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DEVELOPMENT OF A MATHEMATICS, SCIENCE, AND TECHNOLOGY EDUCATION INTEGRATED PROGRAM FOR A MAGLEV

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ABSTRACT. The purpose of the study was to develop an MST Integrated Program for making a Maglev hands-on activity for higher elementary school students in Korea. In this MST Integrated Program, students will apply Mathematics, Science, and Technology principles and concepts to the design, construction, and evaluation of a magnetically levitated vehicle. The focus of this program was to help students to understand and solve integrative problems in relation to Mathematics, Science, and Technology Education in the real world.

KEYWORDS. MST Integrated Program, Hands-on Activity, Technology Education.

INTRODUCTION

This study developed and tested a series of instructional units that were designed to enhance the study of mathematics, science, and technology at the elementary level in Korea. This program sought to tap motivation and interest in mathematics, science, and technology. In PISA 2003 (Program for International Student Assessment), organized by the OECD, Korea was ranked third, fourth, and first, in mathematics, science, and problem solving areas. Korea was located much higher than OECD average of PISA 2000, but Korean students' interest, self-concept, and efficacy in mathematics were lower than other OECD countries and their anxiety in mathematics was very high. It is not desirable for Korean students to feel so negatively about mathematics (KICE, 2004). In addition, pupils say that Science and Science lessons are boring and difficult.

The mathematics, science, and technology education communities are undergoing major reform in curriculum design, instructional strategies. It is therefore necessary to develop instructional methods to improve students' interest and self-related beliefs. It is necessary to develop systematic MST integrated programs to meet students' abilities and attitudes. For this reason, this study's purpose was to create an MST integrated program for elementary school students in Korea.

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MATHEMATICS, SCIENCE, AND TECHNOLOGY EDUCATION

MST Integrated Program Need

The traditional separation of mathematics, science, and technology instruction showing only concretely defined subjects provides an unrealistic view of the world. Today, inter-relatedness is needed to solve problems. Students best realize this when they engage in learning activities that cause them to apply their knowledge of mathematics, science, and technology concepts while seeking solutions to realistic problems.

MST Integrated Program Rationale

Mathematics, Science, and Technology Education Integrated hands-on program is intended to promote the Mathematical, Scientific, and Technological literacy and innovative capacity of elementary and secondary school students.

There is strong support for an integrated curriculum within the areas of mathematics, science, and technology (Wescott & Leduc, 1994). The mathematics community is calling for an increase in an applications-oriented approach. Science educators are encouraging emphasis on an experientially based curriculum and learning. Technology education also recognizes the value of strengthening the curriculum and its programs by including integrated applications of mathematics and science principles; all then becoming more meaningful and relevant to students.

Integrating Mathematics, Science, and Technology Education

A. Mathematics

The National Council of Teachers of Mathematics suggests a framework for the types of technology based activities and content that should be taught (NCTM, 2000). Technology is essential in teaching mathematics. It influences the mathematics that is taught and enhances student learning. With available technological tools students can focus on decision making, reflections, reasoning and problem solving. But technology alone is not a panacea for teaching computational strategies. To enhance student' learning opportunities, teachers must select or create proper mathematical tasks that take advantage of what technology can do efficiently and well. Taught will be graphing, visualizing, and computing.

Problem solving with mathematics and other areas of text is crucial to students better understanding their world. More specific, school mathematics experiences at all levels should include opportunities to learn by working on also the problems arising outside of mathematics.

B. Science

Scientifically literate people should understand the interdependence of science, mathematics, and technology (AAAS, 1993). Observing, thinking, experimenting, and validating, a kind of merger of mathematics and technology into scientific inquiry holds promise for a scientifically literate society. Defining the human experience, technology allows us to interact, shape, or more fully understand our environment. Distinction between technology and science blurs as technology becomes more sophisticated. Seen then can be that technologies shape science as they develop, thereby providing more motivation and direction for theory building.

As with mathematics, it is our belief that technology-rich instruction is integral in nurturing the development of students as active science inquirers. The National Research Council's National Science Education Standards include suggestions for science education reform in technology-based content and its professional development.

