serious chronic conditions.

Dominicans who live in the bateyes live on the edge of survival. Most are undernourished and vulnerable to infectious diseases and the premature onset of disabling chronic conditions. Although free care is provided at the public clinic and hospital, this care is extremely limited due to the poverty of the country and minimal resources allocated to the public health system. As a result, patients must pay for diagnostic tests, medicine, and food. These costs, plus the cost of transportation to a clinic or the hospital, are impossible for Dominicans who struggle just to provide a small daily ration of rice and beans for their families. Crossroads intercedes by providing basic primary care, filling prescriptions, and covering the costs of diagnostic tests, surgeries, and other treatments when financially possible to do so.

Crossroads’ Medical Mission is exclusively a volunteer effort, relying on contributions of medicine and monetary donations to support the Mission. The most critical need is for financial support to pay for diagnostic tests, treatments, and surgeries. Crossroads works closely with the public clinic and hospital to assure that needed treatments and medicine are provided, and also refers critical and complex cases to a private clinic in Puerto Plata. Physicians at both the public hospital and public and private clinics are extremely supportive. However, the need and cost of surgeries and medicines always exceeds the limited funds contributed to the Medical Mission.
Crossroads welcomes health care professionals and student volunteers to assist in its primary care clinic at Ascension and its medical care outreach missions. The objective is to treat those in the greatest need, recognizing that care decisions must take into account cultural factors and lack of access to the “high-tech” medical resources that most volunteers are accustomed to. For these reasons, groups with physicians and other licensed health care professionals work in close collaboration with a Crossroads staff member. Caring for the sickest individuals first assures that clinics are organized in such a way that appropriate triage is undertaken and follow-up care can be provided. Medical, dental, nursing, and other health care students are required to work under the direct supervision of a Crossroads staff member.

**Timmy Foundation International Partners**

The following list outlines some of the general challenges facing the poor children that The Timmy Foundation hopes to serve. Each of these countries has outstanding organizations and foundations working to improve the daily living conditions. This is not meant to be a total picture of the country’s resources. It is intended to illustrate some of the problems and conditions that are present in the country.

**Endemic Diseases and Conditions**

Typical disease or injury: untreated open fractures; malaria; congenital heart disease

Urban or rural — shacks; exposed landfills; sugar cane fields

Mountainous, lowlands or beach

Heat, humidity

Poverty, poor hygiene

Limited nutrition

Little or no potable water

Severely limited education

**Fundación Tierra Nueva**

Quito Sur, Ecuador
Father José Carollo, an Italian-born Catholic priest who moved to Ecuador as a young man, founded the Tierra Nueva Foundation (New World Foundation). A relentless advocate for the poor, Father Carollo moved to southern Quito, the poorest part of Ecuador’s capital city, determined to provide a better life for those who come from scarce economic means. Father Carollo believed that every person, regardless of economic status, deserves a dignified life. His Tierra Nueva Foundation aims to provide that dignified life by working with poor families to improve their physical, economic, emotional and spiritual wellbeing. During the more than three decades that Father Carollo ran the Tierra Nueva Foundation, he built a nonprofit, fully functioning medical hospital, two day care centers, a special education center, a legal services organization and numerous churches throughout southern Quito. When Father Carollo died, in May 2005, the Tierra Nueva Foundation Board of Directors pledged to continue the work of Padre Carollo, including completion of the 100-bed hospital that was his final dream. Today, the Tierra Nueva Foundation continues to strive to improve the wellbeing of Quito’s poor, taking up Father Carollo’s creed: “Our life is a gift. We live it in order to return it as a service to the most needy.”

At present, the Tierra Nueva Foundation continues to operate a medical hospital and pharmacy, two daycare centers, a special education center, and a legal services organization while moving forward with the construction of the new “Song for Life” hospital, now approximately two-thirds complete. Each of Tierra Nueva’s organizations is dedicated to reaching out to those with limited economic means through a combination of financial, medical and legal assistance. Through both international and local collaborations, Tierra Nueva maintains a social work department in each organization, which allows for the foundation to subsidize services for those who could not otherwise pay. Collaborations include private sponsorships and grants, financial assistance from international nonprofits, as well as a medical brigade program that brings doctors and surgeons to Quito to volunteer their services.

The 264-person Tierra Nueva staff serves a community of approximately 600,000 people. This community directly includes all of the neighborhoods of southern Quito, and indirectly includes the marginal, rural areas outside of Quito, from which many poor citizens come to the Tierra Nueva Foundation to seek affordable medical or other services. Through continuing collaborations with both international and local organizations, Tierra Nueva consistently looks to expand their services.

One of Tierra Nueva’s international collaborations is with The Timmy Foundation, which since 2000 has provided a combination of direct medical assistance (in the form of medical brigades to communities of southern Quito) and financial assistance. Today, The Timmy Foundation sends an average of four or five weeklong medical brigades to Tierra Nueva each year. These medical brigades visit needy communities with limited access to health care services, and in an average week attend to more than a thousand patients. These patients receive free medical treatment and medicine. Patients with
diseases, conditions, or sicknesses that require further attention are referred to the Tierra Nueva Medical Hospital, where they receive follow up medical care paid in full by The Timmy Foundation’s financial donations to Tierra Nueva. In addition to the donations that support the medical brigades, The Timmy Foundation also donates $2,000 a month to the Tierra Nueva Social Work Department in an effort to subsidize medical services for the southern Quito community. The Timmy Foundation also refers international volunteers to Tierra Nueva, where they help in numerous ways to further the goals of Padre Carollo and the entire Tierra Nueva staff.

**Endemic Diseases and Conditions**

Typical disease or injury: untreated congenital heart disease, strep throat, tuberculosis, and tetanus

Urban — apartments, markets, and street life

Mountainous valley (9,600 feet above sea level),

Low oxygen level, pollution

Poverty and poor nutrition

Low humidity

Bottled water is purchased or local water is boiled

Required education only to Grade 6
Sociedad Amigos de los Niños
Nuevo Paraiso, Honduras

http://www.saninos.org.hn

Mission
Sociedad Amigos de los Niños (SAN) is a private nonprofit organization founded in 1966 by Sister Maria Rosa Leggol of the School Sisters of St. Francis. The Mission of Sociedad Amigos de los Niños (SAN) is to provide a nurturing environment for the neglected and impoverished children of Honduras. SAN provides shelter, health care, education, training, and the opportunity to live in dignity to children and families ravaged by extreme poverty. SAN addresses their basic needs and at the same time creates the opportunities for each child and young person to acquire the necessary skills to enjoy a productive and meaningful life. SAN provides the tools for and instills the desire in these children to become self-sufficient, caring, and responsible adults.

