Investigation of the appropriateness of "scil" micro-computers in science and mathematics in grades K - 12 and in the training of teachers.

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1. The BASIC Stamp in Alberta's "Science, Technology and Society" Curriculum

A. Introduction of The BASIC Stamp to Science

This section will examine how science education can benefit from the role of the BASIC Stamp in the classroom. The teaching of science and the methods of learning now employed with students will need to be defined before units are identified.

The use of the BASIC Stamp in Alberta science classrooms can be envisioned at most levels from Early Childhood (Kindergarten) to High School students. Realistically, the ideal grades to introduce such a learning tool would be in Division II (grades 3 to 6) for mechanical systems and simple data entry, Division III (grades 7 to 9) for understanding primary electronic components and systems, and Division IV (grades 10 to 12) for more advanced and long term applications. Ideally science becomes the vehicle of entry for the BASIC Stamp followed by cross discipline collaboration on learning. Critical to understanding the choices made here are the methods employed by teachers to the teaching of science in their schools. We will first examine the concepts of "Science, Technology and Society" in the Alberta K to 12 Curriculum before proceeding to more detailed analysis of the grades and units.

B. Concepts

Alberta has become well known in the international setting for success on tests such as The Third International Math and Science Study (TIMSS). Our curriculum has become a primary force in helping to shape the Pan-Canadian Protocol for Science that will determine how many students learn science from coast-to-coast in our country. With the strength of our current curriculum and the guidance of teachers in the field this first section will examine possibilities for matching possible BASIC Stamp applications and classroom experience.

The basic concepts of science instruction include learning about circuits, parallel and series, developing a working understanding of how electro-magnets work, and examining power sources, bulbs, resistors, etc. Many of these knowledge bits can be taught with simple wires, batteries, and bulb arrangements. However, to truly understand how the use of a micro-computer would be an asset to the Alberta curriculum there has to be an understanding of what context this knowledge is taught in.

The teaching of science has undergone many transformations within the last century. Many will remember having to write up a typical inquiry type science experiment in school. The typical science experiment started with the problem. Once identified the problem leads to a possible experiment with properly listed materials, procedure and data collecting charts. Students are asked to hypothesize an educated guess as to the outcome of the experiment. With the experiment conducted, analysis of the data and a conclusion is reached. This is an inquiry lesson, or Nature of Science (NS) investigation, and the outcome is predictable if proper controls are adhered to during the experiment.

Within the last decade, science teachers in Alberta have made great strides in embracing other manners of instructing science. The Science Technology Society (STS) approach to teaching now dominates the curriculum and will for some time to come (Alberta Education, 1990). Inquiry as a method of instruction has not been lost, however we now also apply two other methods of investigation in science. The first of the two new methods is Problem Solving. Problem solving allows for the application of current knowledge and scientific understanding, it is often referred to as the Technology approach (ST). The second approach is Decision Making, or making societal decisions regarding science (STS). Decision making is a manner of examining issues in science to determine what impact on society and the environment these concerns will have. In decision making students often debate ethical, moral, economic, political, educational, etc. implications of changes to our world.

The Technology approach to teaching relies on background knowledge gleaned from previous inquiry lessons and a bit of creativity. Students are given a practical problem to solve that requires some thought and planning. As an example, to investigate how various materials can vary the resistance of electricity moving through a circuit is an inquiry topic. However, to design a circuit that will allow the user to vary the amount of power going through it is a technology problem. In the latter case the students must be aware of what a circuit is and what resistance is created by different materials. Then, as they plan their strategy to solve the problem, they may connect a variety of different resisting materials to switched in parallel with a circuit. The resulting solution to the problem can then be tested and evaluated based on the initial question to see if it successfully completes the task. This type of learning is very different from the inquiry based lesson discussed earlier.

The comparison between the two types of teaching strategies is analogous to a Science Fair versus a Science Olympics competition, or less so with a Computer Programming Competition versus a Invent a Robot Challenge. If the programming competition has a simple question where the code and the answer have very little room for difference between programmers, in other words the minimal code is expected and the answer is expressly clear and singular, then it is like inquiry learning. On the other hand, given very little "common" material to work with but a few rules and guidelines as to dimension, the Sumo Robot competitions result in a wide interpretation of what works and what does not. The resulting mechanisms for moving the device are as varied as they come, wheels, tractors, suction cups, etc. but the scientific principles behind them is well known, adhesion, friction, mobility, etc.. The term technology here may refer to the computerized and manufactured parts, however in the remainder of this paper I will use technology, or ST, to refer to the act and thought process associated with solving the problem.

Given the nature of the BASIC Stamp, and the greatest rewards it would have on the learning of children, it best fits within the Technology approach to learning science and therefore the Science Technology units. The secondary area suggested for its application is in the Inquiry type study where fundamental knowledge of electronics can be taught. Once devices have been constructed with the BASIC Stamp, the electronics understood and an application constructed, it would be well within the guidelines of the curriculum to challenge the use of such technology thereby fulfilling the societal component.

