

Measurable Effects of Elementary School Technology Education (ESTE) Relating to
Math Scores of Fifth Grade Students Resulting From Participation in an
ESTE Unit of Instruction Pertaining to Electricity at River Heights
Elementary School Menomonie, Wisconsin

by

Henry V. Amberson

A Research Paper

Submitted in Partial Fulfillment of the

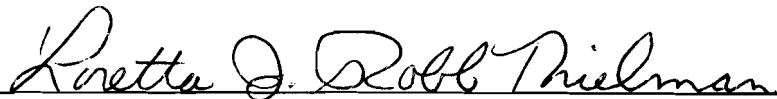
Requirements for the

Master of Science Degree

In

Industrial Technology Education

Approved: 2 Semester Credits

A handwritten signature in cursive script, reading "Loretta J. Thielman". The signature is written in black ink and is positioned above a horizontal line.

Dr. Loretta J. Thielman

The Graduate School

University of Wisconsin-Stout

August, 2006

**The Graduate School
University of Wisconsin-Stout
Menomonie, WI**

Author: Amberson, Henry V.
Title: *Measurable Effects of Elementary School Technology Education (ESTE) Relating to Math Scores of Fifth Grade Students Resulting From Participation in an ESTE Unit of Instruction Pertaining to Electricity at River Heights Elementary School Menomonie, Wisconsin*
Graduate Degree/ Major: MS Industrial / Technology Education
Research Adviser: Dr. Loretta J. Thielman
Month/Year: August, 2006
Number of Pages: 77
Style Manual Used: American Psychological Association, 5th edition

ABSTRACT

The following is quasi experimental study of Elementary School Technology Education (ESTE) and the potential to affect math test scores of 5th grade students at River Heights Elementary School, Menomonie, Wisconsin after participation in a 6 day unit of instruction pertaining to electricity. Though the average difference between pretest and posttest scores increased, the change, when compared to the control group, with multiple regression analysis revealed a statistically significant increase in the scores of the control group over those of the experimental group. This was contrary to the hypothesis, but additional research is suggested to attempt to detect long term changes in student ability resulting from participation in ESTE.

The Graduate School
University of Wisconsin Stout

Menomonie, WI

Acknowledgments

The author wishes to thank his wife, Beth, for being patient, understanding, and supportive through the entire project. The cooperating teachers; Kia Xiong (Science), and Jim Hansted (Mathematics), at River Heights Elementary School, Menomonie, Wisconsin, were instrumental in the teaching and testing phases of the experiment. The generous support of three local businesses was essential to the educational process on which the experiment was based:

Amberson Consulting Design & Fabrication donated significant backing of time, materials, & funding to provide educational props and kits.

Schneider Electric Motors donated copper wire for the electromagnet portion of the class project.

K-Mart, of Menomonie, donated paint sticks for the structure of the class project.

Special thanks to Dr. Loretta J. Thielman are in order for her time, guidance, and support.

TABLE OF CONTENTS

| | Page |
|---|------|
| | |
| ABSTRACT..... | ii |
| Chapter I: Introduction and Basis for Study..... | 3 |
| <i>Introduction</i> | 3 |
| <i>The Nature of Elementary School Technology Education (ESTE) and the Potential to Affect Learning in Other Subject Areas.</i> | 3 |
| <i>The Argument for Implementation of ESTE.</i> | 4 |
| <i>The Need for Research</i> | 5 |
| <i>Basic assumptions of the study.</i> | 6 |
| Chapter II: Review of Literature..... | 7 |
| <i>Preview of Chapter</i> | 7 |
| <i>Historical Background of ESTE as Method</i> | 9 |
| <i>Sense-realism versus structured education.</i> | 9 |
| <i>The object method of education</i> | 10 |
| <i>Victor Della Vos developed an effective method of instruction for engineering students.</i> | 12 |
| <i>Otto A. Solomon developed a system of instruction called Sloyd</i> | 13 |
| <i>Manual Arts consolidated Manual Training and Sloyd.</i> | 14 |
| <i>Industrial arts replaced manual arts.</i> | 14 |

| | |
|---|----|
| <i>The aims of Industrial Arts became divided.</i> | 15 |
| <i>Theories & Supporting Research as a Justification for ESTE as Method.</i> | 17 |
| <i>What is Elementary School Technology Education?</i> | 17 |
| <i>Multiple intelligence theory and technology education, do they suggest common approaches to education?</i> | 18 |
| <i>Mastery learning and technology education.</i> | 25 |
| <i>Potential of ESTE to affect learning by integrating other subjects.</i> | 28 |
| Chapter III: Methodology | 37 |
| Chapter IV: Analysis of Results | 39 |
| Chapter V: Summary, Conclusions, & Recommendations | 39 |
| References | 43 |
| Appendix A: Glossary | 49 |
| Appendix B: Pre-test | 52 |
| Appendix C: Post-test..... | 56 |
| Appendix D: Instructions to Those Administering Tests | 60 |
| Appendix E: ITEA Standards & Benchmark Topics Grades 3-5 | 62 |
| Appendix F: Lesson Plans for the Experimental Unit of Instructions | 67 |
| Appendix G: Materials Lists..... | 73 |
| Appendix H: Data..... | 74 |
| Appendix I: Statistical Results..... | 76 |

Chapter I: Introduction and Basis for Study

Introduction

Technology education is newly situated to become an integral part of the educational process at the elementary level within the United States. In the year 2000, the International Technology Education Association (ITEA) released the *Standards for Technological Literacy: Content for the Study of Technology*. These standards represent the culmination of years of growth, cooperation and consensus between ITEA, numerous governmental agencies, associations, and hundreds of teaching professionals. (ITEA, 2000) This occurrence also represents an opportunity to develop a model of education at the dawn of the new millennium that integrates new and old educational philosophies to meet the needs of the coming generation. As educators in the United States take steps toward a fully deployed kindergarten through twelfth grade system of technology education a more pressing need emerges for research that supports and justifies the dynamic relationship between technology education and other subjects. Some aspects of this perceived relationship, though based on sound reasoning and historical arguments, may or may not impact the educational process as intended or designed.

The Nature of Elementary School Technology Education (ESTE) and the Potential to Affect Learning in Other Subject Areas.

ESTE is believed to provide an environment that enables students to apply learning from other subject areas. This is theoretically accomplished by providing

concrete experiences that reinforce prior learning and serve as scaffolding to support educational growth and development. Few schools have actually adopted this system of education, even though, according to Foster & Kirkwood, it could solve many problems within the United States. (1997, p. 3) In addition to aiding the learning process directly, the activities provided in the ESTE classroom give students opportunities to learn and solve problems together with other students. “Technology activities in the elementary school classroom are usually cooperative activities, and research suggests that collaboration yields unexpectedly favorable results.” . . . “the role of hands-on activities in teaching abstract concepts is being discovered by more and more teachers and researchers. Examples can be found in mathematics, science, social studies and language curricula” (p. 14).

The Argument for Implementation of ESTE.

The ITEA standards were developed in cooperation with the National Research Council, National Academy of Engineering, National Science Foundation, and the National Aeronautics and Space Administration. This effort may be interpreted as a significant endorsement of the standards. The ITEA advocates the use of technology education as an integrator of subject matter for classrooms within the US to augment learning in other subject areas. (ITEA, 2000)

Bonser, a prominent advocate of one of the predecessors of ESTE, (1922, p. 131) stated that “Drawing sharp lines between the subjects is artificial and wasteful. Furthermore, it is entirely unnecessary in the degree usually found in

elementary schools.” Based on this statement, one could assume that Bonser favored integration of subject matter in much the same way that it is currently favored by the ITEA. The isolation of science and mathematics subjects “hinders students’ ability to function as effective problem solvers” according to Underhill & Abdi (1994, pp. 26-29). If ESTE does in fact function as an integrator of subject matter as proposed by the ITEA (ITEA, 2000), then a logical conclusion is that implementation of ESTE would reduce or eliminate the barriers described by Underhill & Abdi, resulting in increased student ability to solve problems. Furthermore, increases in student knowledge or ability would also result in a measurable increase in student ability that could be detected by a corresponding improvement in test scores in the area of interest. Apparently this tenet is currently unsupported by documented research.

The Need for Research.

A theoretical justification for implementation of ESTE could be made on the basis of research that would test for the presence of a statistically significant correlation between participation in ESTE activities and statistically significant increases in mathematical ability. Research has been conducted that supports theories that ESTE, or its predecessors, increase student interest in other subjects. According to Zuga (1997) increased achievement in other subjects has not been linked to participation in ESTE. The arguments for ESTE may be compelling enough to justify increased implementation however, understanding more

completely just how students may benefit from ESTE might allow educators to exploit ESTE more fully or modify approaches to ESTE if necessary.

Design of the study and hypothesis

The study is a quasi experimental design in which two pre-existing groups of fifth grade students take a pretest of mathematical ability. The control group receives previously scheduled science lessons for six days while the experimental group receives a special unit of instruction in Elementary School Technology Education followed by a post test given to both groups. After the close of the experiment, the control group receives the same unit of ESTE instruction while the experimental group receives the previously scheduled Science unit already received by the control group. The hypothesis is that participation in a unit of ESTE will result in a statistically significant increase in test scores of the experimental group when compared against the control group.

Basic assumptions of the study.

The design of this experiment is predicated on several basic assumptions.

1. There is not a significant difference between the experimental and control groups.
2. Interaction of the two groups is minimal.
3. The abilities of the experimental group respond to the experimental treatment prior to the administration of the test instrument.
4. The test instrument is a valid measure of student ability.

Limitation of the study.

The results were not intended to be generalized. Adequate characterization of the experimental and control groups for generalizations to be made, is beyond the scope of this experiment. The modified test instrument for this study was originally given at the beginning of the school year. The use of the instruments nearing the close of the school year may influence the results.

Chapter II: Review of Literature

Preview of Chapter

Elementary School Technology Education is the current manifestation of a range of educational approaches and philosophies that value learning which occurs experientially as children encounter the world around them. This happens as children engage in activities designed to increase the relevance of learning through the medium of technology. (Welty, 1997, p. 168). ESTE may occur in the general education classroom or in classrooms designed specifically for the purpose of ESTE. For the sake of simplicity, references to ESTE will include not only ESTE but also those educational antecedents that contributed to current educational approaches associated with technology education for the elementary grade levels.

Historically the educational approach of ESTE has been upheld as a method of education that follows pedagogical principles put forward by Pestalozzi, Froebel and Comenius among others. More recently however, ESTE appears to be

advocated as not only a method of education but as a topic of education with its own subject matter and content. According to Wright (1999, p. 57) the value of ESTE may be characterized in at least two different ways, content and method. As content, ESTE is thought of as a unique body of knowledge relating to technology, its effects and its uses. The objective of this approach is the acquisition of this knowledge by the student. As method, ESTE may be regarded as a vehicle to achieve educational objectives outside of those specific to technology education.