Founder
Sister Maria Rosa Leggol was born in 1926 in Puerto Cortes, Honduras. Because of her own experience as an orphan, Sister Maria Rosa has always been concerned with the needs of the poor and was inspired to create better conditions and a more loving environment for the children of Honduras. She became a Franciscan Sister in 1949 in Milwaukee, Wisconsin, after which she returned to continue her work in the hospital “La Policlinic” in Honduras.

In 1964 Sister Maria Rosa rescued her first group of children, who were living in the city jails with their incarcerated parents. That was the beginning of Sociedad Amigos de los Niños and her commitment to create a safe and special place for the orphaned, neglected and abused children of Honduras. With love, faith, dedication, and hard work, Sister Maria Rosa has rescued and educated more than 35,000 children, who today are productive citizens of Honduras. Sister Maria Rosa continues working as the general director of SAN. She is a founder and active member of the Honduran National Telethon, a foundation that builds and maintains a network of rehabilitation centers for children with disabilities. Sister Maria Rosa has been the recipient of many prestigious awards.
Endemic Diseases and Conditions

Typical disease or injury: severe asthma; trauma; HIV; diphtheria

Rural — huts; farms; sugar cane fields

Mountainous

No potable water

Air pollution

Limited education
St. Vincent Strambi Clinic
Bull Savannah, Jamaica

Mission

Dr. Carol has a clinic in Bull Savannah, Jamaica, where she tirelessly tends to the needs of anyone who comes her way. The sheer volume of requests for attention from the amiable rural population is so large that it can be difficult to quantify. Dr. Carol and her assistant(s) treat everything from fungal, bacterial, and viral infections to small lacerations and other minor injuries. The clinic she works out of is a converted home, complete with a handful of exam rooms and a makeshift pharmacy for donated remedies. There is even a dental room equipped with two functional chairs and a vacuum system. Patients await their scheduled appointments under a mango tree in Dr. Carol’s side yard. Medical brigades accompanying the doctor attest to seeing hundreds of patients a day.

Endemic Diseases and Environmental Conditions

Typical disease or injury: fungal infections of the skin; hepatitis

Rural village — huts; subsistence farming

Highlands

Temperate climate, humid

Educated
People Like You Making a Difference! — Student Tasks

People like you make significant contributions around the world. There are many things young people can do to help others. Contact the volunteer coordinator at The Timmy Foundation for ideas, guidance, or resources to make the projects real. Review the mission objectives and opportunities available with The Timmy Foundation, including medical supply warehouse, funding outreach, and international service trips. The following list contains suggestions for student service projects. The most important and exciting endeavors are those students create themselves. Share the list with your class. Students may want to work together in pairs or groups, or the whole class may want to collaborate on a joint project.

Service Project

• Start a local Timmy Foundation chapter
• Continue financial support to the NGO (Non-Governmental Organization)
• Monitor and sustain a patient
• Create new Case Study Narratives
• Investigate the impact of governmental policies
• Investigate the impact of corporate policies
• Volunteer
• Create your own service project

Help your students find their passion! People of all ages can make a difference and change the world. Lessons like these last a lifetime.

Young people need to understand how powerful they are. – Charles Dietzen, M.D
Resource Materials

Glossary of Medical Terminology

Abdomen: The part of the body between the chest and the pelvis but excluding the back; also called belly.

Acute: Characterized by sharpness or severity; having a sudden onset, sharp rise, and short course.

Allergy: Exaggerated or pathological reaction (such as sneezing, respiratory distress, itching, or skin rashes) to substances, situations, or physical states that are without comparable effect on the average individual.

Auscultate: To listen through a stethoscope.

Bilateral: Relating to or affecting both the right and left sides of the body or the right and left members of paired organs.

Bilirubin: A reddish-yellow pigment that occurs especially in bile and blood and causes jaundice if accumulated in excess.

Bladder (Urinary): An expandable membranous sac that serves for the temporary retention of urine.

Blood pressure: Pressure exerted by the blood on the walls of the blood vessels and especially the arteries, usually measured on the brachial artery by means of a sphygmomanometer, and expressed in millimeters of mercury.

Bounding: Strong and forceful, as in a bounding pulse.

Bowel sounds: Abdominal sounds, positive or abnormal, made by the movement of the intestines as they push food through.

Breech presentation: Presentation of the fetus in which the buttocks or legs are the first parts to appear at the uterine cervix.

Bruit: Any of several generally abnormal sounds heard on auscultation.

Cachectic: Affect by general physical wasting and malnutrition usually associated with chronic disease.

Cardiovascular accident (CVA): Also called stroke; the sudden diminution or loss of consciousness, sensation, and voluntary motion caused by rupture or obstruction (such as by a clot) of a blood vessel in the brain.
Caries: Tooth decay or cavities.

Clear to auscultation (CTA): No unusual sounds heard through a stethoscope.

Clinic: An institution connected with a hospital or medical school where diagnosis and treatment are made available to outpatients.

Clinical: Involving or concerned with the direct observation and treatment of living patients.

Clubbing: Showing a bulbous enlargement of the tips of the fingers or toes, with convex overhanging nails.

Contracture: A permanent shortening producing deformity or distortion, such as of muscle, tendon, or scar tissue.

Contralateral: Occurring on, affecting, or acting in conjunction with a part on the opposite side of the body.

Costal: Relating to, involving, or situated near a rib.

Cranial nerve: Any of the 12 paired nerves that arise from the lower surface of the brain and pass through openings in the skull to the periphery of the body.

Cyanosis: A bluish or purplish discoloration of the skin due to deficient oxygenation of the blood.

Dentition: The development and cutting of teeth; the character of a set of teeth, especially with regard to their number, kind, and arrangement.

Disability: A physical or mental impairment.

Distention: Unusual or abnormal swelling.

Distress: Pain or suffering affecting the body, a bodily part, or the mind.

Dorsiflex: To flex in a dorsal, or upward, direction.

Edema: An abnormal excess accumulation of watery fluid in connective tissue or a body cavity.

Epidemiology: The sum of the factors controlling the presence or absence of a disease or pathogen.

Erythema: Abnormal redness of the skin due to capillary congestion, such as in inflammation.
**Etiology:** The cause or causes of a disease or abnormal condition.

**Excoriation:** A raw, irritated lesion; an abraded or chafed area of the skin.

**Extraocular:** Any of six small voluntary muscles that pass between the eyeball and the orbit and control the movement of the eyeball in relation to the orbit.

**Fever:** A rise of body temperature above the normal; an abnormal bodily state characterized by increased production of heat, accelerated heart action and pulse, and systemic debility with weakness, loss of appetite, and thirst.