C. BASIC Stamp Fit

When approaching a best fit for matching a new teaching tool to the curriculum, many teachers consider primarily those grades and units with the most direct linkage of learning outcome and apparatus. If resistance is being taught, for example, then resistors of various ratings connected to the appropriate measuring device are used. In the case of the BASIC Stamp there are two primary levels of connection that can be made to the curriculum. First, as a tool for inquiry into fundamental electronic principles, the BASIC Stamp allows for a host of uses and a number of grades. Secondly, as a technological problem solving tool the BASIC Stamp expands in scope to encompass most every grade level.

In the Elementary grades there are two primary units that would benefit greatly from having such a device as a tool. Grade 4, Topic C. Building Devices and Vehicles that Move, and Grade 5, Topic B. Mechanisms Using Electricity are both Problem Solving through Technology based units. Many schools teach by a thematic approach and might link the two if the right resources were available.

Secondary education presents many opportunities for the use of the BASIC Stamp. In Grade 9, Unit 4, focuses on a Technology related Electromagnetic Systems set of concepts that have recently been duplicated, in part, by the new Elementary Curriculum. It is here where expanding the experience students have with this type of micro-computer application would add life to an older curriculum. Science 30, Unit 3, Electromagnetic Energy and Physics 30, Unit 2, Electrical forces and fields, both take a deeper look at the physical and theoretical nature of electrical transmission. Some of the key concepts taught at this level might benefit form the use of tools with a smart interface.

Many other science units still have specific learner outcomes, student objectives, that could be successfully developed into units where the BASIC Stamp could be utilized. The key here will be better described as you progress through the paper. The applications for this tool need to first be developed into a working, simple to explain, example of a useful application. This application can them be attached to a multitude of general and specific learner objectives. In fact, matching the BASIC Stamp to the curriculum may be begging the question of what the BASIC Stamp is.

2. "Less-Traditional" Curricular Applications of The BASIC Stamp

A. Reasons to Explore Further

In an earlier section we explored the obvious science connection of the BASIC Stamp to the Alberta science curriculum. In this section suggestions will be made as to possible courses, units and interdisciplinary linkages where the incorporation of the BASIC Stamp will also be of use.

Technology has become intimately linked with our society and the work place. Children today play with this technology as part of the environment around them. It would not be shocking to find in a typical school students who carried inexpensive pagers to communicate secret messages with friends across the city, lap-top computers for homework, wrist watches with a built in calculator or T.V. remote control, secret sender infrared day planners that allow communication within the classroom, among less recent technology such as walkmans. In such a demanding new society, students need to keep track with where advances are occurring but also to remain aware of the rudiments of this mysterious black box. Many people do not grow up to be scientists. Many people function well in our society with only a basic education in any one of the major fields of science. So it becomes ever more important to make the learning that takes place in our schools applicable to all learners with a future focus in mind. Incorporating the use of simple devices like the BASIC

Stamp into other subject areas can advantage students who would not normally become familiar with the stuff that makes up the ever increasing electronic world around them.

The first, and perhaps most advantageous route for incorporation of the BASIC Stamp is in Career and Technology Studies (CTS). After exploring this natural connection, other subject areas of more academic and non-academic streams will be considered.

B. Career and Technology Studies

The study of Career and Technology Studies in Alberta needs a bit of explanation in order to understand where it fits within our programs of study. Up until a few years ago there were separate courses on the study of typing and clerical skills, computer literacy skills, industrial arts, drafting, etc. Many of these courses can still be found in schools where they have chosen to offer individual programs, however the amalgamation of many of them can be found in the CTS program. CTS has become a catch all that allows for the cross pollination of skills and ideas between these disciplines, therefore students may learn about computer hardware, build a circuit board, test their skills in entering data into the computer, and finally build a case to house their creation.

With the development of CTS there has been a modularization of the program to include many of the knowledge and skill components of the former subjects. Students, for example, can work on a module that would be an introduction to keyboarding skills then move onto a module of word processing or jump into spreadsheets from the keyboarding module and save the word processing for another time. This gives great variety to the students, flexibility to the teacher, and allows for the incorporation of the BASIC Stamp as another tool used to complete many of the modules.

The Electro-technologies module offers introductory, intermediate, and advanced opportunities to explore several themes ideally suited to the use and understanding of the BASIC Stamp. In the Computer Logic Systems theme, learners can explore digital technologies, control systems, microprocessor applications, and interfacing applications. The theme that flows naturally from this would be Robotic and Control Systems.

As well, the Information Processing module offers introductory, intermediate, and advanced opportunities to explore several themes ideally suited to the use and understanding of the BASIC Stamp. In the Systems Operation module some of the more primary software operations can be applied, while in the Object-Oriented and Procedure-Oriented Programming theme students can push the BASIC Stamp to it's limits.

C. Other Subject Areas

Math is a natural for the use and programming of computers. In many of the textbook series there are specific activities designed around application of simple mathematics to computer applications. When students first encounter algebra, they may be shown formulas on the computer where values are replaced by alphabetic characters. This leads naturally into many types of computer coding skills and would be enhanced by use of the BASIC Stamp.