C. Technology

About 2.4 million years ago, the first humans created primitive tools by chipping away the edges of the stones. Tool making was the first technology. It was a means to solve problems. Over the millennia, humans have refined their capability to create technological ways to solve problems. Technology is created, managed, and used by societies and individuals, according to their goals and values (ITEA, 2000). Possible to improve the human situation or damage it, in technology is the potential to save or destroy lives. The promise of the future lies not in technology alone, but in people's ability to use it, manage it, assess and understand it. The major goal of technology education is to develop a technologically literate citizenry, one that has the ability to use, manage, assess, and understand technology. One should further accept it that technology has consequences or impacts affecting individuals, society, and the environment. A full inspection and integration of mathematics, science, and technology based activities and education goals will develop a technological literate society. Technology has shifted from tools, machines, and products to systems, problem solving, and interfacing with science and mathematics.

Technological, scientific, and mathematical literacy go hand in hand. Technologists use math and science, scientists use math and technology, and mathematicians use science and technology. Mathematicians employ reasoning and analysis to explore relationships among abstractions. Scientists use methods of inquiry when observing the natural world and building explanatory structures. Technologists design products and systems to create the human-made world.

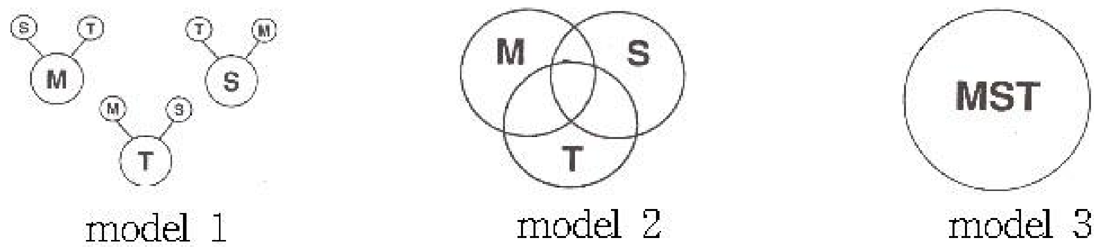
Just as mathematics and science consider problem solving a foundational skill, technology educators include the idea of inductive and deductive problem-solving as essential.

These three disciplines are moving society toward new horizons, and a technologically literate society will help the scientists and technologists of the future to make wise decisions for the benefit of all.

MST Integrated Program Models

There are three types of integrated programs. In model 1, individual teachers help students to make explicit connections between what they learn in a particular M, S, or T class and what they are learning in other classes. The disciplines are connected through a theme or issue that is studied during the same time frame, but in separate classrooms. In model 2, teachers work together to develop interdisciplinary units. The subjects are interconnected in some way beyond the common theme or issue. These connections are made explicit to the students. Model 3 illustrates a fully integrated approach, Students are either block-scheduled into three periods of mathematics, science, and technology or an integrated mathematics, science, and technology course where teachers team teach (New York Education Department, 1997). This approach transcends the disciplines. The disciplines are embedded in the learning, but the focus does not start there. It does not begin with the disciplines in the planning process; rather, the planning begins from a real life context.