**Flaccid:** Not firm or stiff.

**Flex:** To move muscles so as to cause flexion of the joints, such as of the knees; to move or tense a muscle or muscle group by contraction.

**Fluctuant:** A wave-like motion that is felt when a fluid containing structure is palpated.

**Gastrocnemius:** The largest muscle of the calf of the leg that runs from the femur to the Achilles tendon.

**Goiter:** An enlargement of the thyroid gland that is commonly visible as a swelling of the anterior part of the neck.

**Hamstring:** Either of two groups of tendons that run from the upper part of the back of the knee to the back of the thigh.

**Heart disease:** An abnormal organic condition of the heart or of the heart and circulation.

**Heart rate:** A measure of cardiac activity usually expressed as the number of beats per minute.

**Hemiparesis:** Muscular weakness or partial paralysis restricted to one side of the body.

**Human immunodeficiency virus (HIV):** Any of several retroviruses that infect and destroy helper T cells of the immune system causing the marked reduction in their numbers that is diagnostic of AIDS.

**Holosystolic murmur:** An atypical sound heard throughout the entire contraction of the heart ventricles.

**Homans' sign:** Pain in the calf of the leg upon dorsiflexion of the foot with the leg extended that is diagnostic of clotting in the deep veins of the area.
**Hyperpigmented:** Having excessive coloration, as with inflammation.

**Icteric:** Affected with jaundice, a yellowish pigmentation of the skin, tissues, and certain body fluids caused by bile pigment deposits and which follows interference with normal production and discharge of bile (as in certain liver diseases) or excessive breakdown of red blood cells (as after internal hemorrhage or in various hemolytic states).

**Immunization:** Treatment by vaccination.

**Infection:** Contamination by pathogen or disease.

**Jugular vein:** Any of several veins of each side of the neck.

**Lesion:** An abnormal change in structure of an organ or part due to injury or disease.

**Liver:** The largest gland in the human body, which secretes bile and causes important changes in many of the substances contained in the blood that passes through it.

**Lymph node:** Any of the rounded masses of lymphoid tissue that are surrounded by a capsule of connective tissue, are distributed along the lymphatic vessels, and contain numerous lymphocytes which filter the flow of lymph passing through the node.

**Lymphadenopathy:** Abnormal enlargement of the lymph nodes.

**Lymphatic:** Relating to, or produced by lymph, lymphoid tissue, or lymphocytes.

**Malaria:** An acute or chronic disease caused by the presence of sporozoan parasites of the genus *Plasmodium* in the red blood cells, transmitted from an infected to an uninfected individual by the bite of an anopheline mosquito, and characterized by periodic attacks of chills and fever that coincide with mass destruction of blood cells and the release of toxic substances by the parasite at the end of each reproductive cycle.

**Malnourished:** Supplied with less than the minimum amount of the foods essential for sound health and growth.

**Margin:** The outside limit or edge of something, as in the right costal margin, the outside edge of the rib cage on the right side.

**Mass:** An aggregation of matter.

**Midwife:** A person who assists women in childbirth.

**Muscle stretch reflex:** Contraction in response to stretching within a muscle, often tested by tapping on a tendon with a small rubber mallet.
Negative bilaterally: Not occurring on either side.

Neurological: Relating to the nervous system.

Normocephalic: A normal head.

Organomegaly: Abnormal enlargement of the internal organs of the body.

Palpate: To examine by touch.

Paravertebral: Occurring adjacent to the spinal column.

Penicillin: An antibacterial medication made from the molds of the genus Penicillium.

Percussion: The act or technique of tapping the surface of a body part to learn the condition of the parts beneath by the resulting sound.

Perfusion: The pumping of a fluid through an organ or tissue.

Pitting edema: Edema that results in a depression in the tissue.

Plantar: Relating to the sole of the foot.

Potable: Safe to drink.

Pulse: The palpable beat resulting from a regularly recurrent wave of distension in arteries that results from the progress through an artery of blood injected into the arterial system at each contraction of the ventricles of the heart; measured in beats per minute.

Purulent: Containing pus.

Rales: An abnormal sound heard accompanying the normal respiratory sounds on auscultation of the chest.

Rehabilitation: The physical restoration of a sick or disabled person by therapeutic measures and reeducation to participation in the activities of a normal life within the limitations of the person's physical disability.

Relapse: A recurrence of symptoms of a disease after a period of improvement.

Respiratory rate: The speed at which gases move into and out of the lungs, measured per minute.

Retraction: Backward or inward movement of skin or an organ.

Rhinorrhea: Excessive mucous secretion from the nose.
Scoliosis: Lateral curvature of the spine.

Sickle-cell anemia: A chronic hereditary anemia that occurs in some populations and can cause organ failure.

Spastic gait: A manner of walking characterized by spasms of paralyzed muscles.

Sputum: Mucus or other bacterial products produced in diseases of the lungs.

Sternal: Relating to the breastbone.

Suprapubic: Above the pubic bone.

System: A group of body organs or structures that together perform one or more vital functions.

Systolic ejection murmur: An atypical sound of the heart indicating a stenosis, or narrowing. The murmur is caused by turbulent forward blood flow and is graded by volume, 1/6 to 6/6, with 1/6 having the faintest sound.

Tachycardia: Rapid heart action.

Temperature: The degree of heat that is natural to a human body; a normal oral temperature is about 98.6°F.

Thrill: An abnormal fine tremor or vibration in the respiratory or circulatory systems felt on palpation, often associated with a heart murmur.

Trauma: An injury, such as a wound, to living tissue caused by an outside agent.

Tuberculosis: Also called TB, a usually chronic disease caused by a bacterium of the genus *Mycobacterium*, usually communicated by inhalation of the airborne causative agent. It especially affects the lungs but may spread to other parts of the body, and is characterized by fever, cough, difficulty in breathing, and other symptoms.

Upper respiratory infection: Contamination by bacteria or pathogen of the part of the respiratory system including the nose, nasal passages, and nasopharynx.

Urinary tract infection (UTI): Contamination by bacteria or pathogen of the tract through which urine passes and which consists of the kidney, the ureters, the bladder, and the urethra.

Vaccination: The introduction into humans or domestic animals of microorganisms that have previously been treated to make them harmless for the purpose of inducing the development of immunity.
Vertebral: Relating to the spinal column.

Vitals: Short for “vital signs,” the pulse rate, respiratory rate, body temperature, and blood pressure of a person.
Medical Explorer

Assessment and Scoring Rubric

This rubric provides a framework for evaluating each student’s performance in completing medical evaluations from the case studies. The lessons will be evaluated on the student’s ability to research, create reports, investigate, and present findings on subjects presented in case studies. The following criteria will be used.