Younger grades, 6 to 9 would seem to benefit from the use of a tool with limited programming space and simple BASIC commands. Units in math that focus on basic numeracy and operation skills would benefit from the translation of these commands into sequences recognizable to the computer. However, almost any grade can apply the formula driven micro-computer to crunching numbers and producing results suitable for a "real-world" application of mathematics. Next to science, math has to be the strongest area of curricular fit. However, unlike science, math would be more heavily associated with the tasks of software development and not a sharing of the hardware with coding.

Curricular areas where teachers can design applications for the BASIC Stamp are as varied as the number of teachers who are designing their own lessons. It would be an astronomical task to suggest specific examples of lessons for every subject. Good ideas are something that may become the seeds of future development, therefore various teachers brought forward suggestions to be considered. Teaching suggestions have come forward for the following programs of study; Health and personal Life Skills, Environmental and Outdoor Education, Fine and Performing Arts, and Second Language Programs.

Health and personal Life Skills looks at the human body and the basic functioning of it. Equipment that measured and monitored the human body fits this curricular area. Environmental and Outdoor Education would need equipment that would monitor the environment, remotely or for extended time periods, as well as monitoring the humans within that environment. Fine and Performing Arts have used the BASIC Stamp for signaling events and creating interactive electronic works of art. A web site exists on the internet that is devoted to such interactive art. Finally Second Language Programs are always in need of simple equipment to create a linkage with language. Naming the objects worked with, entering simple words that need to be properly spelled would be beneficial to a person encountering our culture and language. Math is an international language and creates a secure base to help this process of coding and writing on the BASIC Stamp.

3. Adapting the BASIC Stamp to Non-Industry Settings

A. Considerations Before Use

The BASIC Stamp computer is a very flexible and adaptable unit that may work well in many scientific and industrial applications, but what concerns are raised when other publics are involved? Are the "manipulative" or probes available from industry for school use at an inexpensive and ubiquitous nature to make them reasonable? Is the construction of BASIC Stamp applications within the powers of students, parents and teachers?

I will address these questions by regrouping them into the following categories; the use of computer technology in schools today, other products in relationship to the BASIC Stamp, the ease of use of the BASIC Stamp, and how transparent it is to the style of learning and teaching already in place.

B. The State of Schools

Alberta schools have a mandate to development technology plans (in this case meaning computer software and hardware, along with other forms of media) and to implement the skills defined in the Alberta Ed Technology Framework Outcomes document. The document can be easily achieved by students having the opportunity to learn word-processing, spreadsheet, database, internet and presentation software, and then applying these skills to integrate computers into every subject area. It does not currently include computer programming, which I personally feel contributed greatly to students ability to refine their logical and analytical thinking. As a result students are also missing a wonderful opportunity to become creative. Schools are more receptive than ever to the incorporation of new problem solving strategies and a closer connection to student literacy of evolving technical products.

Ongoing Upgrading of teachers has recently increased in pace and number of software and hardware packages taught. Especially since the introduction of the internet, staffs are being given inservice booklets, offered day-time and after school inservice both on and off-site. Although some older schools still have Apple][e computers, all have the opportunity to upgrade to IBM 386 computers that are being surplused or recycled from government offices or industry. The likelihood of encountering older technology increases as the grade level drops. If the BASIC Stamp is to be used in the schools then access to hardware is important, and apparently not a concern.

C. Other Products

Teachers are barraged with a plethora of electronic gadgets and systems. Many electronic kits come in units too small to be practical in the regular classroom setting or too rich for the school/district budget. Compared to LEGO Dacta, IBM Personal Science Lab, Radio Shack Kits, and EKI Educational Kits, the BASIC Stamp fared as well or better and usually could be purchased for a lesser cost.

One of the biggest advantages of the BASIC Stamp was its ability for multiple usage and recycleability. Many of the kits it was compared to suffered from one time and single usage problems. To the detriment of the BASIC Stamp it is a "raw" hardware component in that it has exposed surfaces and sensitive connections. More expensive kits include protected and easy to connect hardware. This however also works to the advantage of the BASIC Stamp as the components can be seen in their natural form and cheaply acquired or replaced. The tradeoff is one that needs to be considered before purchase of the product.

Functions of this type of product include; the learning of basic electronics, development of programming skills, and the creation of inexpensive scientific instrumentation for use in the classroom. Compared to finished probes that measure temperature or light, as examples, the BASIC Stamp can be readily adapted to the same function given the proper components and instructions for a similar or lower price. The ability of the BASIC Stamp to be used in multiple applications and to conduct multiple functions weighed heavily in its favor.

D. Ease of Use

During the development of this package of information about the BASIC Stamp many hands were involved. Students from elementary grades up to university level study were observed using the technology and interviewed as to their understanding as they progressed through experiences with it. As well, teachers with experience ranging from little or no understanding of electronics to a good basic understanding of major components were consulted.