The release of the ITEA standards confirms significant impetus of leaders in the field of technology education to justify the content of ESTE. At the same time, numerous statements within the ITEA standards provide evidence of endorsement for the method approach. The argument for content is largely based on opinion and rationale. While significant historical evidence relating to pedagogy affirms the method approach, little in the way of supporting research is documented. (Zuga, 1997) This historical basis forms a weak argument with little or no track record to generate evaluative measures from which to draw conclusions about the overall effectiveness of this approach to education. The following represents an attempt to bring to the fore the historically significant theories relating to ESTE and its predecessors, as well as research that may support the use of ESTE as a method to teach and support other subjects. It is also apparent that the body of knowledge surrounding Technology Education and its effects consists primarily of anecdotal evidence, theories and opinions that deserve critical scrutiny and further

research. The focus of this investigation is on the potential of Technology Education to affect learning in other subject areas.

Historical Background of ESTE as Method

Sense-realism versus structured education.

Wolfgang Von Ratich attempted and failed to implement a successful educational system based on sense-realism and many of the details of his system and the reasons for its failure are not completely understood, however according to Barella & Wright (1981 pp. 21-23) John Amos Comenius was open to the theory and encountered some measure of success by applying the following guidelines:

1. Everything should be taught according to the courses of nature.
2. Only one thing of the kind should be taught at one time.
3. Repetition reinforces learning; therefore, repeat often.
4. Everything should be taught in the mother tongue first. (This seems like a strange principal until one recalls that in the humanistic schools, instruction was conducted in the classical languages.)
5. Teaching should be done without violence; the pupil must not fear the teacher.
6. No learning should be done by rote.
7. There should be uniformity in teaching things.

8. The object should be taught first, then the characteristics of the object.
9. All learning should be accomplished through experiences and investigation.

(Barella & Wright Eds., 1981 p. 21)

In an attempt to glean from these guidelines a sense of the educational method that Comenius advocated, one may dismiss points two, three, five, and seven, as points not directly related to the topic of inquiry. A review of the remaining points may result in some of the following conclusions. By speaking out against rote memorization in point six, one might assume that Comenius intended for genuine understanding to occur in the mind of the learner, not just reflections of the constructs of the instructor. From point four, one may deduce an intention to remove the obstacle of language making communication as simple and uncomplicated as possible. Points one, eight, and nine together indicate a tendency toward a model of education that emphasizes a tactile engagement between the world, objects within the world, and the student.

The object method of education.

Bonser & Mossman credited the school at Oswego, New York, with being the first school in the US to embrace Pestalozzian principles and the first to teach the principles of kindergarten as Froebel proposed. (1936, p. 464, p. 465)

However, as French, 1964, pointed out, "Not all who visited Pestalozzi warmed themselves at his heart. Some took isolated ideas home and

formalized them. This was particularly the case with the Reverend Charles Mayo and his sister Elizabeth, who developed formal lessons on objects rather than lessons from objects", p. 130. This educational fact distorted Pestalozzian ideas toward verbalism without understanding. Cubberly, 1919, described the variance between Prussian and English object teaching by writing, "Where German lands received both the method and the spirit, the English obtained only the form", p. 269. (Barella, Wright Eds. 1981, p. 100)

From the preceding statements, it can be seen that in many ways the Mayos at Oswego, stepped away from sense-realism, even though in name they strove toward it. Mossman (1924) summarized her investigation into the origins of lesson planning in the US with a rigid system attributed to Pestalozzi, and a clear and distinct yet more flexible plan associated with Herbart's influence. However, given the preceding quotation it is quite possible that the novel implementation of the object lesson in America may have drifted from Pestalozzi's intent, yielding incorrect interpretations of Pestalozzi's method to be drawn on American soil. It is possible to conclude based on this atmosphere of dissent that some educators clearly envisioned learning not far removed from real life and based on significant interaction with objects as Pestalozzi may have originally intended. This constitutes both the method and the spirit of Pestalozzi's object method of teaching.

Victor Della Vos developed an effective method of instruction for engineering students.

The manual training movement was developed originally by Victor Della Vos of Russia to augment theoretical instruction in engineering. Relative to ESTE, one can assume that motivation of the post-secondary student was significantly different than what motivation might have been needed for elementary students. However, even within the engineering curriculum of Della Vos, three components complimented each other to provide an effective educational method. The first component was the manual training series of exercises used to establish competency among students in manual skills. The second component was the theoretical training of the engineering curriculum. The third component was the real life experience gained by serving in the school's shops that built actual products for industry. The manual training component of this program was rigorous, but it was also part of a larger educational system that provided a complete post secondary education with motivation and training that was appropriate for its students. In summary, Manual Training was only a small component of the educational model and its success was based on more than just the series of exercises traditionally associated with Manual Training.

Stombaugh, (1936, p. 22) mentioned that as educators attempted to implement manual training, a text book was developed in order to make instruction more efficient by minimizing the need for individualized instruction. The

efficiencies of this change represent a compromise that may have eroded some of the core values of this approach to education. For students with difficulty reading, this subtle shift might have become an insurmountable barrier to the acquisition of manual skills. On the other hand, a text could be seen as a reading challenge coupled with sufficient motivation for the student to overcome reading difficulties resulting in improved reading ability and acquisition of the subject matter. In any case, the presence of a text represents a significant deviation from the principles of Pestalozzi.

The educational merits of manual training on the elementary level may have emerged from the development of a basic skill set early on, that paved the way for the introduction of more complex concepts later in the curriculum. Educational motivation for such a system could have been derived from the sheer delight that children often display as they develop simple motor skills.

Otto A. Solomon developed a system of instruction called Sloyd.

The movement called Sloyd was based on hand crafts and spread within the US through significant effort on the part of Gustaf Larsson. This Swedish system grew in the US together with manual training particularly in the earlier grades. Instruction was project oriented, often based on models that students could observe, measure, touch, and feel, as they created their own project with few obstacles to the domain specific learning of hand crafts. As the student would create a bird or spoon out of wood, there were no dimensioned drawings to work

from. The student would look at the model directly and replicate it. If measurements were required by the student, they were taken directly from the model rather than from a drawing. A child possessing manual skill would not be hindered or impeded by a deficiency in the verbal linguistic domain. However, the utility of verbal abilities might have been more apparent to the student through such activities.

Manual Arts consolidated Manual Training and Sloyd.

Once a significant movement in the US, manual training gave way to manual arts. The major difference being largely one of motivation for students. In the manual arts system, a series of useful projects replaced the series of exercises characteristic of manual training. The term manual arts represented the merger of manual training and Sloyd. This resulted in a project that the student would take home upon completion. Slightly more emphasis may have been placed on the precision of such projects than with Sloyd alone as the manual training approaches melded with Sloyd.

Industrial arts replaced manual arts.

In 1904 the term industrial arts began to replace manual arts as a more accurate reflection of the methods used in producing projects. Manual training and manual arts developed skills primarily with hand tools. The term industrial arts was adapted to address the mechanization of industry and the need for students' learning to adapt to those methods found in industry. A significant definition of industrial

arts is that of Bonser & Mossman (1936, p. 5) cited in the glossary. Bonser & Mossman, saw industrial arts as a study for all students as part of a general education. The use of industrial arts as method was of primary importance and acquisition of skills, though a valuable benefit of industrial arts, was listed only as a secondary benefit (p. 13).

The aims of Industrial Arts became divided.

Through the years following the introduction of industrial arts, debate as to the general direction of the field's multiple purposes arose. This division is evident in the following excerpt from a speech given in 1938. Though some supported one or another approach, they were not necessarily independent of one another.

There are two complementary phases or kinds of industrial education - the general or industrial arts phase, and the strictly vocational or training phase. These should be thought of not as mutually exclusive and different offerings, but as closely allied and interdependent parts of a complete service. (Smith 1938, p. 11).

The general education phase likely would have been based more on the method approach, while the vocational education phase might have been based more on the content approach. Arguments could be made that benefits would be evident in other subject areas resulting from both strategies. According to Wright (1999) the further division of the field into content and method approaches

developed significantly in the 1960's as curricula were developed that capitalized on the content of industrial arts. This became a significant force on the elementary level as industrial arts became a part of general education.

The release of the ITEA standards in 2000, presented the content approach, the method approach, and to a certain extent, the vocational approach consolidated under the umbrella of Technology Education. The content standards reflect age appropriate content to be mastered as the student progresses through the educational process. The education benchmarks cover the elementary ages and are a significant point of convergence for ESTE and the standards for math and science education. It could be debated that vocational education is also served by the current direction of ESTE even though it may be significantly different from vocational education as practiced earlier in this century. According to Maughan & Prince Ball (1999) the needs of contemporary industry are for workers that are capable of adapting in a quickly changing work environment. The following statement describes technology students as connected to today's world of work just as vocational education students were connected with industry in the past.

“It is pointless to conceive of technology education purely as liberal education, when the true strength of the subject may lie in its real-world connections. Context helps students give meaning to school knowledge, and work is an important context for technology in the real world. Technologists are workers” (Lewis, 1999, p. 50).

This contextual learning, combined with the increased relevance described by Welty, (1997, p. 168), might help student achievement in other areas. “ESTE does appear to significantly enhance career education efforts and increase students’ interest in other subject areas when used as a teaching method” (Wright, 1999, p. 61).

Whether the benefits of ESTE are most significant resulting from the content approach or the method approach, possible effects on student performance in other subject areas appear tangible. The goals and objectives of technology education and its predecessors have changed, but the importance of using ones hands and mind to accomplish or create something of value has been an essential part of the learning process associated with ESTE. This educational process was arguably present even before the beginnings of formal instruction as one individual naturally learned from another how to fashion a crude shelter, to find safe food, or any number of tasks that can be taught and learned.

Theories & Supporting Research as a Justification for ESTE as Method.

What is Elementary School Technology Education?

In the classroom of today, it may be confusing to educators just what ESTE is, and how it is to be applied and taught by teachers that have no formal training in its methods and/or content. Technology education easily becomes mixed up with educational technology. Calculators and computers in the classroom are frequently confused with technology education. (Childress & LaPorte, 1997)

These manifestations of technology, when used in the classroom, are educational technology, not technology education. (ITEA, 2000)

Foster & Kirkwood (1997), define ESTE as, “an educational program in which children engage in constructional activities designed to help them learn about themselves and the world around them.” As such, the content of ESTE is largely already present within many educational programs. “Construction activities in the elementary school are based on precedents dating back to early nineteenth century in the history of schools in the United States” (Gerbracht, & Babcock, 1959, p. 3). “The use of manipulatives and technology in elementary school mathematics education has been a major reform effort for several decades” (Childress & LaPorte, 1997, p. 77). Zuga (1997) documented contemporary approaches to ESTE at least as early as 1955 (p. 315). These examples of a long-time presence are not however, an indicator that the method of ESTE has been fully implemented or used to its full educational potential.