Figure 1. MST Integrated Program Model



HANDS-ON, MINDS-ON ACTIVITY

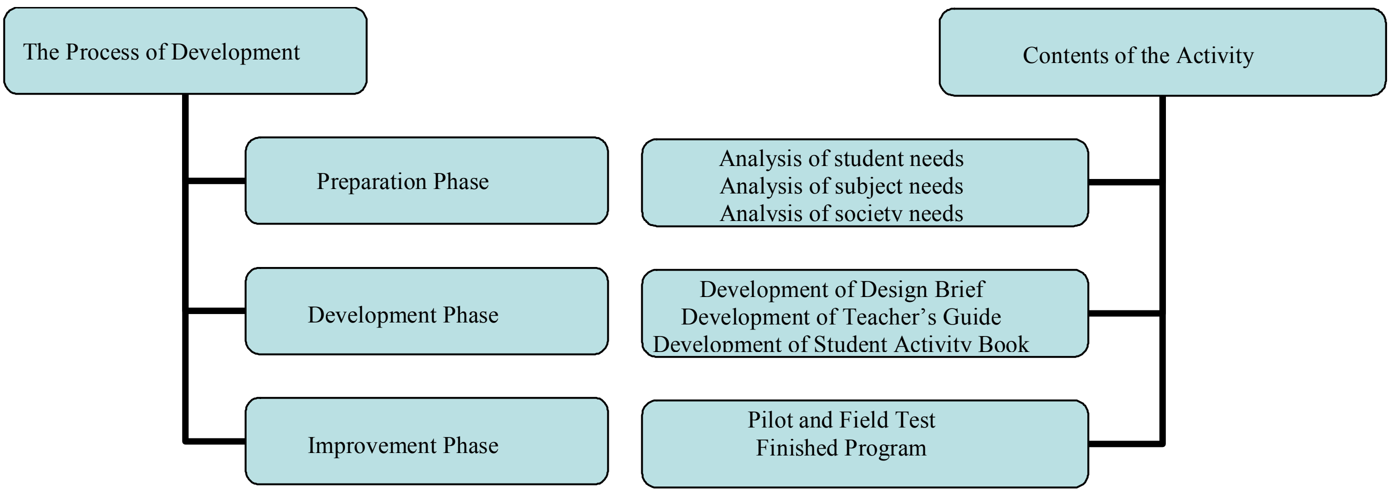
Homo sapiens have been called the animals that make things, and at no time has that been as apparent as the present (ITEA, 2000). The term 'learning–by-doing' suggests that students will be more interested, learn more easily, and retain learning longer if they are actively engaged in constructing, manipulating, and experimenting (Foster & Kirkwood, 1997). A hands-on, minds-on activity is the interaction of mind and hand, inside and outside of the head (Todd, 1997). The concentration is not only on the thinking and decision making processes that result in an end product, but also on why and how pupils choose to do things rather than on only what it is they choose to do. Students often believe that they have worked out a complete solution in their minds, and they will set out to translate that idea into a final form. This belief seldom if ever is satisfactory, for they cannot mentally sort out all the issues and difficulties in the task, let alone reconcile them in a successful solution. To enable an idea to develop fully, it is necessary to take it out of the mind and express it in concrete form. To accomplish a significant hands-on activity there must be a minds-on activity.

This hands-on activity requires students to work in groups to discuss ideas, to identify a problem, to draw preliminary plans, to collect materials, to construct a Maglev model from their initial plans, and to evaluate their final Maglev model for creativity and problem solving abilities in the technology lab. The Maglev hands-on activity defines the principle of magnetic levitation and the application of mathematics and science to the construction of a Maglev. Maglev utilizes a near frictionless method of transportation using magnetic fields.

DEVELOPMENT OF THE MST INTEGRATED PROGRAM

To achieve its objective, this study was designed in three phases. The developmental model of this MST integrated program shown as figure 2 includes the preparation phase, the development phase, and the improvement phase. Each phase includes several steps, and a general description of these steps follows (Park, 2005; Park, 2006a; Park, 2006b).

Figure 2. Development Model of the MST Integrated Program



Preparation Phase

The preparation Phase includes a developmentally appropriate analysis of subject needs, society needs, and student needs (Tyler, 1949). In the analysis of needs of students, the developmental level of the student is a factor in determining the sequence of the MST integrated program. Needs, interests, abilities, and the experiences of students are important in deciding the nature of the MST integrated program. In the analysis of needs of the subject, the subject's needs are organized into broad areas of study rather than into the traditional areas. Mathematics, science, and technology are organized as parts of a single cluster (Black & Atkin, 1996). In the analysis of the needs of society, we are seeing dramatic changes. Mathematics, science, and technology are essential to the education of today's children for tomorrow's world and all will be at the center of radically causing, shaping, and responding to it (Black & Atkin, 1996).

Development Phase

The development phase consisted of three sections: the development of a design brief, the development of a teacher's guide, and the development of a student activity book.