The simplicity of components, combined with the visual nature of an open electronic working model, was a powerful tool for teaching. Basic concepts of electricity such as the design of a circuit, resistance, switching, etc. can be taught with powerful learning outcomes if the students are hands-on with them. This aspect of the design was it's strongest asset.

This simplicity of components also made construction with the BASIC Stamp complicated as you descend through the grades. Younger hands do not have the motor control to handle smaller components, even when working with bread boards. Tiny components can become lost over time and need to be replaced. Difficult tasks like stripping wire, soldering connections, or attaching proper power supplies need the consultation of the teacher and/or a parent helper. This need for more direct teacher involvement in activity may translate into use of the BASIC Stamp with smaller groups, such as noon-hour clubs, or the improbability of it's use with typically larger average classrooms. The class size in Alberta ranges from district to district and yearly, however a class size of 30 students is not uncommon and is often considered typical.

Breadboards and connecting clips are the method of choice when constructing application with Junior High and younger children. Beradboards and the connecting clips are also expensive items that may add to the cost of using the BASIC Stamp. In test runs with small groups of students, simple circuits can be constructed with used or recycled material and a bit of creative construction. In one example, students used a block of styrofoam as the base, components were secured by inserting them into the foam and securely twisting the proper wires together on the reverse side. This proved to be economical however impractical for larger projects and apparatus that will be kept as part of future experiments. Ideally, educational packages of starter components and connectors would make this product more palatable to the teaching community.

Secondly, and perhaps most important is the technical nature of the construction of devices to go with the BASIC Stamp. The manual provided gives several simple and several more complex examples of devices that can be built for use with the computer. A handful of teachers may know enough about the components to be able to construct the devices suggested. An even smaller percentage of teachers have the expertise to read schematic diagrams and figure out the connections implied and the electronic components, or substitute components, that are called for. Without a question, the first activity needed in order to bring this tool into the classroom has been to design lessons with instructional potential for both the student and the teacher.

When given an overview of the BASIC Stamp usage, teachers are often open and excited about the possibilities it holds for varying their instruction. The question of learning to master the technical aspects of this product, not the incorporation into the curriculum, becomes the major concern. If future products are designed to overcome these concerns then the BASIC Stamp could integrate very well into existing classrooms.

E. Transparency to Existing Teaching Styles

The issue, of incorporation such a tool into the teaching of classroom teachers, becomes irrelevant in light of the comments made in the above sections of this report. Many tools are currently in use in education, including overhead projectors, calculators, computers, electronic thermometers and probes, heart rate measuring devices, and stop watches, among many others. Teachers welcome any new tool that can simplify a task or give students an opportunity to apply concepts in a new or extrapolated way. For example, the introduction of the calculator is welcomed in a physics class where estimation of very large numbers allows students to overcome the drudgery of crunching numbers. Where the calculator is not used is in younger grades when numeracy skills are being introduced. So too the BASIC Stamp can become a tool of application if teachers can be brought up to speed with it's use within a short period of time.

4. Where Should the Genesis of Incorporation Start?

A. Questions to be answered

There are many questions around the implementation of this tool on teaching. A few to be considered will take a stab at enhancing future development of this tool and be cautionary for those seeking to take this investigation further. First we must ask how and where to introduce the BASIC Stamp to current educators. Secondly, there is the question of who will develop the appropriate resources needed. The final questions to be discussed include; should "Teachers-in-training" be exposed to teaching with this material before they enter the educational environment, and what modifications to their training might be required?

B. Possible Solutions

In order to get the product in the hands of the people who will be using it, the micro-computer needs to be demonstrated. Product catalogues and advertising are routes that business may be aware of, in my discussions with teachers I have found that many prefer to see it in action before they make a decision as to its use in the classroom. Presenting the BASIC Stamp to a audience at the Alberta Teachers' Association Science Council Conference brought out many questions and allowed teachers to try out the micro-computer in a safe environment. Similar seminars can be run by regional councils of the same association or private inservices booked for districts or schools who request it. On a more interdisciplinary scale, workshops can be designed for larger gatherings of teachers such as the Calgary Regional Conventions.

Teachers are very adept at applying new tools to their teaching, the problem with many rejected products is the initial start-up time. If a set of activities can be developed that fit a given grade and subject, the likelihood of the micro-computer being incorporated increases substantially. If the unit is also clearly designed so as to take minimal time to learn and begin using, then the likelihood of use increases as well. Once in the hands of the teacher the micro-computer may take on a life of it's own as the first initial lessons help to teach the teacher as well as the students. Mastering initial concepts often leads to new challenges and further extensions of that knowledge. Show a teacher how to properly wire and operate a transistor and that person will be more likely to invent new ways to challenge the students.

Should teachers be introduced to the BASIC Stamp while in training? Teaching is a multi faceted job that requires much from its participants. Skills that are required by teachers on the average take three or more years to become proficient. Within the teacher training programs at The University of Calgary, students have many avenues to explore in the area of advanced technology. As a matter of learning about the theory and practice of teaching, students often encounter computers. It is unlikely that specific instruction of the BASIC Stamp, or other product, will become a mandatory part of all new teacher instruction, however students and instructors in the undergraduate program may wish to leave the door open to such a possibility.