Multiple intelligence theory and technology education, do they suggest common approaches to education?

In the last two decades of the twentieth century a new concept of intelligence has emerged that has implications in the field of education. The term Multiple Intelligence (MI) was coined by Howard Gardner to describe the unique domains of a person’s intelligence more completely. He states that “we do not all have the same kinds of minds (that is, we are not all distinct points on a single bell

curve); and education works most effectively if these differences are taken into account” (Gardner, 1999, p. 91). MI theory is based on significant research relating to the structure of the brain and the biological connections to different intelligences and abilities in addition to anthropological considerations. There are at least seven intelligences proposed by Gardner; Linguistic, Logical-Mathematical, Musical, Bodily-Kinesthetic, Spatial, Interpersonal, and Intrapersonal. While additional intelligences are under consideration, the naturalist intelligence seems to be the most significant eighth candidate. (Gardner, 1999).

Gardner defines an intelligence “as a biopsychological potential to process information that can be activated in a cultural setting to solve problems or create products that are of value in a culture” (pp. 33-34). This definition bears an uncanny resemblance to the definition of Industrial Arts given in 1936 by Bonser & Mossman.

The industrial arts are those occupations by which changes are made in the forms of materials to increase their values for human usage. As a subject for educative purposes, industrial arts is a study of the changes made by man in the forms of materials to increase their values, and of the problems of life related to these changes. (1936, p. 5)

The theory of multiple intelligences is a suggestion that we do not have the tools to completely measure intelligence with standard intelligence tests, and that education is more effective when these different types of intelligence can be

strengthened and encouraged. Bird (1922) in a correlational study of machine shop students ranging in age from ten years six months, to sixteen years seven months, found little correlation between Stanford Binet intelligence quotient scores and scores of a series of assignments in a controlled laboratory classroom. This suggests that performance within the TE classroom is centered outside the realm of standard intelligence measures.

Gardner has documented systemic problems in the educational process and the performance metrics that allow some students to excel without developing true understanding.

These investigations document that even students who have been well trained and who exhibit all the overt signs of success - faithful attendance at good schools, high grades and high test scores, accolades from their teachers-typically do not display an adequate understanding of the materials and concepts with which they have been working. (Gardner, 1991, p. 33-34).

The similar observations of Gardner, Korwin & Jones and Wright (1999) seem to indicate the presence of a common educational phenomenon. Each observed a juxtaposition of students in conventional classrooms as MI theory and TE respectively, were applied. In each case cooperation and appreciation among students of varying performance levels was enhanced. As one looks at the theories and approaches surrounding education and more specifically Technology

Education, two key concepts prevail; Technology Education teaches using a different part of the intellect, and early learning should be as domain specific as practicable. (Ruskin, 1884, Stombaugh, 1936, Gardner, 1999, Gardner, 1991, and Beebe, 1902).

Wright's description of the failure of conventional testing to measure the beneficial aspects resulting from technology studies may be the key indication that ESTE activates alternate means of thinking and learning.

However, based on the few research studies available, it does not appear to significantly increase student performance in other subject areas. Perhaps measures other than standardized tests should be used. Indeed, standardized tests may not be designed to assess what children are actually learning or are able to do as a result of technological studies. (Wright, 1999, p. 61)

The theory of multiple intelligences appears to support Technology Education as a method that at least shares convergent philosophies of intelligence measures and the means to activate different intelligences. By teaching in such a way that a student who does not perform well in a more didactic environment would have the opportunity to grow and to perform in an area of potential strength that would not otherwise be recognized, the marginalized student may develop abilities to stay in the main stream classroom. For those that excel in the traditional educational environment these experiences could prove humbling and challenging. This scenario could promote appreciation and understanding of fellow classmates'

strengths and weaknesses as observed by Gardner and Korwin & Jones. This possibility is also held by other educational professionals evidenced by the following:

And, properly employed, it is ESTE that can allow the individual student to grow, to celebrate his or her individuality and to learn to get along with others by accepting challenges truly designed to prepare him or her for the future (Foster & Kirkwood, 1997, p. 20).

Such social values as those involved in sharing, respecting the efforts and property of others, accepting responsibility, appreciating the uniqueness of individuals, and understanding the purpose of economy in the use of materials are among the generally accepted goals of education today. (Gerbracht & Babcock, 1959, p. 8).

The need to engage all manner of intelligences to allow personal development is underscored by Gardener. “Even people who seemed gifted in a particular intelligence or domain will accomplish little if they are not exposed to materials that engage the intelligence.” (1999, p. 88). Additionally, Gardener observed that students that refrained from expressing one intelligence area or another could be coaxed to expression of another intelligence through what he called bridging activities. In this instance the student could easily transition from the area of strength to an area of presumed weakness. (p. 137)

Once the groundwork is prepared and the foundations for instruction in Technology Education are laid, the educator may begin to depart from wholly domain specific learning to learning that blends real objects with more abstract content such as the word pictures described by Beebe.

“This object must of necessity be a representation, more or less perfect, of the mental image that existed in the mind of its creator. The progress of such an image from its initial vagueness to clearness and definiteness is dependent upon the mode of its final expression. The least perfect method is by the written or spoken word, for all mere descriptions must be more or less vague. One common expression, "a word-picture," used in connection with any unusually good piece of writing or speaking, is a recognition of this truth. Next in order of completeness comes a drawing or a series of drawings representing the object; and lastly the actual object constructed from the necessary materials and giving the hitherto unreal an actual existence.” (Beebe, 1902, p. 88)

Similarly, following Gardner’s direction, “one must distinguish between language as a means of communication and language as the essence of learning. As long as viewers understand the questions and are comfortable speaking, language becomes a mere convenience, and the questions themselves soon become invisible.” (Gardner, 1999, p. 188). The student that is exposed to many concrete

experiences in an ESTE setting could then find learning in other domains to be more meaningful.

Research “does support the idea that technology education increases interest in other school subjects” (Zuga, 1997, p. 320). It seems logical, that increased interest in other subjects would result in increases in student achievement in related subject areas. The increased level of interest may be an artifact of the increased ease of the student to grasp concepts that have been reinforced by concrete experiences. As of yet increased student achievement in other subject areas has not been documented, but “reading comprehension as a skill and not as a subject matter seems to improve after exposure to technology education” (p. 321). By developing vocabulary in parallel experiences with concrete objects and language, a strengthening of verbal-linguistic aptitude could theoretically occur.

Bloom, Hastings and Madaus, found a high correlation between verbal ability and Grade Point Average (GPA), among high school and college level students. The urgency to develop verbal ability early in the educational process is underscored by their assertion that these improvements that can be expected to “diminish with increasing age.” (1981, p. 56). In other words, the efforts to improve verbal ability had a more significant impact when applied to younger students than when applied later in the educational process. Intervention is recommended in the preschool and elementary grades. This is further supported by the anecdotal evidence of Sukhomlinsky.

the earlier the child begins to read, the more naturally reading is connected with its entire inner life, the more complicated are the thinking processes which go on during reading, and the more reading gives to intellectual development. The child that begins to read before it is seven has gained a very valuable skill: its visual and mental perceptions of words and parts of sentences go beyond mere pronunciation of sounds. When reading, the child is not chained to the word. It can divert its gaze from the book and think through the meaning of the sounds. In such a fashion, the child reads, thinks, and imagines simultaneously. Our collective experience convinced us that precisely such fluent reading is one of the most important elements of reading with comprehension. (Sukhomlinsky, 1981, pp. 135-136)

If verbal ability could be improved by providing concrete experiences in Technology Education, and early intervention is recommended, then the need for a program of ESTE becomes more urgent.

Mastery learning and technology education

The concept of mastery learning is based on the proposition that if given sufficient time, students of a range of ability levels can be taught in such a way that all students can be elevated to a level of superior performance or mastery. Typically, teaching and learning in schools is optimized for the good of the group rather than for the individual. (Bloom, Hastings & Madaus p. 55). This means that students requiring more time for mastery will perform poorly in a setting that

allows a percentage of students to fall below acceptable performance measures. The significance of mastery learning lies in the ratio of time required for mastery between students performing in the upper fiftieth percentile and those in the lower fiftieth percentile. (p.59). Through early intervention, this ratio may be reduced from about six to one to a ratio of less than two to one. (Bloom, 1974 in Bloom, Hastings & Madaus, 1981, p. 59). Reducing this ratio through early intervention may increase the efficiency of instruction. By addressing fully the diverse needs of the preschool and elementary level learner through a wide range of educational approaches and media, the needs of the average student in middle and secondary school could become more homogeneous. The use of ESTE as an alternate means of reaching marginal students corresponds with Gardner's assertion that "...any uniform educational approach is likely to serve only a small percentage of children optimally." (1999, p. 91).

Whether in the ESTE classroom or elsewhere, the need to experience domain specific learning is stressed by Gardner. (1999, p. 88). By combining the promise of more uniform acquisition and mastery among students with the promise of higher grade point averages in later years, the need to intervene early in the life of the student with an educational approach that addresses differing abilities and ways of learning becomes paramount. As Bauder (1938, p. 7). suggested, the resources of the school should be adapted "to the diverse needs and abilities of different groups." This is similarly stated by Dewey and Sukomlinski.

Speaking generally, the younger the child, the greater the role of overt, as distinct from implicit, activity. . . . With increasing maturity, the ratio of implicit activity increases. But there are also great individual differences. . . . Differences show themselves early in life. Some children are distracted and confused by the amount of doing that is a stimulus to others, while the latter are benumbed by conditions that are suited to the former. (Dewey, 1934, p. 82)

the essence of thinking, is only possible when either a real, vivid example or an extremely clear verbal picture, through which the child can "see, hear, and feel" what is being discussed... (Sukhomlinsky, 1981, p. 53-54)

By adapting and channeling educational resources to diverse student needs early in the educational process, learners as a group, will develop a more homogeneous skill set and be better adapted to public education. The importance of early intervention is underscored by the strong possibility that resources may not be available to meet the needs of an educationally diverse student body later in the educational process. For example consider the cost of providing a relevant concrete learning experience elementary school as compared to a relevant secondary level experience. If the elementary level experience is provided, the basis for understanding a text book description of an experience allows the student to clearly imagine the process if not possible to reproduce in the classroom. Alternatively if denied the elementary level experience, the complexity of the elementary level

experience must be increased to maintain relevance to the students on the secondary level but if already constrained by cost the experience is degraded to such a point that it lacks relevance to students at both the upper and lower range of the performance spectrum. This alternative lacks relevance because the new concept is presented one step removed from truly contextual learning and because of the absence of the introductory scaffolding at the elementary level. The ideal learning experience then becomes a more costly demonstration involving costly equipment, materials and space that could be in jeopardy if cost is a concern. It is ESTE that can facilitate subject-matter integration and help teachers and students efficiently meet objectives. (Foster & Kirkwood, 1997, p. 20).