Students demonstrate the ability to

• read and study the case history of a child
• understand and use medical vocabulary and terminology
• extract important medical history from a provided clinical narrative
• determine significant information from a narrative of a physical exam
• analyze and put into their own words information from a medical evaluation
• work in small Consultation Teams to learn information and share it with the class
• research the climate and diseases endemic to the region
• research the cultural and socioeconomic factors of the region
• investigate long-term and public health issues of the region
• report to the class information collected during research
• write detailed reports about the region where the child lives
• come to a consensus on a medical assessment of the child’s condition
• investigate selected diseases or medical conditions
• investigate selected treatment plans for the child
• outline a treatment plan for the child
• present findings to the class
Medical Explorer

Topics of Interest and Online Resources

Topics of Interest

Body Systems

Cells

Immunization & Vaccination

Hygiene

Diet and nutrition

Genetics (Human Genome)

Culture and languages

Medical ethnology

Medical abbreviations and terminology

Online Resources

CalTech Precollege Science Initiative: Human Body Under Attack

http://www.capsi.caltech.edu/

Centers for Disease Control and Prevention

http://www.cdc.gov/

Children’s Museum of Indianapolis — Agricultural Biotechnology Unit of Study, Genetics and Cell Biology


Global Polio Eradication

http://www.polioeradication.org
Indiana AHEC Program — Student Resources on Health Careers
http://www.ahec.iupui.edu/studentresources/default.htm

MedLine Plus: Health Topics

MedLine Plus: Medical Encyclopedia

MedLine Plus: Medical Dictionary

Museum of Science & Industry: Live . . . From the Heart
http://www.msichicago.org/ed/educ_liveheart.html

National Academies Press
www.nap.edu

National Institutes of Health Curriculum Supplements — High School
http://science.education.nih.gov/Customers.nsf/highschool.htm

National Institutes of Health Curriculum Supplements — Middle School
http://science.education.nih.gov/Customers.nsf/middleschool.htm

National Institutes of Health — Diseases and Conditions Index

Science, Medicine, and Animals: Teacher’s Guide
http://orsted.nap.edu/books/0309101174/html

The Timmy Foundation
http://www.timmyfoundation.org

United States Department of State — International Travel Information
WISE: Web-Based Inquiry Science Environment

http://wise.berkeley.edu/

World Health Organization

http://www.who.int/en/

Indiana Academic Standards: Language Arts, Science and Social Studies

Science: Biology

Standard 1 — Principles of Biology

B.1.17 – Understand that and describe how the maintenance of a relatively stable internal environment is required for the continuation of life and explain how stability is challenged by changing physical, chemical, and environmental conditions, as well as the presence of disease agents.

B.1.20 – Recognize that and describe how the human immune system is designed to protect against microscopic organisms and foreign substances that enter from outside the body and against some cancer cells that arise within.

Language Arts

Standard 1 — Reading: Word Recognition, Fluency and Vocabulary Development

9.1.3, 10.1.3, 11.1.2, 12.1.2 – Apply knowledge of Greek, Latin, and Anglo-Saxon roots and word parts to draw inferences about new words that have been created in the fields of science and math (e.g., gene splicing, genetic engineering).

Standard 2 — Reading: Comprehension

9.2.3 – Generate relevant questions about readings on issues that can be researched.

Standard 4 — Writing: Process

9.4.4 – Use writing to formulate clear research questions and to compile information from primary and secondary print or Internet sources.
9.4.6 – Synthesize information from multiple sources, including almanacs, microfiche, news sources, in-depth field studies, speeches, journals, technical documents, and Internet sources.

10.4.4 – Use clear research questions and suitable research methods, including the investigation of text and electronic resources and the conducting of personal interviews, to compile and present evidence from primary and secondary print or Internet sources.

11.4.7 – Develop presentations using clear research questions and creative and critical research strategies, such as conducting field studies, interviews, and experiments; researching oral histories; and using Internet sources.

12.4.7 – Develop presentations using clear research questions and creative and critical research strategies, such as conducting field studies, interviews, and experiments; researching oral histories; and using Internet sources.

**Standard 5 — Writing: Applications**

10.5.6 – Write technical documents, such as a manual on rules of behavior for conflict resolution, procedures for conducting a meeting, or minutes of a meeting

11.5.7, 12.5.7 – Use precise technical or scientific language when appropriate for topic and audience.

**Standard 7 — Listening and Speaking**

9.7.16., 10.7.15, 11.7.16 – Deliver expository (informational) presentations

**Social Studies: World Geography**

**Standard 2 — Places and Regions**

WG.2.2 – Categorize characteristics of places in terms of whether they are physical (natural) or cultural (human). Know and apply the subcategories of physical and cultural characteristics when describing any given place.

**Standard 4 — Human Systems**

WG.4.7 – Identify patterns of economic activity in terms of primary (growing or extracting), secondary (manufacturing) and tertiary (distributing and services) activities. Realize that the percentage of the working population in each of these categories varies by country and changes over time, and that the trend everywhere is toward an increase in the percentage involved in providing services. (Economics)
Appendix C:

Key Medical Explorers Project Leaders and Partnerships

- **Lance Brand, MA, Medical Explorers Project Director.** Brand has partnered with the Timmy Foundation since 2005 to develop the Medical Explorers curriculum and implement the pilot program. Brand will continue to provide leadership throughout project implementation. Brand is currently completing his studies to earn an Ed.D. of Biology from Ball State University in Muncie, IN. He will complete a comprehensive assessment of the project’s effectiveness and outcomes in partnership with Ball State’s Department of Biology.

Brand earned his Bachelor of Science in Biology and Premedical Preparation from Ball State University, and shortly thereafter earned a Master of Arts in Biology from Ball State. Brand has been a science educator at the secondary school level for more than a decade and is an Adjunct Biology Instructor at Ball State University. Brand has held several leadership roles throughout his career and has helped to reform the pedagogical approaches to teaching science at the secondary level. Brand has received several honors and awards for his achievements, including the 2005 Milken Family Foundation National Educator Award, the Ball State University Teachers College Alumni of the Year in 2006 and 2007, and Sigma Xi Teacher of the Year in 2007. Brand has been awarded several competitive grants to continue his work in the field, including three Teacher Creativity Grant from the Eli Lilly Science Education Outreach program.

- **Charles M. Dietzen, MD, Timmy Foundation Founder and Executive Director.** As the Executive Director of the Timmy Foundation, Dr. Dietzen (commonly referred to as “Dr. Chuck”) will oversee the overall direction and progress of the Medical Explorers project. Dr. Chuck earned his Bachelor's Degree in Agriculture from Purdue University and his Medical Degree from Indiana University. He is a Pediatric Rehabilitation Specialist and currently practices at Crossroads Easter Seals and St. Frances Hospital in Indianapolis.