5. Sample Teaching Materials for the BASIC Stamp

A. The Plan of Action

In this section of the paper sample lessons will be presented. Many of the features of these lessons address the concerns raised earlier in this paper. Teachers examined, construct and compared notes on the use of the Stamp. Rough lesson plans were developed. Selected groups of students attempted to use the BASIC Stamp as a tool according to the lesson plan. Finally the lesson plans were compared to the success the students achieved and how closely their learning matched the objectives for conducting that lesson.

The trial activities produced several simultaneous outcomes. Students may be engaged in learning about data entry while keying in, loading or downloading software to the BASIC Stamp. Students learn a technical task or skill by conducting such work. Once the rudimentary aspects of usage have been learned, modification and design of their own software raises the cognitive level and complexity of task conducted by students. Students learn that computers need instructions to complete tasks, that is, what to do and when to do it. The need to get instructions to the micro-computer provides students with an introduction to the need for creating lists of instructions and personal development of logical reasoning skills. Computers are considered to be a powerful aid to mental activities and the dissemination of the results of these mental activities. The BASIC Stamp can provide such a learning experience with a computer.

Other outcomes of using the micro-computer include skills related to motor coordination and physical task completion. With the addition of new challenges, students become inventors and apply knowledge to the development of more sophisticated models. After the creation of the technical tool has been achieved, the societal role that tool plays, as a tool of an information-based society, can be called into question. Subjects such as artificial intelligence and robotics are just beginning to become significant in the educational setting.

What came from these trial activities became the basis for a plan of action for future units. Materials should be referenced, part numbers out of catalogues where possible. Circuit diagrams should be accompanied by three dimensional appearing pictures of the parts the require and the physical layout rendered. The more realistic and detailed the diagram the better the chance of success. The code for the software needs to be remarked on within the stack, and a hard copy provided along with the black-line masters of the schematic diagram. Extension and contingency lesson information is usually sufficient for teachers to envision new applications with their students, and therefore the description and drawing of an initial answer to the design is all that may be needed.

Especially in younger grades the design of activities should be simple and adaptable. Running lights, motors, and simple switches would go a long way when applied to different construction and data entry tasks. For such activities the act of connecting wires correctly and downloading premade code would be sufficient in many large classes. With practice students can develop code of their own. However, providing possible software solutions on disk would allow large numbers of students to quickly download their project from a central computer. This eliminates the need for many computers, especially if the work is done within a typical classroom that may have only one to three computers.

The focus on generic projects, and pictorial diagrams, makes the following set of lessons applicable to a wide variety of instructional grades and subjects. Each project represents a different level of difficulty. Extensions to each lesson are stated in a way that the teacher may wish to challenge their students to master the concept being taught or advance into an new area of understanding. Taken as a stepping stone to further development, it is hoped that observation of the use of these lesson plans will refine the incorporation of such micro-computers into regular classroom usage.

B. Lesson Examples

When hearing about these lesson examples, please consider that the teachers involved in this study have the experience and training to establish their own lesson plans. In fact, teachers enter the profession often proficient in the area of lesson plan development. Depending on numbers of micro-computers, personal computers, students, electrical components, and a host of other concerns, teachers are adept at making choices to enhance the learning environment for children. with the broad range of ability levels and interests, teachers are also capable of generating titles and scenarios, metaphors and evaluative tools to manage such instruction. Where this study was the most helpful was in the generation of simple, graphical, and user-friendly sets of ideas around a project. Such projects then become the basis for a single lesson plan or unit of sequential activities. In the following text, a description of the base activity will be followed both hardware and software information that enables the maximum possible audience to benefit from using the micro-computer in their teaching.