Potential of ESTE to affect learning by integrating other subjects.

In many respects Technology Education could provide a venue for the application and expression of learning from other subject areas. Beebe describes the activity of expression as the goal of the educational process through which the effectiveness of the educator may be measured.

Froebel, the founder of our kindergarten system, thus expresses this psychological fact : "The educator must make the external internal and the internal external." That is, he must so elucidate and make clear the essential facts of the subject in hand that they enter into and become part of the very being- of the pupil. This, however, is but half the task of the true educator, for he must then by some means or other enable the pupil to make this

internal external; that is, he must give the pupil the power to again give out what he has taken in, and enriched with his own personality. The individual must have ideas to express, but, having them, they are worthless unless he can make them useful to, and understood by, others. (Beebe, 1902, p. 88)

The opportunity to evaluate student understanding of concepts and ideas mentioned by Beebe is dependent on real world situations in the Technology Education classroom that truly test the abilities of the learner and can winnow out false understandings and misapplication of principles. The facility with which educators can measure the progress of the learner is a significant fringe benefit but the motivational aspect of Technology Education may be even more significant according to Gerbracht & Babcock. "The opportunity to work with material things is not the only type of motivation the teacher can use, but it is a forceful one. The desire to work with tools to make things is strong in most children." (1969, p. 18). Similarly, Vance was emphatic about the enthusiastic responses of students in a similar educational setting.

Pupils have always shown preferences for subjects that require physical as well as mental adjustment. . . . Manual training, sewing, cooking, art, physical education, band, orchestra, and typing are more popular with a greater number of children than are history, Latin, mathematics, literature, and science. The activity school has utilized this knowledge. It is not uncommon in some schools for children to attend because they like to do so.

The interest and enthusiasm pupils show for extracurriculum activities reveal a human tendency that the administrator cannot afford to ignore if he is to plan wisely. (1938, p. 20).

Similarly, Bonser (1922) described industrial arts in the elementary grades as concrete learning that capitalizes on the natural tendency of children to learn by doing

industrial arts at the elementary (K-6) level is a means to an end. It is one avenue leading to generally accepted goals of modern elementary education. Industrial arts at this level involves material things; it is concrete and it is active; it includes making things, doing things, and using things (Gerbracht & Babcock, 1959, p. 1).

“Learning begins with contact with the real world, and establishing that contact is a fundamental task of the elementary school. Attempts at learning without such contact result in children acquiring incorrect, inadequate, or "hollow" meanings.” (Gerbracht & Babcock, 1969, p. 1). Though not advocating the reduction of concrete experiences later in the educational process, Richards does concede: “As the power of visual imagination increases, concrete expression plays a less and less necessary part,” (1901, pp. 7-8)

Every unit of work to be experienced is presented as something to be done. Some of these activities are constructive, some are investigative, and some are appreciative - all involve participation. In most of those listed, more

than one kind of activity is required. Constructive work is presented as a means of awakening intellectual inquiries, of giving meanings and values, of cultivating appreciations, and of leading on to further interests on levels higher than those apparent at the beginning of the constructions. Selections of work of all kinds are often deliberately made to stimulate an inquiring attitude of mind, to arouse a desire to find meanings and values, and to open up lines of interest and possibility for continued and permanent mental growth by thinking, aided by observation, experimentation, and reading. (Bonser & Mossman, 1936, p. vii)

“Technology activities by their very nature allow children to use a wide variety of materials and to engage in a wide range of activities” (Foster & Kirkwood, 1997, p.17) This ability of the TE classroom situates ESTE favorably as a tool to integrate the content of other subjects and to aid the student in assembling knowledge fragments into a usable whole. The direct method of observing learning and doing is illustrated by the following quotations.

The periodically recurrent theme of every educational reform and reformer from Rousseau clear through the years to our present day agitation for curriculum revision is always, in one way or another, the plea for a return from the artificialities and sterilities of formalized schooling to training through the stimulating realities of life as it must be lived. (Quigley, 1938, p. 38)

Educators are generally agreed that one of the prime objects of education is to fit the pupil for independent individual action. As Professor Wiliston has said, the demand today is for men of originality and energy who can do things that have never been done before; who can bridge over the gulf that has so long existed between thinking and doing. Herein lies the great strength of manual training, as it combines the thought and the action, resulting in a real object which, with greater or less success, embodies and presents to all who see it the ideas of the man who made it. (Beebe, 1902, p. 88)

“many leaders advocated the use of hand training to round out the education of youths and to supplement the seeming deficiencies of intellectual training” (Stombaugh, 1936, p. 17).

“Technology will be an essential part, as content, of everyone's education starting at the elementary school level. It appears that this infusion will occur, at least at the onset, through the integration of technology content principally with science and mathematics” (Childress & LaPorte, 1997, p. 70).

Bode (1942) while advocating the physical activity of industrial arts, tied the emotional and physical responses together theorizing that emotional responses are based on bodily responses. It is unclear just how this conclusion was drawn, but some current day educators propose that combining physical activity with learning

helps increase memory retention. Korwin & Jones (1990), concluded that technology education experiences aid the learning process by helping to increase both long term and short term memory retention. This may be true but Gardner (1999, p 90) discounts this association as an “artifact” that is trivial in nature. Essentially this approach uses multiple intelligence theory as a mnemonic device.

Incidental learning and introduction of concepts.

The concept of incidental learning or approaching a topic tangentially is described by Bode as a significant part of the educational method. This allows the student considerable latitude with the material to take ownership in the educational process.

Even a casual survey of the material gathered by the Committee reveals the fact that 'Activity Movement' in education is both comprehensive in scope and obscure in meaning. It suggests a kind of educational procedure in which physical activity is the most outstanding trait, but we soon learn that it goes considerably beyond this. It also suggests a procedure in which learning is incidental to other more 'practical' ends; but this suggestion likewise turns out to be misleading. If the reader harbors the notion that the activity movement stands for complete freedom, on the part of the pupil, in the selection of enterprises to be undertaken, he must be prepared to find that this freedom may be restricted to an undetermined degree. The Activity Movement, in brief, appears to include everything from 'incidental learning'

to any kind of learning that involves purposefulness and interest; or from the complete repudiation of 'subjects' to certain devices for facilitating the acquisition of previously organized subject matter. A reader who expects to gain a simple and workable notion of the Activity Movement merely from an inspection of this material is likely, before long, to find himself coming up for air. (Bode, 1934, pp. 78-79)

Similarly Welty describes the ability of technology topics to present the possibility for students to learn on many levels. Perhaps it is this tangential method of delivery that engages the marginalized students referred to in the previous section by creating more active learners.

“Many topics in technology are too sophisticated for elementary school students to genuinely understand. Although the students may not be ready to study a given technology in detail, the topic can still be used to provide a rich context for making other concepts and skills in the curriculum more relevant, interesting, and ultimately, more meaningful” (Welty, 1997, p. 168).

ESTE why is it needed on the elementary level?

Implementation of ESTE has been presumed to be coupled with increased achievement on a rather limited scope. “These results suggested that true mathematics and science curriculum integration and curriculum integration in the form of correlation may be effective in improving the science achievement of

elementary school students who are assessed at low-ability levels” (Childress & LaPorte, 1997, p. 83). Even though the recipients of this aspect of ESTE may be a limited number of students the implications for those students could be a significant intervention at a key point in the development of the individual student. The need for timely intervention and the cost of delay is upheld by the following statement.

The strong conviction that the pre-school and elementary years largely determine the future of the person, does not deny the possibility of re-educating the person in later years. The power of re-education was brilliantly demonstrated in the experience of Soviet educator Anton Makarenko. But he also recognized the exceptional significance of the early years. The proper task of education is not to correct mistakes made in early childhood, but to avoid making them in the first place, thereby eliminating the necessity for re-education. (Sukhomlinsky, 1981, p. 21).

Timely intervention of ESTE may help the marginalized student to find a place in the school by providing an alternate means of expression and learning as described by Struck.

Many pupils are poorly adjusted primarily under academic influence. They appear normal enough during out-of-school hours. Theirs is a mental set against "book-learning" but not against learning through doing. To many the industrial arts shop is a workshop not unlike those found in industrial establishments. (1938, p. 15).

Gardner too encourages the use of alternate methods of instruction stating "...any uniform educational approach is likely to serve only a small percentage of children optimally." (1999, p. 91).

Pertinent Research

Stevenson & Stigler (1992) after studying American, Chinese, and Japanese school children concluded that the influence of parents and the presence of a national curriculum, are the two most striking differences contributing to the poor mathematics test scores of American school children.

In a comprehensive side by side study Gunther (1931) trained classroom instructors in the methods of industrial arts and controlled variables of instruction from group to group. She concluded that the manipulative participation of industrial arts did in fact increase student learning over the conventional method of instruction. This appears to be the only research that correlates ESTE or in this case a predecessor to ESTE, with increased performance.

Zuga (1997) stated that little research based studies have been done in the area of ESTE. The majority of studies relating to ESTE were descriptive in nature, and were not characterized as "being rigorously descriptive, experimental, or evaluative" (p. 305). One cannot prove that there are no other studies that have been conducted that evaluate increases in student ability in other subject areas, but the lack of evidence appears to be an indication of need in this area. Additionally the arguments for the use of Elementary School Technology Education as a method

to convey other subjects list numerous benefits that are not yet proven or documented. It appears that there is much work to be done in order to support or refute the numerous claims made on behalf of ESTE and its predecessors.

Chapter III: Methodology

Two preexisting groups of students were selected for participation at River Heights Elementary School, Menomonie, Wisconsin. The primary reason for selection of the two groups was based on proximity to the University of Wisconsin-Stout, and a willingness of the school district and teachers to participate.

Participation in the experimental unit of instruction was conditional based on completed consent forms returned to the school for each participating student prior to testing and instruction. Some students were anonymously held back from taking the tests based on individual education plans that suggested administering a test would present a stressful situation for the student. These students were allowed to participate in the lessons without being identified to the researcher.

The pretest and post test instruments were derived with permission, from the instrument used by Stigler, Lee & Stevenson (1990), to evaluate American, Japanese, and Chinese fifth grade students' math performance. The original test consisted of fifty problems. The pretest was taken from the odd numbered problems and the posttest was taken from the even numbered problems yielding two 25 problem tests of mathematical ability. These appear in appendices A and B

respectively. A copy of the instruction sheet for administering the tests is included in Appendix C. The pretests and posttests were administered to both groups on April 15th 2002 and April 25th 2002 respectively with some additional post tests administered on April 26th 2002 and April 29th 2002 because of high absenteeism the date of the post test.