The Timmy Foundation’s staff and medical interns will provide assistance with the overall coordination and implementation of the service learning trips and clinical experiences for the students. Moreover, Timmy Foundation’s Educational Committee, a sub-committee of the Board of Trustees, will assist with the evaluation of the project.
- **WFYI, Channel 20, and affiliate of the Public Broadcasting Corporation.**
  WFYI produces a successful educational series, entitled *Indiana Expeditions*, which is now in its second season. *Indiana Expeditions* engages youth in learning science through an exploration of real science that is occurring throughout the state and region. WFYI will create a video documentary of the *Medical Explorers* project, and it will become a featured episode of Indiana Expeditions.

The *Indiana Expeditions* series features well-known science educator, Rick Crosslin, M.A. Crosslin assisted with the development of the pilot *Medical Explorers* project, and has nearly 30 years of teaching experience. Crosslin has been the recipient of several national teaching awards, and has worked with prominent organizations such as National Geographic, Inquisitive Kids, Inc., the Children’s Museum of Indianapolis, and the Indiana Department of Education to create inquiry-based science curriculum.

- **Bill Rogers, Ph.D., Ball State University Biology Department.** As the lead instructor and director of undergraduate biology instruction for non-science majors Dr. Rogers has become well-respected in science education. He is actively involved in scholarship regarding the teaching of non-science majors and his leadership within the field of science education has led to him being chosen to develop numerous textbook ancillaries, being invited by McGraw-Hill Publishers to co-author a new textbook intended for high school students, as well as multiple publications and professional presentations. In addition, Dr. Rogers currently serves as an elected officer of the National Association of Biology Teachers. Dr. Rogers has been the recipient of multiple educational grants including two NSF (National Science Foundation) based grants and a Lilly 2 Grant which supported his scholarship in the area of teaching non-majors biology.

- **Jennifer Hicks, Ph.D., Indiana Department of Education.** As the Science Curriculum Specialist for the Indiana Department of Education, Dr. Hicks has been a key player in transforming science instruction in the state of Indiana. As a director of science curriculum and instruction, she supports the use of inquiry instruction, case studies, and problem based learning. Such instructional methodologies actively engage the learner in the process of science. Dr. Hicks has served as a consultant in the development of the *Medical Explorers* curriculum and fully supports the study and use of this case study curriculum within the classroom.
## Appendix D: Medical Explorers Final Project Assessment Rubric

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<th>Criteria</th>
<th>Unsatisfactory</th>
<th>Basic</th>
<th>Proficient</th>
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<tbody>
<tr>
<td><strong>Medical Evaluation: History and Physical Exam (20 pts)</strong></td>
<td>Presentation of medical evaluation is not rewritten, but simply copied from initial information. Medical &quot;jargon&quot; has not been deciphered into terms that the average person could understand. (0-10 pts)</td>
<td>Medical evaluation is restated into some of the students' own words, but sections seem to remain unchanged from initial history given. Some medical terminology has been boiled down, but use of unnecessarily complicated words still evident. (11-15 pts)</td>
<td>Students have rewritten the <strong>history and physical exam</strong> of the patient in their own words. Presentation is clear enough to be understood by just about anyone, having translated all the medical terminology. It is evident that students understand their patient's history and know the details of their examination. (16-20 pts)</td>
</tr>
<tr>
<td><strong>Research Tasks: Epidemiology, Geography, Economics, Culture, and Religion (20 pts)</strong></td>
<td>Students make little or no mention of the geography of their patient's home. There is little or no reference to the most common diseases in that part of the world, how the culture might influence their patient's health, or what limitations socioeconomic status might play on treatment. Religion, education, and their impact on patient health are evident in negligible amounts. (0-10 pts)</td>
<td>Presentation contains some mention of where their patient is from, common diseases in that area of the world, and the patient's socioeconomic mention. It is clear that students know the culture, religion, and education of their patient, but fail to take into account how these factors may or may not impact the health of their patient. (11-15 pts)</td>
<td>Students make explicit mention of where their patient is from and the most common diseases in that area of the world. Discussing if any of these common diseases match their patient's symptoms and why. It is clearly outlined how the patient's socioeconomic status may impact treatment. Students also outline how the patient's religion, culture, and education may have contributed to their illness, or if they might impact treatment. (16-20 pts)</td>
</tr>
<tr>
<td>Medical Assessment and Diagnosis (25 pts)</td>
<td>Students do not take into account all of their patient's symptoms, or ignore certain symptoms without providing a rational. No official diagnosis is given, or is only mentioned in passing. (0-7 pts)</td>
<td>Students take into account some of the patient's symptoms, and mention how they contributed to diagnosis. However, some symptoms are ignored without reason, and official diagnosis is made, but poor. (8-14 pts)</td>
<td>Students take into account all symptoms listed during the medical evaluation and physical. Symptoms not related to diagnosis are explained. Official statement of diagnosis is given and clearly based on research into symptoms. (20-25 pts)</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Criteria</td>
<td>Unsatisfactory</td>
<td>Basic</td>
<td>Proficient</td>
</tr>
<tr>
<td>Treatment Plan (25 pts)</td>
<td>Treatment plan discusses only medical treatment. Aspects such as education, nutrition, equipment, etc… are ignored. (0-14 pts)</td>
<td>Treatment plan discusses medical treatment, and at least two other aspects, such as education, nutrition, surgery, or equipment involved. Patient prognosis is also described. No durations for treatment listed. (15-19 pts)</td>
<td>Treatment plan discusses not only specific and detailed medicinal plan, but also plans on educating the patient and patient's family, nutrition requirements, equipment needs, and any possible future medical procedures. Treatment plan also outlines patient prognosis, and provides durations for remainder of illness. (20-25 pts)</td>
</tr>
<tr>
<td>Professionalism (20pts)</td>
<td>Content of the case report or presentation has many inaccuracies. Case report is unprofessional in nature. Presentation, although creative and fun is unprofessional in nature. (0-10 pts)</td>
<td>Content of the case report or presentation has several inaccuracies. Case report is professional in nature. Presentation, although creative and fun is mostly professional in nature. (11-15 pts)</td>
<td>Content of both the case report and presentation are accurate. Case report is professional in nature. Presentation, although creative and fun is professional in nature. (16-20 pts)</td>
</tr>
<tr>
<td>Creativity (20 pts)</td>
<td>Presentation includes little to now variety in color, pictures/graphics, and no use of multimedia (i.e. whole presentation is verbal, no PPT, video, or website). (0-10 pts)</td>
<td>Presentation includes a small variety of creative aspects. It is colorful, includes a mixture of media, and incorporates pictures of both patient and illness. (11-15 pts)</td>
<td>Presentation includes a good variety of creative aspects. For example, a website with video clips, hand crafted book, or a video shot by students involving all members. Construction of a website with pictures and videos, acting out the presentation, or powerpoint mixed with models would be great). (16-20 pts)</td>
</tr>
</tbody>
</table>

Due Date: _______________ 130 Pts.