Project 1: Morse Code

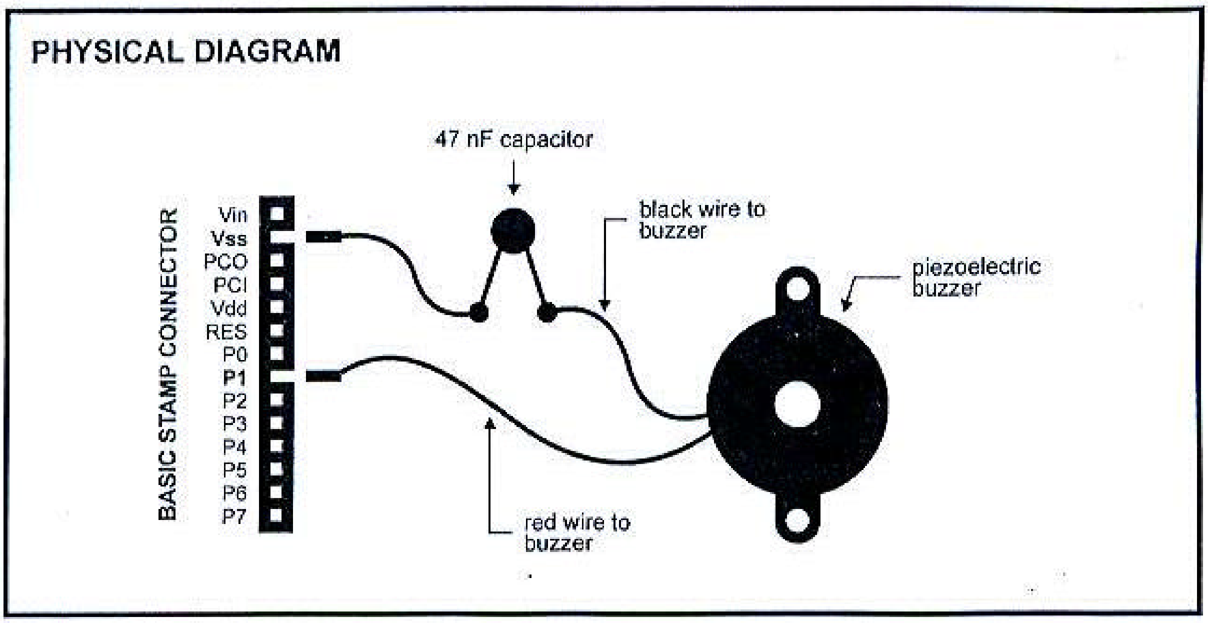
The first of the Black Line Masters may look familiar to anyone who has read the standard BASIC Stamp manual. Taken directly for the manual, the Morse Code sender is used to demonstrate the difference between the text provided in a technical manual for electrically proficient individuals and the novice user (Parallax pp. 105-110). Starting with the base design from the BASIC Stamp manual, you may be able to identify the differences in how the information is presented to teachers and students.

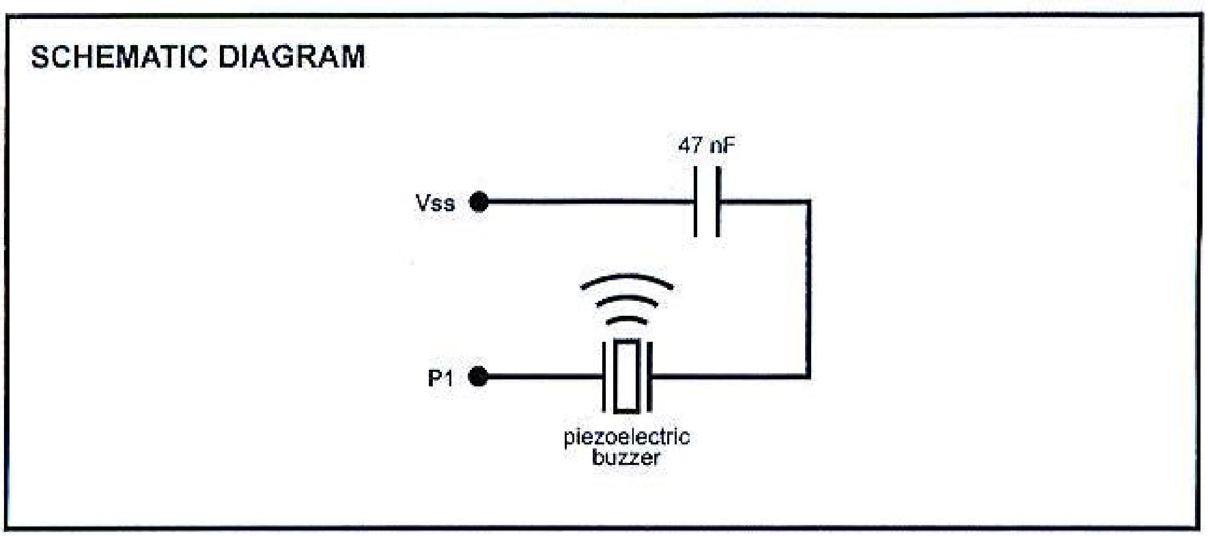
This project is simple enough to start most students on. Once the mechanical act of connecting electrical components is complete, students can be taught how to download the premade software to the micro-computer form a personal computer. This type of activity allows for teaching about proper usage, care, maintenance, safety, and coding information.

The higher mental activities arise after the Morse Code device is built and operated. Changes such as new code in the software to send different messages, changing the hardware from a sound producing device to a light emitting device, and others offer further exploration and manipulation of the device. Once students master construction and programming, new challenges can be introduced. A popular teaching tool called the Science Olympics has arisen the past few years. As a science olympic activity, students can be given the task of communicating a message down a long hallway of a school. Teams of students are supplied with a pair of BASIC Stamps, a grab bag of components, a spool of wire, paper, tape, etc. and allowed a portion of a period to decide how to solve the task. Some groups may decide to encode a message in the BASIC Stamp and design a paper sled to launch the message carrying device down the hall to the group member at the other end. Another solution might be to rig the BASIC Stamp with wires long enough to reach to the opposite end of the hall and send the message electronically. Regardless of the solutions, and I am certain most students are creative enough to vary the response, if they address the task requirement then they succeed. This a type of application for which the BASIC Stamp is well suited.