To protect the identity of the students each student was assigned a code number. The corresponding names and code numbers were known only by the regular classroom teacher. A list of code numbers and the associated sex and birth date of each participating student was given to the researcher to record the test results without specific knowledge of the identity of each student. The results of each problem from each student were tabulated in the same way that results were displayed by Stigler, Lee, and Stevenson, so that performance on individual problems could be evaluated if desired.

The unit of instruction pertained to electricity. The topic was selected because of its application and demonstration of mathematical principles. Lesson plans for this unit of instruction were created by researcher and are included in Appendix E. ITEA and Wisconsin State standards were cited for relevance on each lesson plan. The intended level of hands on learning to be encountered by the students was the assembly level according to Foster & Kirkwood, 1997. This is based on a ranking of; handling, manipulation, assembly, and construction, in order of increasing levels of difficulty (p. 19). The experimental group received the unit

of instruction April 16, 17, 18, 22, 23, & 24, 2002 while the control group received the unit of instruction April 29, 30, May 1, 2, 6, & 7.

Chapter IV: Analysis of Results

The data were assembled into a table using Microsoft Excel 2000. This table appears in Appendix G. Subject numbers begin at one hundred. Since subjects were removed from the study because of absence or education plans breaks in the sequence exist. Apart from these exclusions the data are presented complete. References to the Chicago Standard are the results obtained by Stigler, Lee, & Stevenson. (1990). Multiple regression analysis was run using Microsoft Excel 2000 on the complete data set. The results of each run were reviewed with respect to the standard error. The variable with the largest error was removed until only P values less than 5% remained. The values of the final regression analysis appear in Appendix H. The correlation that would support the hypothesis did not occur, in fact the opposite was observed.

Chapter V: Summary, Conclusions, & Recommendations

Though student mathematics test scores did increase above expected values, the increases in the scores of the control group were greater than the experimental group by a statistically significant difference based on regression analysis of the data at a ninety-five percent confidence level. One explanation for the increase above those values expected is that the Chicago values from Stigler,

Lee & Stevenson were generated from a single test taking event. The two part instrument allowed students the opportunity to improve their abilities in the time between the two tests.

The experimental design failed to control or characterize the activities of the control group lessons between the pretest and posttest. It is possible that a significant event in the previously scheduled lesson plans improved the abilities of the control group over the experimental group.

During the water flow experiments some simple math calculations were done on the chalk board resulting in quizzical looks from the students. Apparently the students' methods of calculating were significantly different than those of the researching instructor. The students had been encouraged to use algorithms to derive a solution rather than the methods demonstrated during the ESTE unit of instruction. The potential for this to have caused some confusion for the experimental group is significant.

To make the assumption that ESTE must increase student achievement in other subject areas in order to justify implementation of ESTE is to assume that the content of ESTE is not the most significant value of ESTE. The value of ESTE may lie in content, method or both. Though it may seem logical to assume that student learning and knowledge should measurably increase given an opportunity to implement learning from other subject areas, measurable results were contrary to this theory.

The quasi experimental design of this study might also be a flaw characterized by the unbalanced number of withdrawals of the experimental group as compared to the control group. Since ESTE has been shown to increase student achievement levels among the more marginal students. By excluding these students from testing it is possible that the most significant area of impact was removed from the data.

If the results of this study are assumed to be accurate and student knowledge did not increase as much as the control group it does not preclude the possibility of a delayed response that might increase measures of student knowledge resulting from participation in ESTE later in time.

A recommendation for more comprehensive research would include a long term study to observe delayed effects of ESTE, increased controls during the experiment or even training the regular classroom teacher to deliver the unit since he or she is more intimately aware of the development of each student. These sentiments are echoed by the following quotations.

“Only the regular teacher can bring the hand work into harmonious relation to the school life and use it as a true medium of expression of the other school work” ... “when we substitute for the idea of teaching handwork the idea of teaching through hand work.” (Richards, 1901, p. 11)

“The classroom teacher is the only person acquainted with both the curriculum material under consideration and the children in any particular group,

and can best determine which industrial arts activities are most appropriate”

(Gerbracht & Babcock, 1969, p. 25).

REFERENCES

- Barella, R., & Wright, T. (Eds.). (1981) *An interpretive history of industrial arts: the interrelationship of society, education, and industrial arts.*
Bloomington, IN: McKnight Publishing Company.
- Bauder, C. F. (1938, Feb/Mar). Expanding the program of industrial education in the public schools. In American Association of School Administrators, *The expanding program of industrial education*, 5-10. Atlantic City Convention: National Education Association.
- Beebe, G. (1902, Jan). Creative manual training. *Manual Training Magazine*, 3 (2), 88-94.
- Bird, V. A. (1922, Sept). A study in the correlation of general intelligence and progress in learning machine shop work as related to the problem of educational guidance. *Industrial education Magazine*, 24 (3), 67-69.
- Bloom, B. S., Hastings, J. T., & Madaus, G. F. (1981). *Evaluation to Improve Learning*. New York. McGraw-Hill.
- Bode, B. H. (1934). In Whipple, G. M. (Ed.). The thirty-third yearbook of the society for the study of education part II the activity movement.
Bloomington, IL: Public School Publishing Company.
- Bode, B. H. (1942). *Industrial arts and the American tradition*. Columbus: Epsilon Pi Tau.

- Bonser, F. G. (1922, Nov). The place of industrial arts in the elementary school. *Industrial Education Magazine*, 24 (5), 131-134.
- Bonser, F. G., & Mossman, L. C. (1936) *Industrial arts for elementary schools*. New York: The Macmillan Company.
- Childress, V. W., & LaPorte, J. E. (1997). Mathematics, science, and technology. In Kirkwood, J. J., & Foster, P. N. (Eds.), *Elementary school technology education. 46th yearbook, 1997*, (pp. 69-110). Peoria, IL: Glencoe/McGraw-Hill.
- Dewey, J. (1934). In Whipple, G. M. (Ed.). *The thirty-third yearbook of the society for the study of education part II the activity movement*. Bloomington, IL: Public School Publishing Company.
- Foster, P. N., & Kirkwood, J. J. (1997). The child, the school, and the world. In Kirkwood, J. J., & Foster, P. N. (Eds.), *Elementary school technology education. 46th yearbook, 1997*, (pp. 1-26). Peoria, IL: Glencoe/McGraw-Hill.
- Gardner, H. (1991). *The unschooled mind*. New York: Basic Books.
- Gardner, H. (1999). *Intelligence reframed*. New York: Basic Books.
- Gerbracht, C., & Babcock R. J. (1959). *Industrial arts for grades K-6*. Milwaukee, WI: Bruce Publishing Company.

- Gerbracht, C., & Babcock R. J. (1969). *Elementary school industrial arts; classroom and laboratory*. New York: Bruce Publishing Company.
- Gunther, T. C. (1931). *Manipulative participation in the study of elementary industrial arts*. New York: Bureau of Publications, Teachers College, Columbia University.
- International Technology Education Association. (2000). *Standards for technological literacy; content for the study of technology*. Reston, VA: Author
- Kirkwood, J. J. (2000, Spring). The status of technology education in elementary schools as reported by beginning teachers. *Journal of Industrial Teacher Education*, 37 (3), 94-113.
- Korwin, A. R., & Jones, R. E. (1990, Spring). Do hands-on, technology-based activities enhance learning by reinforcing cognitive knowledge and retention. *Journal of Technology Education*, 1 (2), 26-33.
- Lewis, T. (1999, Spring). Research in technology education – Some areas of need. *Journal of Technology Education*, 10 (2), 41-56.
- Lush, C. K., Engle G. E. (1946). *Industrial arts electricity*. Peoria, IL: Manual Arts Press.
- Maughan, G. R., & Prince Ball, K. S. (1999, April). Synergistic curriculum for the

- Mossman, L. C. (1924). *Changing conceptions relative to the planning of lessons*.
New York: Bureau of Publications, Teachers College, Columbia University.
- Quigley, T. H. (1938, Feb/Mar). Coordination of industrial education and industry.
In American Association of School Administrators, *The expanding program of industrial education*, 38-42. Atlantic City Convention: National Education Association.
- Richards, C. R. (1901, Oct.). Handwork in the primary school. *Manual Training Magazine*, 3 (1), 1-11.
- Ruskin, J. (1884). *The Pleasures of Learning*. New York: Crowel.
- Savage, E., & Sterry, L. (1990). *A conceptual framework for technology education*.
Reston, VA: International Technology Education Association.
- Smith, H. J. (1938, Feb/Mar). Aims and types of industrial education. In American Association of School Administrators, *The expanding program of industrial education*, 10-14. Atlantic City Convention: National Education Association.
- Stevenson, H. W., & Stigler, J. W. (1992) *The learning gap*. New York: Summit.
- Stigler, J. W., Lee S. Y., & Stevenson H. W. (1990). *Mathematical knowledge of Japanese, Chinese, and American elementary school children*. Reston, VA: National Council of Teachers of Mathematics, Inc.

- Stombaugh, R. M. (1936). *A survey of the movements culminating in industrial arts education in secondary schools*. New York: Bureau of Publications, Teachers College, Columbia University.
- Struck, F. T. (1938, Feb/Mar). Industrial arts and the maladjusted pupil. In American Association of School Administrators, *The expanding program of industrial education*, 14-18. Atlantic City Convention: National Education Association.
- Sukhomlinsky, V. A. (1981). *To children I give my heart*. (H. Smith, Trans.). Moscow: Progress Publishers. (Original work published 1974).
- Underhill, R. G., & Wali, A. S. (1994, Jan). The Virginia state systemic initiative: A brief overview of the lead teacher component and a description of the evolving mathematics & science integration outcomes. *School Science & Mathematics*, 94 (1), 26-29.
- Vance C. E. (1938, Feb/Mar). Industrial arts from the viewpoint of the superintendent. In American Association of School Administrators, *The expanding program of industrial education*, 19-24. Atlantic City Convention: National Education Association.
- Welty, K. (1997). Engaging the senses in a quest for meaning. In Kirkwood, J. J., & Foster, P. N. (Eds.), *Elementary school technology education. 46th yearbook, 1997*. (pp. 163-198). Peoria, IL: Glencoe/McGraw-Hill.

Wright, M. D. (1999, winter/spring). Technology education in the American elementary school. *Journal of Technology Studies*, 25 (1), 56-63.