II components or the Medical Explorer project must be presented in both your professional Case report and in your visual presentation. Projects must be submitted on time, **15% deduction will be taken for each day late.** All presentation, video, or media must be playable through a standard DVD player, using Windows Media Player, PowerPoint, or over the internet.

Comments:
Appendix E: MSLQ

Participant Code______________________

**MOTIVATION & SELF-REGULATION of LEARNING QUESTIONNAIRE**

To identify your strengths and weaknesses as a learner, you need a diagnostic tool. The Motivation & Self-regulation of Learning Questionnaire (MSLQ) was developed to measure the types of learning strategies you use and your academic motivation. It is important that you answer all of the questions honestly. These are opinions about yourself; there are no right or wrong answers.

**Directions:** Below are statements that people use to describe themselves. Please circle the number of the response that best describes you using the following scale:

<table>
<thead>
<tr>
<th>Statement</th>
<th>Not at All True of Me</th>
<th>Very True of Me</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. In a class like this, I prefer course material that arouses my curiosity, even if it is difficult me.</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>2. If I study in appropriate ways, then I will be able to learn the material in this course.</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>3. When studying for this class, I read my class notes and the course readings over and over again.</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>4. I usually study in a place where I can concentrate on my course work.</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>5. The most important thing for me right now is improving my overall grade point average, so my main concern in this class is getting a good grade.</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>6. I try to relate ideas in this subject to those in other courses whenever possible.</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>7. I work hard to do well in this class even if I don’t like what we are doing.</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>8. I think I will be able to use what I learn in this course in other courses.</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>9. I’m confident I can do an excellent job on the assignments and tests in this course.</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>10. When I study for this course, I go through the readings and my class notes and try to find the most important ideas.</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>11. I try to work with other students from this class to complete the course assignments.</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>12. When I have the opportunity in this class, I choose course assignments that I can learn from even if they don’t guarantee a good grade.</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>13. If I try hard enough, then I will understand the course material.</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
</tbody>
</table>
14. When a theory, interpretation, or conclusion is presented in class or in the readings, I try to decide if there is good supporting evidence. Not at All True of Me 1 2 3 4 Very True of Me 5 6 7

15. Even if I have trouble learning the material in this class, I try to do the work on my own, without help from anyone. Not at All True of Me 1 2 3 4 Very True of Me 5 6 7

16. I want to do well in this class because it is important to show my ability to my family, friends, employer, or others. Not at All True of Me 1 2 3 4 Very True of Me 5 6 7

17. When I become confused about something I’m reading for this class, I go back and try to figure it out. Not at All True of Me 1 2 3 4 Very True of Me 5 6 7

18. I make good use of my study time for this course. Not at All True of Me 1 2 3 4 Very True of Me 5 6 7

19. When I study, I try to understand and apply the information instead of just memorizing enough to “get by”. Not at All True of Me 1 2 3 4 Very True of Me 5 6 7

20. When course work is difficult, I give up or only study the easy parts. Not at All True of Me 1 2 3 4 Very True of Me 5 6 7

21. I set goals that I want to accomplish both in the immediate and the long-term future. Not at All True of Me 1 2 3 4 Very True of Me 5 6 7

22. When reading for this class, I try to relate the material to what I already know. Not at All True of Me 1 2 3 4 Very True of Me 5 6 7

23. When I can’t understand the material in this course, I ask the instructor or another student in this class for help. Not at All True of Me 1 2 3 4 Very True of Me 5 6 7

24. I expect to do well in this class. Not at All True of Me 1 2 3 4 Very True of Me 5 6 7

25. I break down my assignments according to how much time I think they will take. Not at All True of Me 1 2 3 4 Very True of Me 5 6 7

26. I often find that I don’t spend very much time on this course because of other activities. Not at All True of Me 1 2 3 4 Very True of Me 5 6 7

27. I think the course material in this class is useful for me to learn. Not at All True of Me 1 2 3 4 Very True of Me 5 6 7

28. I try to think through a topic and decide what I am supposed to learn from it rather than just reading it over when studying. Not at All True of Me 1 2 3 4 Very True of Me 5 6 7

29. If I have problems with an assignment or a test, I study harder instead of ignoring my problems. Not at All True of Me 1 2 3 4 Very True of Me 5 6 7

30. When I study, I put the material into a more simple form, such as an outline or a concept map. Not at All True of Me 1 2 3 4 Very True of Me 5 6 7

31. I organize my time according to how difficult or easy each assigned task is likely to be. Not at All True of Me 1 2 3 4 Very True of Me 5 6 7

32. Whenever I read or hear an assertion or conclusion in this class I think about possible alternatives. Not at All True of Me 1 2 3 4 Very True of Me 5 6 7

Demographic Questions In an effort to help identify the group members participating in this research project, please circle your answer to the following questions. You do not have to answer any questions you do not want to answer.

1. Indicate your Gender: Male Female
2. Choose what group best describes you:

- White/Caucasian
- Hispanic/Latino
- Black/African American
- Asian/Pacific Islander
- Native American
- Other

The MSLQ survey above was adapted from the following sources:

Appendix F:

Participant Code: __________________________

Relevant CAT: Attitude Survey  
Discipline: Biology

The Biology Attitude Scale

<table>
<thead>
<tr>
<th>Likert-type scale</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>Strongly agree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Be undecided</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disagree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly disagree</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

1. Biology is very interesting to me.                              A B C D E
2. I don’t like biology, and it scares me to have to take it.       A B C D E
3. I am always under a terrible strain in a biology class.          A B C D E
4. Biology is fascinating and fun.                                  A B C D E
5. Biology makes me feel secure, and at the same time is stimulating. A B C D E
6. Biology makes me feel uncomfortable, restless, irritable, and impatient. A B C D E
7. In general, I have a good feeling toward biology.                 A B C D E
8. When I hear the world “biology,” I have a feeling of dislike.     A B C D E
9. I approach biology with a feeling of hesitation.                 A B C D E
10. I really like biology.                                           A B C D E
11. I have always enjoyed studying biology in school.                A B C D E
12. It makes me nervous to even think about doing a biology experiment. A B C D E
13. I feel at ease in biology and like it very much.                 A B C D E
14. I feel a definite positive reaction to biology; it’s enjoyable.  A B C D E
15. I believe I would enjoy a career in life-science (biology).  
16. I can see myself flourishing in a life-science (biology) career.  
16. A career in the medical field interests me.  
17. I believe I would be successful in a medical related career.  