PROJECT 1

MORSE CODE





Project 2: Stampmobile

This project, and the one that follows, may become part of a larger unit on motion and machines. Not intended to be a starting activity, it is here where many of the components that are suitable for use with the BASIC Stamp may be introduced. Before beginning to build electric cars students should be aware of the general use of motors and the electrical requirements of that device. The scientific concept of the conversion of electrical potential energy into kinetic energy of motion is also an ideal concept at this time. Transistors need also to be introduced at this lesson or could be expanded on form previous study.

Actual teaching about electrical components is an essential to making students aware of the purpose of each in the system. Therefore, simple text and related concrete examples of simpler devices would assist in student understanding. An example of three components appear in this project. The following three descriptions would be at the level of explanation to suit most educational needs in our current curriculum.

Starting with the transistor, when using off the shelf transistors it became essential simulate a more powerful transistor by connecting more than one in parallel known as the Darlington Arrangement. This arrangement may not need to be explained to the student, however, the following text would be essential to a basic understanding. The purpose of a transistor is to allow the small amount of power from the BASIC Stamp to control a larger amount of power that controls the motor. Put simply, the transistor acts as a switch to control the flow of electricity that flows through the motor. Transistors have three legs, two of which are on the circuit with the larger amount of power for the motor. The third leg of the transistor is called the "base." It is the job of the base to turn on or off the power flowing through the circuit with the motor when it receives an electrical signal from the BASIC Stamp.

The capacitor is used to prevent electricity from going in the wrong direction, and returning to the BASIC Stamp. When not used there is a possibility this stray electricity can confuse the BASIC Stamp, what electrical engineers call an undefined state.

Resistors are wires that are not perfect conductors. Used in this application, the resistor protects the transistor from having too much current flowing through it. Transistors are sensitive to burning out. To limit the amount of power sent to the transistor, prevent over control of the circuit. Finally, resistors slow the feedback of current to the BASIC Stamp.

The task that would be assigned to students is to construct the device as shown and perhaps enter or download the code. The Stampmobile itself is a construction task that would require any number of creative materials. The main intent is to provide students with a way to switch on and off simple circuits using the minimum number of, simple, standard electrical components possible. From this simple starting point it is easy to visualize lessons coming forth. In fact the number of lessons would be infinite, however the following paint a picture of the possibilities that exist.

The first activity builds anticipation. The building of the stamp mobile itself from any material or kit that the teacher finds appropriate. Students need to consider that the cart needs room for the motor and it's power source along with the BASIC Stamp and it's power source. Finally, the design of a gearing or belt drive system to attach the motor to the wheel and axle combination that moves the Stampmobile.