Zuga, K. F. (1997). Review and synthesis of research. In Kirkwood, J. J., & Foster, P. N. (Eds.), *Elementary school technology education. 46th yearbook, 1997*. (pp. 305-335). Peoria, IL: Glencoe/McGraw-Hill.

Appendix A: Glossary

Elementary School Technology Education. “is used to include all forms of elementary level activities that involve children from grades K-5 in hands-on, experiential activities that promote their understanding of the technological world in which they live. This includes design and technology activities, problem-solving activities, and others that engage students in active inquiry about technology” (Kirkwood, 2000, p. 94)

Educational Content Approach to ESTE. “technology is the primary focus.” (Wright, 1999, p. 57).

Educational Method Approach to ESTE. A means of conveying other school subjects. (Wright, 1999, p. 57).

Educational Technology. “Using multimedia technologies or audiovisual aids as a tool to enhance the teaching and learning process” (ITEA, 2000, p. 238).

General Education. Education that is of use to all students.

Industrial Arts. “The industrial arts are those occupations by which changes are made in the forms of materials to increase their values for human usage. As a subject for educative purposes, industrial arts is a study of the changes made by man in the forms of materials to increase their values, and of the problems of life related to these changes” (Bonser & Mossman, 1936, p. 5).

Intelligence. “a biopsychological potential to process information that can be activated in a cultural setting to solve problems or create products that are of value in a culture” (Gardner, 1999, pp. 33-34).

Manual Arts. A system of manual training designed to motivate students as they create useful objects. (Barella & Wright Eds., 1981)

Manual Training. A method of education developed by Victor Della Vos to develop skill through a series of hands-on exercises to complement the theoretical training offered to engineering students. The projects used a minimum of material and were discarded upon satisfactory completion. (Barella & Wright Eds., 1981)

Mastery Learning. A method of education by which students of a range of ability levels can be taught so that all students can be elevated to a level of superior performance or mastery. (Bloom, Hastings & Madaus p. 55).

Sense-realism. The educational approach taken by Wolfgang Von Ratich to educate students using the senses in as direct and intuitive a manner as possible so that learning was not obstructed with associations with language etc. (Barella & Wright Eds., 1981)

Sloyd. A system of training developed largely through the efforts of Otto A.

Solomon, in Sweden, that promotes the use of home crafts as a method of instruction and as a means of economic development. (Barella & Wright Eds., 1981)

Technology. “1. Human innovation in action that involves the generation of knowledge and processes to develop systems that solve problems and extend human capabilities. 2. The innovation, change, or modification of the natural environment to satisfy perceived human needs and wants” (ITEA 2000, p. 242).

Technology Education. “technology education is the study of technology and its effect on individuals, society, and civilization” (Savage & Sterry, 1990, p. 20).

Vocational Education. Education with a primary emphasis of preparing the student to enter a trade or profession.

Appendix B: Pre-test

Pre-test Instrument

Instructions: *Please wait to begin until your teacher tells you to begin the test.*

Record your answers in the [] space for each problem. You may use the blank space to the right of each problem to work out problems if you need it. When you have finished, please turn your test over, place your pencil on your desk, and wait for further instructions

1. $5 \times 9 = [\quad]$

2.
$$\begin{array}{r} 704 \\ - 268 \\ \hline [\quad] \end{array}$$

3. $14 \div 1 = [\quad]$

4.
$$\begin{array}{l} 712 \div 89 = 8 \\ 8 \times 89 = [\quad] \end{array}$$

5.
$$\begin{array}{r} 198 \\ \times 4 \\ \hline [\quad] \end{array}$$

6. $3457 = (3 \times 1000) + (4 \times 100) + (5 \times 10) + 7$
 $2683 = [\text{_____}]$

7. $5 \overline{)3281}$

8. $6 \overline{)1586}$

9.
$$\begin{array}{r} 45 \\ \times 26 \\ \hline \end{array}$$

[_____]

10. $46 \overline{)3572}$

11.
$$\begin{array}{r} 38.15 \\ - 9.43 \\ \hline \end{array}$$

[_____]

12.
$$\begin{array}{r} 353 \\ \times 477 \\ \hline \end{array}$$

[_____]

13. $\frac{5}{7} - \frac{2}{7} = [\text{_____}]$

14. $2.079[\underline{\quad}]2.465$
($<$, $>$)

15. $\frac{1}{2} = \frac{[\quad]}{6}$

16. $2\frac{4}{6} + \frac{3}{6} = [\underline{\quad}]$

17. $\frac{3}{4} - \frac{1}{6} = [\underline{\quad}]$

18. $\frac{3}{8} \div 4 = [\underline{\quad}]$

19. $\frac{1}{4} = [0.\underline{\quad}]$

20. $\frac{8}{9} \times 4 = [\underline{\quad}]$

21. $0.02 = \frac{2}{[\underline{\quad}]}$

$$22. \quad \frac{1}{3} = [0.\underline{\quad}]$$

$$23. \quad \frac{5}{11} \div \frac{1}{9} = [\underline{\quad}]$$

$$24. \quad 3:10 = [\underline{\quad}]:100$$

$$25. \quad 0.33 \times \frac{1}{3} = [\underline{\quad}]$$

Note. The instrument was adapted from that used by Stigler, Lee, & Stevenson. (1990). Reprinted with permission from [*Mathematical knowledge of Japanese, Chinese, and American elementary school children*], copyright [1990] National Council of Teachers of Mathematics. All rights reserved.

Appendix C: Post-test

Post-test Instrument

Instructions: *Please wait to begin until your teacher tells you to begin the test. Record your answers in the [] space for each problem. You may use the blank space to the right of each problem to work out problems if you need it. When you have finished, please turn your test over, place your pencil on your desk, and wait for further instructions*

1. $[] - 34 = 32$

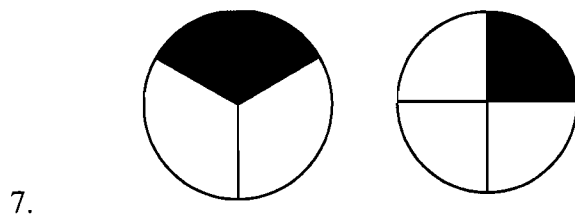
2. $13 \div 13 = []$

3. $8 \times 0 = []$

4. $42 \div 6 = []$

5.
$$\begin{array}{r} 206 \\ \times 3 \\ \hline [] \end{array}$$

6. $6 \overline{)432}$



$$\frac{1}{3}$$

$$\frac{1}{\boxed{}}$$

8. $98634[\boxed{}]98745$
($<$, $>$)

9. $5.3 - 4.6 = [\boxed{}]$

10. $\frac{3}{8} + \frac{2}{8} = [\boxed{}]$

11. $3600 \overline{)843000}$

12. $2\frac{3}{5}[\boxed{}]\frac{4}{5}$
($<$, $>$)

13. $12 \overline{)13.08}$

$$14. \quad \begin{array}{r} 0.034 \\ \times 17 \\ \hline \end{array} \quad [\quad]$$

$$15. \quad \begin{array}{r} 46.725 \\ - 23.123 \\ \hline \end{array} \quad [\quad]$$

$$16. \quad .025 \overline{)36}$$

$$17. \quad 0.08 \times 10 = [\quad]$$

$$18. \quad \frac{1}{5} [\quad] \frac{1}{6} \\ (<, >)$$

$$19. \quad 2\frac{3}{4} \times \frac{1}{6} = [\quad]$$

$$20. \quad \frac{3}{5} \times \frac{1}{9} = [\quad]$$

$$21. \quad 6 \times \frac{4}{7} = [\quad]$$

$$22. \quad 1\frac{2}{3} \div \frac{7}{8} = [\text{_____}]$$

$$23. \quad 12 \div \frac{8}{9} = [\text{_____}]$$

$$24. \quad 4\frac{1}{7} \div 2 = [\text{_____}]$$

$$25. \quad 5 + (-4) = [\text{_____}]$$

Note. The instrument was adapted from that used by Stigler, Lee, & Stevenson. (1990). Reprinted with permission from *[Mathematical knowledge of Japanese, Chinese, and American elementary school children]*, copyright [1990] National Council of Teachers of Mathematics. All rights reserved.

Appendix D: Instructions to Those Administering Tests

Instructions to teachers / assistants for administering tests.

All personnel administering the test should read and understand the following before administering the test.

- Answer any questions related to procedure as clearly as possible without helping the students to solve test problems.
- Students that are visibly struggling with a problem should be encouraged to leave a difficult problem and return to it after the other problems have been solved (it is OK for a student to leave a question blank if it is too hard).
- During the test, check to see that all students have correctly filled in their first and last names, and the date of birth.

Begin the test by handing out all tests face down and then by reading from the following script (in italics).

Today we will be taking a test. Do not turn the test over until I say you may turn your tests over. You may take as much time as you need to complete each of the problems. If you cannot finish a problem, leave it and come back to it after you have tried the other problems.

OK you may turn your tests over now. I will read the instructions and then you may begin the test.

Please wait to begin until your teacher tells you to begin the test. Record your answers in the [____] space for each problem. You may use the blank space to the right of each problem to work out problems if you need it. When you have finished, please turn your test over, place your pencil on your desk, and wait for further instructions.

Are there any questions before we begin?

You may begin now.

Mark the time: _____ and date: _____.

Instructor's name: _____.

Mark the time that the tests are completed: _____ and collect the tests.

Place the tests in the envelope(s) provided and seal them. **Thank you!**

Appendix E: ITEA Standards & Benchmark Topics Grades 3-5

ITEA Standards & Benchmark Topics Grades 3-5

1. The Characteristics and Scope of Technology
 - a. Things found in nature and in the human-made world
 - b. Tools, materials, and skills
 - c. Creative thinking
2. The Core Concepts of Technology
 - a. Systems
 - b. Resources
 - c. Requirements
 - d. Processes
3. The Relationships Among Technologies and the Connections Between
Technology and Other Fields
 - a. Technologies integrated
 - b. Relationships between technology and other fields of study
4. The Cultural, Social, Economic, and Political Effects of Technology
 - a. Good and bad effects
 - b. Unintended consequences

5. The Effects of Technology on the Environment
 - a. Recycling and disposal of waste
 - b. Affects environment in good and bad ways
6. The Role of Society in the Development and use of Technology
 - a. Changing needs and wants
 - b. Expansion or limitation of development
7. The Influence of Technology on History
 - a. Tools for food, clothing, and protection
8. The Attributes of Design
 - a. Definitions of design
 - b. Requirements of design
9. Engineering Design
 - a. Engineering design process
 - b. Creativity and considering all ideas
 - c. Models
10. The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving
 - a. Troubleshooting
 - b. Invention and Innovation
 - c. Experimentation

11. Apply the Design Process

- a. Collecting Information
- b. Visualize a solution
- c. Test and evaluate solutions
- d. Improve design

12. Use and Maintain Technological Products and Systems

- a. Follow step-by-step instructions
- b. Select and safely use tools
- c. Use computers to access and organize information
- d. Use common symbols

13. Asses the Impacts of Products and Systems

- a. Use information to identify patterns
- b. Asses the influence of technology
- c. Examine trade-offs

14. Medical Technologies

- a. Vaccines and medicine
- b. Development of devices to repair or replace certain parts of the body
- c. Use of products and systems to inform

15. Agricultural and Related Biotechnologies

- a. Artificial ecosystems
- b. Agriculture wastes
- c. Processes in agriculture

16. Energy and Power Technologies

- a. Energy comes in different forms
- b. Tools, machines, products, and systems use energy to do work

17. Information and Communication Technologies

- a. Processing information
- b. Many sources of information
- c. Communication
- d. Symbols

18. Transportation Technologies

- a. Transportation system use
- b. Transportation systems and subsystems

19. Manufacturing Technologies

- a. Natural materials
- b. Manufacturing processes
- c. Consumption of goods
- d. Chemical technologies

20. Construction Technologies

- a. Modern communities
- b. Structures
- c. Systems used

Note. Adapted from Standards for technological literacy; content for the study of technology. (pp. 211-214), International Technology Education Association 2000, Reston, VA: Author. Copyright 2000 by International Technology Education Association. Adapted with permission.