Semantic differential scale

Below are some scales on which we would like you to rate your feelings toward biology. On each scale, you can rate your feelings toward biology as an A, B, C, D, or E. There are no correct answers. Also, some of the scales seem to make more sense than others. Don’t worry about it. Just rate your feelings toward biology on these scales as best you can. Please don’t leave any scales blank.

**BIOLOGY IS:**

18. Good  
19. Clean  
20. Worthless  
21. Cruel  
22. Pleasant  
23. Sad  
24. Nice  
25. Fair

Reprinted with permission from the National Association of Biology Teachers. Instrument appears in Russell and Hollander (1975).
Authors:
Hollander, Steven (Marketing Research Division, Standard Oil Co., California)
Russell, James (Education, Purdue University, West Lafayette, Ind.)

Selected References:
Appendix G: Consent form

Students & Parents/ Guardians,

Mr. Brand’s advanced science classes will be using case studies this spring as a part of the science curriculum in hopes of making learning more meaningful for the students. A case approach emphasizes active construction of knowledge gained from simulated experience. Because of this, I have been utilizing case studies in my instruction at Delta for several years. There is strong evidence to indicate that case studies are a powerful form of instruction at the post-secondary level but little information has been gathered on its impact at the high school level. As a part of my doctoral research, I will be collecting pre and post data from student participants at Delta High School in hopes of analyzing the impact of case study instruction on the development of critical thinking, confidence as a learner and self-guided study skills, and finally attitudes toward life science and careers in life science.

Study Title Analysis of Medical Explorers: A Case Study Curriculum

Inclusion/Exclusion Criteria
To be eligible to participate in this study, your child must be a junior or senior who is currently enrolled in an advanced life science course.

Participation Procedures and Duration
For this project, your child will be asked to complete a series of pre and post instruments about his/her development of critical thinking, confidence as a learner and self-guided study skills, and finally attitudes toward life science and careers in life science. These instruments will be in the form of multiple choice questions, scaled response opinion questions, and there will be no open ended questions. The three pre and post instruments will be completed at Delta High School through a secure online testing site and in print form. It will take approximately 50-55 minutes to complete the three instruments. All students in the class will be involved with the case study curriculum and pre and post analyses as a regular part of the course. A participation grade will be given as a normal part of the course grade for completing each analysis to the best of their ability and not on personal performance.

Volunteering to allow or not allow your child’s individual data from the pre and post data analyses to be used in this study will have no positive or negative impact on any student’s grade. All students who return a completed student/ parent consent form to Mrs. Lewman within one week, regardless of your choice to participate in the study or not, will receive bonus points toward their course grade which will account for no more than 1% of your overall grade.

Data Confidentiality or Anonymity
All consent forms MUST be submitted to Mrs. Lewman so that Mr. Brand is blind to the participation of any student in this study. Mrs. Lewman will randomly assign each student a unique identifier code and no names will be used on any of the analyses. Consent forms will be retained for two years by Mrs. Lewman in a locked cabinet and then will be shredded. Coded data without student names will then be passed on to Mr.
Brand. All data will be maintained as confidential and no identifying information such as names will appear in any publication or presentation of the data.

**Storage of Data**
Paper data will be stored in a locked filing cabinet in Mr. Brand’s office for three years and then be shredded. A unique alphanumeric identifier code will be assigned to each student and student names will not be linked to any stored instrument data. A master list of individual identifier codes will be stored by Mrs. Lewman until all post data has been collected and then will be shredded. The data will also be entered into a software program and stored on Mr. Brand’s password-protected computer. Only members of the research team will have access to the data.

**Risks or Discomforts**
The only anticipated risk from participating in this study is that your child may not feel comfortable answering some of the questions or may be anxious concerning their performance on the critical thinking analysis. Your child will be informed during the assent process that he or she is only asked to do his or her personal best, may choose not to answer any question that makes him/her uncomfortable, and he/she may quit the study at any time.

**Who to Contact Should Your Child Experience Any Negative Effects from Participating in this Study**
Should your child experience any feelings of anxiety, there are counseling services available to you through the Delta High School student counseling office, 288-5597.

**Benefits**
One benefit your child may gain from participating in this study is a better understanding of how case study instruction benefits them as an individual learner, and will hopefully make learning more meaningful for them. Participation will primarily aid science educators at the state and national level in obtaining information which hopefully will improve science education and make learning more meaningful for your child as well as for all students.

**Voluntary Participation**
Your child’s participation in this study is completely voluntary and you are free to withdraw your permission at anytime without penalty or prejudice from the investigator. Please feel free to ask any questions of the investigator before signing this Parental Permission form and at any time during the study.

**IRB Contact Information**
For one’s rights as a research subject, you may contact the following: Research Compliance, Sponsored Programs Office, Ball State University, Muncie, IN 47306, (765) 285-5070, irb@bsu.edu.

If you have any questions or concerns please contact Mr. Brand at lbrand@delocmschools.org or 288-5597 (ext 1229) or Mrs. Lewman at alewman@delocmschools.org.
Analysis of Medical Explorers: A Case Study Curriculum

Student participant:

I, ____________________________ ( DO / DO NOT ) wish to allow my pre & post analyses data to be used in this study. Your signature on this form means that you understand the information presented. You understand that participation is voluntary, and you may withdraw from the study at any time.

Participant signature: ________________________________ Date: __________

If the student participant is under the age of 18 a parent signature is required.

I ____________________________ ( DO / DO NOT ) wish to allow my child ____________________________’s pre and post analyses data to be used in this study. Your signature on this form means that you understand the information presented. I understand that only my child’s data will be used and that their name will never be used as a part of this study. You understand that participation is voluntary, and your child may withdraw from the study at any time.