Design Brief

A design brief is a written plan that identifies a problem to be solved, its criteria, and its constraints (ITEA, 2000). It is a short description of a design problem and a proposed solution. It provides a planning tool for the project. A design brief includes a sketch or sketches of the solution. This may include a written report, the construction of a model, data collection and its report, or a multimedia presentation to the class. The students are expected also to keep with this design portfolio, and any additionally generated drawings or other relevant papers.

1. Situation. The situation sets the context and rationale for the activity. A narrative description places the challenge in a context that gives it real meaning for the student. A 'real world' scenario frames the problem to be solved. Here is an example.

> Fossil fuels are dwindling. They are also a source of pollution that is threatening our atmosphere. Maglevs do not need engines. They do not burn fuel. Maglev is the transportation technology of the future. Unfortunately, Korea is not the world leader in Maglev technology, so now is a good time for her young and budding Maglev designers to make a name for themselves.

2. Problem. The problem explains generally what needs to be accomplished through the problem-solving process. A very concise statement of the task facing the student is made.

> Use math, science, and technology to optimize the design of a Maglev vehicle. Research, design, and construct a vehicle that will levitate on a magnetic track and travel a 100cm track in the shortest amount of time.

3. Design constraints. The design constraints are resources, materials, tools, machines, software, and limitations of time or other conditions imposed upon the students. They will identify the maximum size and the allowable materials to be used in the solution of the problem.

> The materials needed to build the maglev device include: two pieces of formboard (6x50x0.5cm, 6x10x0.5cm), ten pieces of ferrite magnet (1.3x10x0.3cm), both-sided sticky tape, two pieces each of acrylic (2x50x0.3cm, 1x10x0.3cm), a 1.5 volt battery, Styrofoam (2x2x3cm), a motor, and a propeller. The students must achieve levitation along a track 100 cm in length of a maglev device powered by the motor and the propeller. The maglev must operate without being touched, or otherwise being interfered with once it is in place at its starting position on the track.

4. The Challenge. The challenge is clarified in a statement that describes the design problem that the student needs to solve, describes the competitive event that is used to assist with the evaluation of the student solutions; and, whenever feasible, it is important to run the Challenge two or more times so that the students may revise their designs and retest them. This notion of 'iterative testing' is very important. In the 'real world' there are problems solved only after many tests have been completed.

> Your challenge is to develop an innovative Maglev that is significantly different from any conventional train. This maglev hands-on activity demands that you design new methods of moving people on trains using magnetism. You will examine the magnetic levitation principle and be introduced to relevant applications of math and science. You will research, design, construct, and contest run a magnetic levitation vehicle. A winner will be decided through racing a 100cm in the shortest amount of time. Recycling, design, problem solving, teamwork and safety will be covered.

5. Documentation. The students will be evaluated using a list of expectations that defines what the student needs to complete the challenge successfully. Documentation included provides some suggestions for the type of work that should be included in the portfolio that students are to use to record their work as they proceed through the activity.

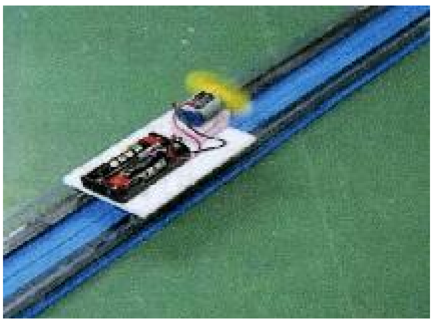
> Document the problem-solving and critical thinking processes used to solve, design, and produce your Maglev in a design portfolio. Document the math and science processes and skills used to solve, design, and produce your Maglev. Present, and demonstrate your completed Maglev design to the class, identifying its unique features and user considerations.

Development of the Teacher' Guide

1. Sample solution. Provide an illustration of what a typical solution to the problem described in the design brief might look like. This is intended for the teachers' eyes only, as students who are shown one or more sample solutions often tend to copy those designs. Strongly encourage them to design their own creative solutions to the problem that is posed in the design brief. Given the opportunity, students generally are very creative in formulating solutions in this MST integrated program.