Water Flow

Grade Level: 5

Subject: Science / Tech. Ed.

Prepared By: Henry Amberson

| | |
|---|---|
| Overview & Purpose Students will learn the tangible concept of a circuit and a schematic that addresses water flow through a simple flow demonstration. | ITEA / Wisconsin Standards Addressed ITEA - 10.a, 11.a, 12.a, 13.c, 16.b, WI - A.4.1, A.4.2, A.4.8, B.4.2, B.4.3, C.4.5, D.4.2 |
|---|---|

| Water Flow: to Introduce Electrical Concepts Using Tangible Means | | |
|---|--|--|
| Objectives (Specify skills/information that will be learned) | Students will be able to: <ol style="list-style-type: none"> 1. Draw a schematic of water flow in the form of a circuit. 2. Compare and evaluate alternate methods based on common measures (efficiency). 3. Compare volumes of different containers. 4. Measure rate of flow based on units derived in class. | Materials Needed <ul style="list-style-type: none"> • Paper • Pencil • Demonstration materials <ul style="list-style-type: none"> ◦ Pump Assy. ◦ Measuring pails ◦ Contrasting containers ◦ Mop / Towels |
| Information (Give and/or demonstrate necessary information) | Demonstrations <ul style="list-style-type: none"> • Establish a unit of measure for water volume and give it a name. • Demonstrate that the same volume can occupy several different containers. • Ask, How much water is flowing as different people pump water? • Measure water flow through one valve. • Measure water flow through two valves. • Block the intake pipe, what happens? • Construct a simple schematic. | |
| Verification (Steps to check for student understanding) | Verbal questioning throughout demonstrations. Is the same amount of water in both containers? How much water is flowing? Will we get more water through two open valves? Or will we get something different? What are the parts of our system? Student drawing of apparatus with labels. | Other Resources Parental questioning |
| Activity (Describe the independent activity to reinforce this lesson) | Students will ask their parents to describe the hardest rainfall that they remember. (We will begin the next lesson by comparing descriptions of rainfall.) | |
| Summary | Students should clearly understand measures of volume and rate of flow and the "feel" of the energy input to move water. | Additional Notes |

Current Flow

Grade Level: 5 **Subject:** Science / Tech. Ed. **Prepared By:** Henry Amberson

| | |
|---|---|
| <p>Overview & Purpose</p> <p>Students will learn the concept of current flow and current division.</p> | <p>ITEA / Wisconsin Standards Addressed</p> <p>ITEA – 2.a, 5.b, 10.c, 11.a, 13. a, 20.c WI - A.4.1, A.4.2, A.4.4, B.4.2, B.4.3, B.4.4, C.4.2, C.4.5, D.4.2, D.4.4</p> |
|---|---|

| Current Flow: to introduce Electrical Concepts Using Tangible Means | | |
|---|--|---|
| <p>Objectives (Specify skills/information that will be learned)</p> | <p>Students will be able to:</p> <ol style="list-style-type: none"> 1. Draw a schematic of water flow in the form of a circuit. 2. Measure rate of flow based on units derived in class and convert to common units of measure. 3. Form a visual basis for considering current flow. | <p>Materials Needed</p> <ul style="list-style-type: none"> • Paper • Pencil • Demonstration materials <ul style="list-style-type: none"> ◦ Sump Pump. ◦ Valve. ◦ Measuring pails. |
| <p>Information (Give and/or demonstrate necessary information)</p> | <p>Demonstrations</p> <ul style="list-style-type: none"> • Establish a need for conversion to common units of measure based on information label from a commercially available sump pump. • Use converted flow rates in a design problem based on rainfall. • Demonstrate construction and use of a schematic diagram. • Construct various circuits in the form of a relay using crumpled paper. • Measure flow through various parts of circuit. | <p>Other Resources Parental questioning</p> |
| <p>Verification (Steps to check for student understanding)</p> | <p>Verbal questioning throughout demonstrations.</p> <p>What does a valve do? Where does our city water come from? Will water come from a well without a source of fresh water flowing into the ground? What happens if water becomes polluted? What results if more outlets would be added to the pump use in the previous lesson? (flow rate, difficulty, etc.)</p> <p>Student schematic of circuits.</p> | <p>Other Resources Parental questioning</p> |
| <p>Activity (Describe the independent activity to reinforce this lesson)</p> | <p>Students will check to see if the building that they live in uses a sump pump to keep the building dry.</p> | <p>Other Resources Parental questioning</p> |
| <p>Summary</p> | <p>Students should feel comfortable with schematic diagrams and be able to visualize current flow through a circuit.</p> | <p>Additional Notes</p> |

Electric Current Flow

Grade Level: 5

Subject: Science / Tech. Ed.

Prepared By: Henry Amberson

Overview & Purpose

Students will learn how to estimate relative electrical current flow based on simple observations.

ITEA / Wisconsin Standards Addressed

ITEA – 2.a, 5.b, 10.a, 10.c, 11.a, 12.a, 13. a, 16.a, 19.d
WI - A.4.1, A.4.2, A.4.4, B.4.2, B.4.4, D.4.2

| Current Flow: to Introduce Electrical Concepts Using Tangible Means | | |
|---|---|---|
| Objectives (Specify skills/information that will be learned.) | Students will be able to: <ol style="list-style-type: none"> 1. Draw an electrical schematic of a simple circuit. 2. Estimate relative flow through different parts of a circuit based on observations. 3. Form a visual basis for considering current flow. | Materials Needed <ul style="list-style-type: none"> • Paper • Pencil • Demonstration materials <ul style="list-style-type: none"> ◦ Sectioned battery. ◦ Six volt battery. ◦ Three bulbs. |
| Information (Give and/or demonstrate necessary information) | Demonstrations <ul style="list-style-type: none"> • Establish the similarities between batteries, pumps, switches, valves, conductors, and pipes. • Show the inside of a battery cut vertically through the central axis. • Demonstrate construction and use of a schematic diagram. • Construct various circuits using a six volt screw terminal battery and three bulbs with pigtail connections soldered on (to simplify connections). • Measure flow through various parts of circuit by observing light intensity and heat emitted. | |
| Verification (Steps to check for student understanding) | Verbal questioning throughout demonstrations. Where do batteries go when we are done with them? What do you see happening? Student schematic of circuits and conclusions. | Other Resources Parental questioning / observation in the home environment. |
| Activity (Describe the independent activity to reinforce this lesson) | Students (in groups of six) construct at least three circuits using the above mentioned materials. Each circuit will be drawn in schematic form and conclusions about current flow and bulb intensity will be recorded for each. Check how many devices are in each of your homes. | |
| Summary | Students should feel comfortable with schematic diagrams and be able to visualize current flow through a circuit and estimate relative current flow based on observations. | Additional Notes |

Electric Current Flow Conductors & Insulators

Grade Level: 5 **Subject:** Science / Tech. Ed. **Prepared By:** Henry Amberson

| | |
|---|--|
| <p>Overview & Purpose</p> <p>Students will construct a simple flashlight, switch, and continuity tester.</p> | <p>ITEA / Wisconsin Standards Addressed ITEA – 1.a, 1.b, 2.d, 10.a, 17.c, 19.b, 19.d WI – A.4.1, A.4.2, A.4.8, B.4.6, C.4.6</p> |
|---|--|

| Current Flow: to Introduce Electrical Concepts Using Tangible Means | | |
|---|--|--|
| <p>Objectives (Specify skills/information that will be learned.)</p> | <p>Students will be able to:</p> <ol style="list-style-type: none"> 1. Follow step by step instructions. 2. Build a simple project (Flashlight / Continuity Tester). 3. Test multiple materials to determine their ability to conduct electricity. | <p>Materials Needed</p> <ul style="list-style-type: none"> • Pencil • Flashlight Kit. • Workstation One-Wrenches / Super Glue. • Workstation Two-Hot Glue • Workstation Three-Bend Battery Clips / Testing |
| <p>Information (Give and/or demonstrate necessary information)</p> | <p>Demonstrations</p> <ul style="list-style-type: none"> • Schematic diagram of project and explanation of continuity tester. • Soldering Demonstration – Soldering pigtailed on a light bulb – Stripping wire – Use of Flux – Alloys that alter melting points Tin(450°F) Lead(620°F) Alloy <400°F. • Verbal instructions relating to manufacturing stations and construction of project (a completed sample of the project at the various stages of progress will be the primary form of instruction). | <p>Other Resources None</p> |
| <p>Verification (Steps to check for student understanding)</p> | <p>Student project completed correctly. Student list of materials and their ability to conduct electricity (use of constructed project).</p> | |
| <p>Activity (Describe the independent activity to reinforce this lesson)</p> | <p>Students (in groups of three) construct a flashlight / continuity-tester and use it to test different materials together. Students will construct a code that may be used to communicate with a friend using light.</p> | |
| <p>Summary</p> | <p>Students should develop a feel for which materials are conductors. Also students will use problem solving skills to assemble kit without written instructions.</p> | <p>Additional Notes</p> |