Parent (guardian) signature: ________________________________ Date: __________

Researcher Contact Information

Principle Investigator: Faculty Supervisor:
Lance G. Brand, Graduate Student Dr. William Rogers
Biology Department Biology Department
Ball State University Ball State University
Muncie, IN 47306 Muncie, IN 47306
Telephone: (765) 288-5597 Telephone: (765) 285-8801
Email: lgbrand@bsu.edu Email: wrogers@bsu.edu
## Appendix H: Experimental Group Descriptive Data

<table>
<thead>
<tr>
<th>Student Code</th>
<th>Consent (+ / -) or NR (Not returned)</th>
<th>Gender M/F</th>
<th>Ethnicity: C- Caucasian, AA - African American, H- Hispanic, A - Asian, O - other</th>
<th>Grade Level</th>
<th>SAT or PSAT (Math / LA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>Y</td>
<td>F</td>
<td>C</td>
<td>12</td>
<td>480-560-530</td>
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<tr>
<td>E2</td>
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<td>C</td>
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<td>M</td>
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## Appendix I: Control Group Descriptive Data

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<th>Grade Level</th>
<th>SAT or PSAT (Math / LA)</th>
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Appendix J: Experimental group MSLQ Subcategory Data

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Appendix K: Control Group MSLQ Subcategory Data

MSLQ scores are based on a likert of 1-7 which for analysis purposes was converted to a 0-6 scale. Questions corresponding to each subcategory are indicated.

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Appendix L: Written & Verbal Announcement of the Study

The following announcement was to be read verbally in class by both the key investigator and key personnel, displayed on an overhead projector, and a printed copy will be given to each student to take home.

In class this semester you will be using case studies as a part of the science curriculum in hopes of making learning more meaningful. A case approach emphasizes active construction of knowledge gained from simulated experience. An example of this would be a situation where you would take on the role of a physician and go through the process of diagnosing and developing a treatment plan for a simulated patient. As a part of Mr. Brand’s doctoral research, he would like to collect pre and post data from student participants in hopes of analyzing the impact of case study instruction on the development of critical thinking, confidence as a learner and self-guided study skills, and finally attitudes toward life science and careers in life science.

All students in the class will be involved with the case study curriculum and pre and post analyses as a regular part of the course. Being a participant in this study is voluntary and you will only be asked to complete all pre and post data collection instruments to the best of your ability, you may choose not to answer any question that make you uncomfortable and may quit the study at any time. The pre and post instruments are designed to measure changes in the development of critical thinking, confidence as a learner and self-guided study skills, and finally attitudes toward life science and careers in life science. These instruments will be in the form of multiple choice questions, scaled response opinion questions, and there will be no open ended questions. The three pre and post instruments will be completed in paper and pencil form. All pre and post instruments will be completed during the normal class hour and will not require any preparation on your part. A participation grade will be given as a normal part of the course grade for completing each analysis to the best of your ability and not on personal performance. Volunteering to allow or not allow your individual data from the pre and post data analyses to be used in this study will have no positive or negative impact on any student’s grade.

If you choose to allow your pre and post analyses data to be used as a part of this study, published results will not contain any individual student name(s), all identifying information will be secured by Mr. Brand and limited to only those directly involved in the research study so all individual data collected will remain confidential. Participation will primarily aid science educators at the state and national level in obtaining information which hopefully will improve science education and make learning more meaningful for you as well as for all students.
Please take home the student / parent consent form and discuss your participation with your parents. If you are willing to participate in this study and allow your coded data to be used, both you and your parent need to complete the form and circle I “DO” wish to allow my pre & post analyses data to be used in this study. If you do not wish to participate in this study and allow your coded data to be used, please complete the form and circle I DO NOT wish to allow my pre & post analyses data to be used in this study. All students who return a completed student/parent consent form to Mrs. Lewman (media specialist) within one week, regardless of your choice to participate in the study or not, will receive 10 bonus points toward your course grade which will account for no more than 1% of your overall grade. To secure the anonymity of your choice to participate or not participate in this study, your consent forms must **ONLY** be returned to Mrs. Lewman so that Mr. Brand is unaware of your choice.

If you have any questions or concerns please contact Mr. Brand at lbrand@delcomschools.org or 288-5597 (ext 1229) or Mrs. Lewman at alewman@delcomschools.org.
Appendix M: Superintendent letter of support

OFFICE OF SUPERINTENDENT
DELAWARE COMMUNITY SCHOOL CORPORATION
7821 State Road 3 North
Muncie, IN 47303
Phone: 765-284-5074
Fax: 765-284-5259

Board of Education
John Adams, President
Sean Burcham, Vice-President
Tyece Stetilis, Secretary
Nord Heban, Member
Trent Fox, Member

Steven R. Hall, Superintendent
Darin K. Gillen, Assistant Superintendent

November 2, 2009

BSU IRB Committee
Ball State University
Muncie, In

Dear Committee,

Please accept this letter of support for Lance Brand, Delta High School, in his dissertation research. Lance is an outstanding educator. He is dedicated to his profession on so many levels. He has, and continues to offer outstanding instruction to his students on a daily basis. He is well prepared and knowledgeable of both subject matter and pedagogy. He is an excellent role model both in the classroom and in the community. He is well respected by his peers, other professionals and has served on numerous state committees to help improve the educational programming throughout the state. He is a dual credit instructor and is a past Milken Education Award winner.

Lance has taken great care to respect the privacy of the students who would be involved in his research. Parental permission is required to participate and student confidentiality has been addressed and as a school superintendent I am satisfied that Lance will honor and maintain the integrity of his study.

I believe the outcome of this research may have an impact on the method and delivery of instruction currently being used in many classrooms. Additional investigation on the impact of case based instruction in regard to student achievement and understanding can only aid in the delivery model. Our students participating in this type of research may aid science educators in obtaining information and insight that will make learning science more enjoyable, more meaningful and more relevant.

In summary, I support Lance Brand in his efforts to conduct research that is meaningful to his classroom instruction. As a school corporation we appreciate his willingness to put in the time and effort to do meaningful investigation which may impact the overall learning of our students. We will work cooperatively with Lance and provide resources when available to help him complete his study. Thank you for your consideration of this research project.

Sincerely,

Steven R. Hall
Superintendent
Delaware Community School Corporation
Appendix N: Medical Explorer Author Letter of Support

Rick Crosslin  
348 W. Marion Street  
Danville, IN 46122  
November 15, 2009

Lance Brand  
Teacher – Dissertation Student  
Medical Explorer, Timmy Foundation  
2112 N. Sierra Dr.  
Muncie, IN 47303

Dear Lance:

I am pleased to learn that you and your students have been using the Medical Explorer science curriculum in your study and classroom. As the author of the Medical Explorer unit of study I give you full permission for you to use the materials for your project.

I have reviewed your lessons and plans for your project. Your efforts have brought this project to many more students. Thank you for selecting Medical Explorer for study. I look forward to your results.

If you need any further help, please contact me at your convenience to schedule a meeting. You can reach me by phone at 317-250-8474 or by e-mail at RickCrosslin@comcast.net.

I look forward to hearing from you.

Sincerely,

Rick Crosslin