During their program, the students are to apply learned mathematics, science, and technology principles, as well as their own concepts to the design, construction, and evaluation of a magnetically levitated vehicle. A possible solution is shown in Figure 3.

Figure 3. Sample a Solution of Maglev



2. Objective. The overall objective of this MST integrated program is for students to apply the concepts, principles, and skills learned in mathematics, science, and technology to design, construct, and evaluate their Maglev.

The students are expected to design and engineer a maglev vehicle that travels 100cm track in the shortest possible amount of time; develop a design and solve problems through the construction of a Maglev vehicle driven by a motorized propeller; and develop critical thinking skills and creative design ideas.

3. Applications list. Here are some of the concepts and principles to be actively applied from each of the three areas of mathematics, science, and technology.

The mathematics applications are distance/rate/time, graphic and mathematical relationships, and cost analysis. Science applications are electrical circuits, motors, and magnetic fields and forces. Technology applications are transportation, magnetic levitation, vehicle design and fabrication, engineering, and testing.

4. Suggested instructional sequence. A chart depicts the relative order for the topics suggested in this MST integrated program. Very useful during the planning stages, it provides each teacher with a general idea of what will be studied and approximately when a topic will be addressed within the scope of the activity.

Table 1: Suggested Instructional Sequence

	Mathematics	Science	Technology
Designing		Ferrite magnets and magnetic Fields (attraction and repulsion flux lines, field strength Series and Parallel circuits, (motor and propeller)	Designing a Maglev Levitation Real-world Maglevs Design considerations
Constructing			Constructing a Maglev
Evaluating	Speed, distance, time Calculate speeds Average speed Cost Analysis	Concept of speed	Evaluating a Maglev Testing the Maglev Weighing the maglev

5. Phases of the activity. The suggested instructional sequence of the MST integrated program shows its design, construction, and evaluation phases described in general terms. Thinking of the MST integrated program is a good way to better understand how all phases work in practice.

In the design phase, the students need to apply their knowledge of magnetism, magnetic fields, and magnetic forces to help them to create a Maglev. Show the students how to brainstorm and capture their ideas on paper before trying to rush into a design. In the construction phase - primarily done in the technology education laboratory – the Maglev vehicle prototypes that the students will be building should serve as instructional props for the teachers. Directly related to the Maglev problems, the Maglev track may be set up also in either or both the science and mathematics classes to further relate all contributed from and in these two areas. As students try different body types, as well as power and propulsion systems, they found that the Maglev systems required the least amount of force needed to move the vehicle. In the evaluation phase, the students will test their vehicle's performance during the Challenge. Real data on vehicle weight, distance traveled, and elapsed times are collected during the Challenge. Students also determine the cost of their vehicles. Students tested their Maglev, evaluated the results, made modifications to their design and tested the Maglev again.

6. Sequence of student activities. This is similar to the 'Suggested Instructional Sequence' but this sequence specifically addresses the essential student activities that take place. It lists these activities in sequential order. It identifies the class (technology, science, or mathematics) in which each student activity will take place. Laid out is the sequence of student activities that allows each teacher to see how the focus of the activity shifts from one class to another.

Table 2: Sequence of Student Activities

Class	Student Activity
All three classes	General design considerations
Technology	Begin sketches and drawings of designs
Science	Ferrite magnets (attraction and repulsion) Flux Lines Field strength Series and parallel circuits
Technology	Construction of a Maglev
Science	Concept of speed
Mathematics	Speed, distance, time Calculation of speeds Average speed Cost analysis
Technology	Evaluating the Maglev

7. Introduction. Some teachers may need more general background material in order to implement this activity successfully.