Electromagnet

Grade Level: 5 **Subject:** Science / Tech. Ed. **Prepared By:** Henry Amberson

| | |
|---|--|
| Overview & Purpose Students will add an electromagnet and an additional switch to the previous project. | ITEA / Wisconsin Standards Addressed ITEA – 1.a, 1.b, 2.a, 2.d, 10.c, 17.c, 19.a WI – A.4.1, A.4.2, A.4.8, B.4.6, C.4.6 |
|---|--|

| Current Flow: to Introduce Electrical Concepts Using Tangible Means | | |
|---|---|--|
| Objectives (Specify skills/information that will be learned.) | Students will be able to: <ol style="list-style-type: none"> 1. Follow step by step instructions. 2. Build a simple project (Flashlight / Continuity Tester). 3. Test multiple materials to determine if they are attracted to an electromagnet. | Materials Needed <ul style="list-style-type: none"> • Pencil • Flashlight Kit. • Coil winding tools <ul style="list-style-type: none"> ◦ Drill ◦ Wire ◦ Spool ◦ Measuring Wheel Other Resources None |
| Information (Give and/or demonstrate necessary information) | Demonstrations <ul style="list-style-type: none"> • Revisit Schematic diagram for light and magnet. • Winding of electromagnet. • Help students to spin a compass by turning magnet on and off in order to understand how a simple motor works. | |
| Verification (Steps to check for student understanding) | Student project completed correctly. Student list of materials and a designation as magnetic or non-magnetic. | |
| Activity (Describe the independent activity to reinforce this lesson) | Students (in groups of three) construct an electromagnet and use it to test different materials together. | |
| Summary | Students should develop a feel for which materials are magnetic. Also students will learn the basic function of a motor. | Additional Notes |

Generators

Grade Level: 6 **Subject:** Science / Tech. Ed. **Prepared By:** Henry Amberson

| | |
|---|---|
| <p>Overview & Purpose</p> <p>Based on experiences with electromagnets, students will observe a simple electric motor and a generator connected to an exercise bicycle.</p> | <p>ITEA / Wisconsin Standards Addressed</p> <p>ITEA – 2.a, 2.b, 10.c, 16.a, 16.b WI – A.4.1, A.4.2</p> |
|---|---|

| Current Flow: to Introduce Electrical Concepts Using Tangible Means | | |
|---|---|--|
| <p>Objectives (Specify skills/information that will be learned.)</p> | <p>Students will be able to:</p> <ol style="list-style-type: none"> 1. state that motors and generators convert kinetic and electrical energy from one to the other. 2. tell the difference between a series and a parallel circuit. 3. tell which common household items consume more energy. | <p>Materials Needed</p> <ul style="list-style-type: none"> • Small electric motor. • Three horse permanent magnet electric motor connected to an exercise bicycle as a generator. |
| <p>Information (Give and/or demonstrate necessary information)</p> | <p>Demonstrations</p> <ul style="list-style-type: none"> • A simple electric motor. • Use of a generator. • Series and parallel configurations of 100 watt light bulbs. • Braking action of a load. | <p>Other Resources 4-H Clubs and activities</p> |
| <p>Verification (Steps to check for student understanding)</p> | <p>Verbal questioning during demonstrations.</p> | <p>Other Resources 4-H Clubs and activities</p> |
| <p>Activity (Describe the independent activity to reinforce this lesson)</p> | <p>Students will have an opportunity to power the generator under different loads and configurations.</p> | <p>Other Resources 4-H Clubs and activities</p> |
| <p>Summary</p> | <p>Students should become aware that different appliances consume different amounts of energy and the reversibility of the conversion from kinetic to electrical energy.</p> | <p>Additional Notes</p> |

Appendix G: Materials Lists

Flashlight Materials List

| | | |
|---|----|--------|
| Paint Stick | 1 | |
| Jumbo Paper Clip | 5 | |
| 1/4" x 1" Bolt | 3 | |
| 1/4" Nut | 5 | |
| 1/4" Washer | 8 | |
| Pen Light Bulb (<i>W/Soldered Pigtails</i>) | 1 | |
| Bell Wire (<i>for pigtails</i>) | 16 | inches |
| Rubber bands to hold battery & connections | 2 | |

Electromagnet Assy, Materials List

| | | |
|--------------------|----|-----------------------|
| 26 ga.. Motor wire | 25 | Feet* |
| 5/16 x 2-1/2" Bolt | 1 | |
| 5/16 Nut | 1 | |
| 1/4" Washer | 2 | |
| Electricians' Tape | 5 | inches <i>Approx.</i> |

Electromagnet Kit List

| | | |
|------------------|---|--|
| Electromagnet | 1 | |
| 5/16" Nut | 1 | |
| Jumbo Paper Clip | 1 | |
| 1/4" x 1" Bolt | 1 | |
| 1/4" Nut | 3 | |
| 1/4" Washer | 4 | |

Sized according to values found in (Lush, 1946).

Appendix H: Data

| Subject No. | Response variable Change in test score | Expected Change (Chicago scores) | Experimental group =0 Control =1 | Sex F=0 M=1 | Pretest Performance 0=Below 1=At or Above Chicago Standard | Change in test scores relative to Chicago standard 0=at or below 1=greater than | Age in months at time of pretest |
|--------------------|---|---|---|--------------------|---|--|---|
| 101 | 0.04 | 0.0384 | 0 | 0 | 0 | 1 | 139 |
| 102 | 0.08 | 0.0384 | 0 | 0 | 0 | 1 | 138 |
| 103 | -0.04 | 0.0384 | 0 | 1 | 1 | 0 | 132 |
| 104 | 0 | 0.0384 | 0 | 1 | 1 | 0 | 139 |
| 105 | 0.2 | 0.0384 | 0 | 1 | 1 | 1 | 129 |
| 107 | 0.04 | 0.0384 | 0 | 0 | 1 | 1 | 136 |
| 108 | 0.16 | 0.0384 | 0 | 0 | 1 | 1 | 128 |
| 109 | 0.08 | 0.0384 | 0 | 1 | 1 | 1 | 130 |
| 110 | 0.04 | 0.0384 | 0 | 1 | 0 | 1 | 134 |
| 111 | 0.08 | 0.0384 | 0 | 0 | 0 | 1 | 127 |
| 114 | 0.16 | 0.0384 | 0 | 1 | 0 | 1 | 149 |
| 115 | 0.12 | 0.0384 | 0 | 1 | 1 | 1 | 136 |
| 116 | 0.08 | 0.0384 | 0 | 1 | 0 | 1 | 142 |
| 119 | 0 | 0.0384 | 0 | 0 | 0 | 0 | 134 |
| 120 | 0.12 | 0.0384 | 0 | 0 | 0 | 1 | 135 |
| 121 | -0.12 | 0.0384 | 0 | 1 | 1 | 0 | 134 |
| 122 | 0.16 | 0.0384 | 0 | 0 | 0 | 1 | 138 |
| 123 | 0.24 | 0.0384 | 0 | 0 | 1 | 1 | 136 |
| 124 | 0.04 | 0.0384 | 0 | 1 | 1 | 1 | 139 |
| 126 | 0.08 | 0.0384 | 0 | 0 | 1 | 1 | 138 |
| 127 | 0.04 | 0.0384 | 0 | 0 | 0 | 1 | 129 |
| 128 | 0 | 0.0384 | 0 | 1 | 0 | 0 | 141 |
| 130 | 0.12 | 0.0384 | 0 | 0 | 1 | 1 | 132 |
| 131 | -0.04 | 0.0384 | 0 | 0 | 0 | 0 | 134 |
| 132 | 0.2 | 0.0384 | 0 | 1 | 0 | 1 | 140 |
| 133 | 0.2 | 0.0384 | 0 | 1 | 0 | 1 | 132 |
| 134 | -0.04 | 0.0384 | 0 | 0 | 1 | 0 | 150 |
| 135 | -0.04 | 0.0384 | 0 | 0 | 1 | 0 | 129 |
| 136 | 0 | 0.0384 | 0 | 0 | 0 | 0 | 128 |
| 137 | 0.12 | 0.0384 | 0 | 0 | 0 | 1 | 132 |
| 143 | 0.32 | 0.0384 | 1 | 0 | 0 | 1 | 136 |
| 144 | 0.16 | 0.0384 | 1 | 0 | 0 | 1 | 129 |
| 145 | 0.04 | 0.0384 | 1 | 0 | 0 | 1 | 128 |

| | | | | | | | |
|-----|------|--------|---|---|---|---|-----|
| 146 | 0.24 | 0.0384 | 1 | 1 | 0 | 1 | 135 |
| 148 | 0.16 | 0.0384 | 1 | 0 | 0 | 1 | 141 |
| 149 | 0.04 | 0.0384 | 1 | 1 | 1 | 1 | 143 |
| 150 | 0.08 | 0.0384 | 1 | 0 | 1 | 1 | 133 |
| 152 | 0.08 | 0.0384 | 1 | 1 | 0 | 1 | 138 |
| 153 | 0.12 | 0.0384 | 1 | 1 | 1 | 1 | 133 |
| 154 | 0.12 | 0.0384 | 1 | 1 | 0 | 1 | 136 |
| 155 | 0.16 | 0.0384 | 1 | 1 | 0 | 1 | 137 |
| 156 | 0.12 | 0.0384 | 1 | 0 | 1 | 1 | 144 |
| 158 | 0.2 | 0.0384 | 1 | 1 | 0 | 1 | 127 |
| 160 | 0.16 | 0.0384 | 1 | 0 | 0 | 1 | 141 |
| 161 | 0.08 | 0.0384 | 1 | 1 | 0 | 1 | 139 |

Appendix I: Statistical Results

SUMMARY OUTPUT

| <i>Regression Statistics</i> | |
|------------------------------|-----------|
| Multiple R | 0.3641 |
| R Square | 0.1325688 |
| Adjusted R Square | 0.112396 |
| Standard Error | 0.0838825 |
| Observations | 45 |

| ANOVA | | | | | |
|------------|-----------|-----------|-----------|----------|-----------------------|
| | <i>df</i> | <i>SS</i> | <i>MS</i> | <i>F</i> | <i>Significance F</i> |
| Regression | 1 | 0.04624 | 0.046 | 6.5717 | 0.013941 |
| Residual | 43 | 0.30256 | 0.007 | | |
| Total | 44 | 0.3488 | | | |

| | <i>Coefficients</i> | <i>Standard Error</i> | <i>t Stat</i> | <i>P-value</i> | <i>Lower 95%</i> | <i>Upper 95%</i> | <i>Lower 95.0%</i> | <i>Upper 95.0%</i> |
|-----------------------|---------------------|-----------------------|---------------|----------------|------------------|------------------|--------------------|--------------------|
| Intercept | 0.0706667 | 0.015315 | 4.614 | 4E-05 | 0.039781 | 0.10155 | 0.04 | 0.10155 |
| Experimental group =0 | | 0.02652 | | 0.013 | | 0.1214 | | |
| Control =1 | 0.068 | 0.02652 | 2.564 | 0.013 | 0.014505 | 0.12149 | 0.01 | 0.12149 |