Maglev has the promise of becoming the largest development in transportation technology since the wheel. Maglev does away with the wheel and all the problems inherent with it. Maglev uses magnetism to levitate a vehicle above a track and to move it from one place to another. Maglev is an abbreviated form of Magnetic levitation, which uses basic principles of magnets to replace the old steel wheels and track. Magnets use the fact that opposite poles attract and like poles repel each other, the principle behind electromagnetic propulsion. Electromagnets are similar to other magnets in that they attract metal objects, but the magnetic field is temporary. Maglevs are high-speed trains that use electromagnets to float only inches above a track. Maglev is the ideal mass transport system of the future. A magnetic levitation vehicle is safe, fast, quiet, and non-polluting. The greatest advantage to this is the absence of friction. Maglev vehicles float above tracks instead of riding on wheels. While the Maglev was first proposed more than a century ago, the first commercial maglev train - developed and tested by the German company, Transrapid International - made its debut run in Shanghai, China, in 2002. Germany and Japan are both developing maglev technology and are currently testing prototypes of their trains. Although based on similar concepts, the German and Japanese trains have distinct differences.

8. Glossary of terms. Here is a brief description of terms that teachers may need to better understand this particular MST integrated program.

Superconductivity is a phenomenon occurring in certain materials at low temperatures, characterized by the complete absence of electrical resistance and the damping of the interior magnetic field (the Meissner effect).

Ferrite magnet is most widely used because of its low cost, high-energy, good electric insulation, and excellent resistance to demagnetization.

Levitation is the act of an object being suspended in air, seemingly in defiance of the forces of gravity.

9. Resources. This activity is supplied with a list of helpful reference sources. It includes literature, suggested software, and so forth. The following may be used when studying terms in the MST integrated program.

International Technology Education Association. (2003). Models for Introducing Technology: A Standards-Based Guide.
http://www.transrapid.de
http://kowon.dongseo.ac.kr/~seewhy/Science/Maglev.htm
http://www.rtri.or.jp/
http://www.most.go.kr/most/Young_most/rnd_6.html
http://www.kimm.re.kr

Development of a Student Activity Book

A student activity book covers specific topics and suggested instructional activities. Its technology component describes the design and construction of solutions that would typically take place in the technology education laboratory; as well, it provides guidance for designing, constructing, and evaluating a Maglev that will solve the problem stated in the design brief. Science and mathematics components describe experiments and activities for related science and mathematics concepts. Mathematics principles are related to the product, to product performance, and to real world problems. The science component relationships deal with principles related to designing, constructing, and/or evaluating the product and to real world situations.

Improvement phase

The improvement phase included a pilot and field test. The researcher performed a pilot test for increasing reliability and a field test for establishing content validity. Interviews resulted in more elementary school student level pictures, examples, word size considerations, and margin and blank areas between lines; and all helped to increase the effectiveness of the program. Overall, the MST integrated program was made easier and more interesting. Unnecessary or overly difficult sections were eliminated. The program was made to fit the teachers and provide particular focus on the goals. The MST integrated program became additionally clear, interesting, and a better fit for the level of the participating students.

According to the testimony of the field-test teachers, the MST integrated program was conceptually rich, pedagogically sound, time and cost effective, and for the most part, developmentally appropriate. The field-test teachers felt that their students were able to learn more by using the MST integrated program than with all three subjects taught in isolation of one another.

CONCLUSIONS AND RECOMMENDATIONS

Students enjoyed the opportunity to become design engineers and create Maglev. Students designed, constructed, tested, and modified the Maglev. Students continued the process of testing, modification, and testing again to fine tune the performance of their Maglev. This MST integrated hands-on program required that student research, design, experiment, and problem solve. As a development study, this program has involved both questionnaire and pilot/field tests. A hands-on activity was chosen because higher elementary school students were perceived to be interested. The study was performed in three major phases: preparation, development, and improvement. In the preparation phase, the research conceived the development of an MST integrated program for making a Maglev hands-on activity through the literature review for the needs of students, society, and subject matter. In the development phase, the design brief consisted of situation, problem, design constraints, challenge, and documentation. The Teacher's Guide consisted of a sample solution, overall objective, listing of applications, suggested instructional sequence, phases of the activity, sequence of student activities, introduction, glossary of terms, and resources. The student activity book consisted of mathematics applications, science applications, and technology applications. In the improvement phase, the research performed a pilot test for increasing reliability and a field test for establishing content validity.

More objective evaluation will determine the usefulness and impact of the MST integrated program on elementary students and teachers.

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