An activity for making the BASIC Stamp mobile. Students are instructed as to the main components of the code that drives the system. Establishing communication between the Stampmobile and the BASIC Stamp requires sending signals to the transistor to turn on or off the circuit controlling the wheel. Using the pin P1 on the carrier and a corresponding command of "output 1" will help to make the mental connection of signalling more clear to the students. An example of the software would include:

```
output 1
top:
low 1
pause 1000
high 1
pause 1000
goto top
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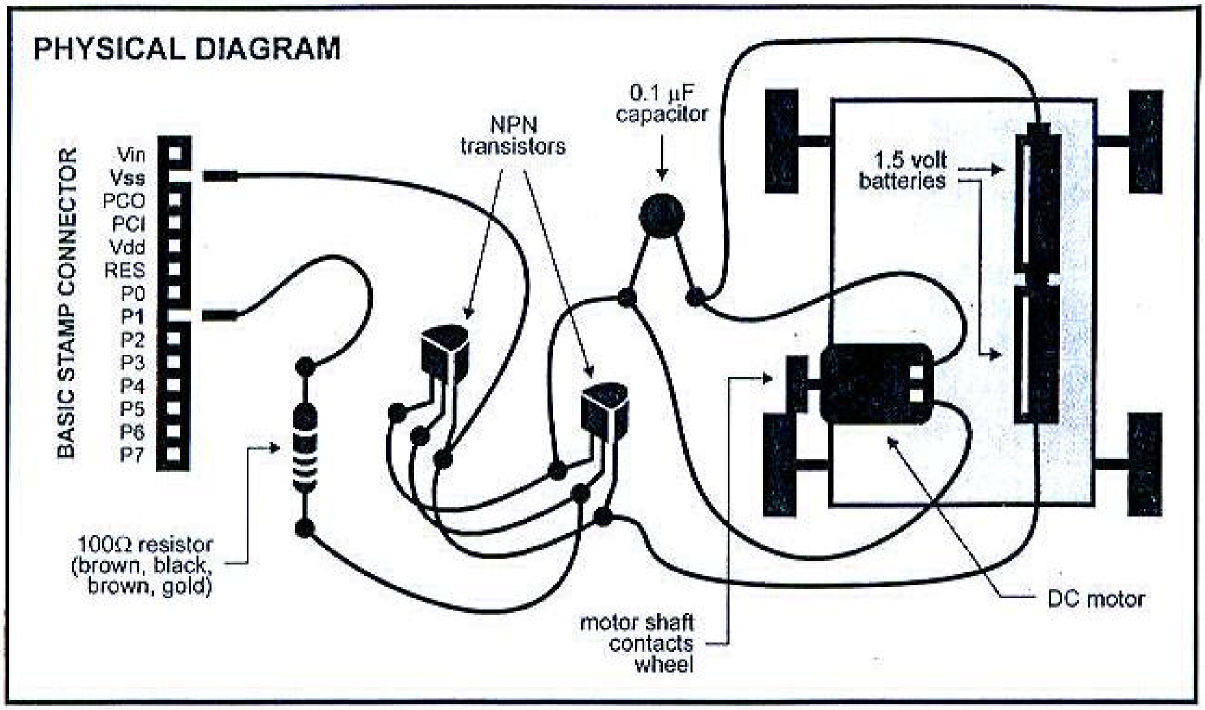
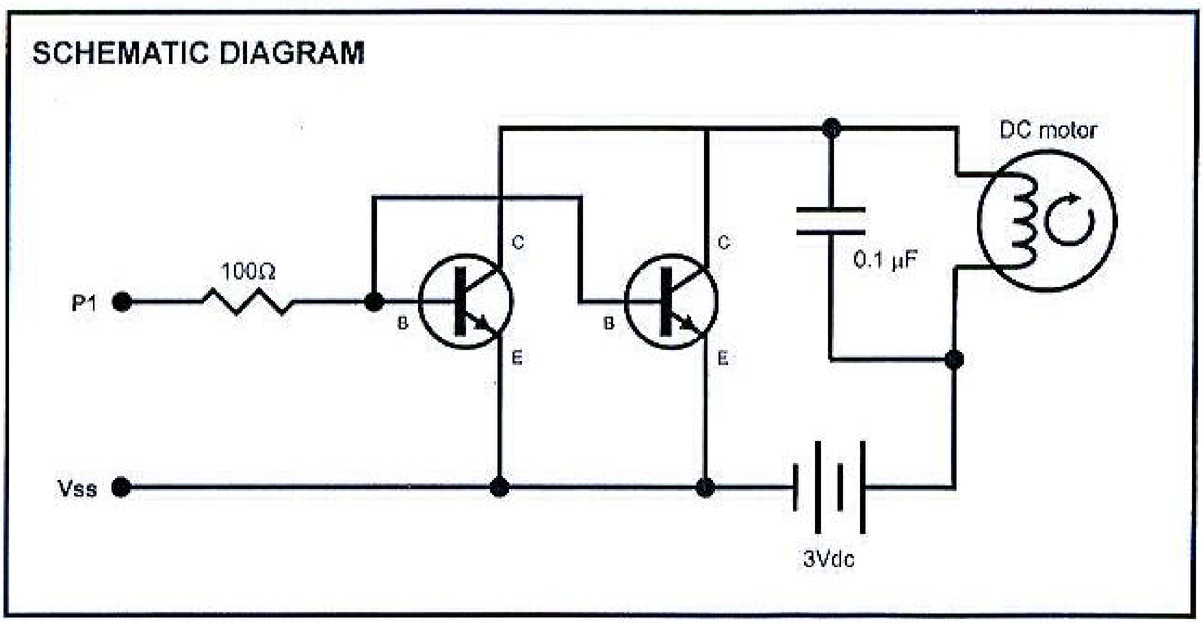
Instructions such as, the command "low 1" turns the power to the base of the transistor off, and the command "goto top" is the bottom of a loop that starts at the line "top," teach basic coding rules to the students. As a suggestion, students may try exchanging the "low 1" and "high 1" to discover if the order of commands matters to the Stampmobile. Other commands, such as increasing the value of pause, changing the duration of the loop, and having two sequences of different durations within the loop can be used as enrichment and prepare the students for the next few activities.

The two wheeled Stampmobile activity. By adding a second motor to the other side of the vehicle students can control the direction it will take. If one wheel is on and the other is off then the mobile will likely turn. If the students have only been given the Black Line Master for Project 2 as instruction then they are challenged to solve two puzzles. First they must connect a similar motor set using P2, or other chosen, for the electrical connection. Secondly, new code must be written to include power to this new circuit using the instruction "output 2." Students may need to be told that whatever pin they choose, P3 as an example, then the corresponding instructions, "output 3," must be added to their code. Now, like the turtle of early LOGO programming days, the students can be given another software problem of making the Stampmobile match a set course.

PROJECT 2
STAMPMOBILE





Project 3: New and Improved Stampmobile

This version, of the Stampmobile, includes an H bridge of transistors. with a single motor, students can design a switching system to allow electrical current to flow in either direction through the motor thereby allowing for forward and back motion of the Stampmobile. Power in this arrangement would flow to opposite corners of the bridge transistors turning on the current in alternating directions. Care must be taken in the code to see that all four outgoing pins are turned off at the start and only two at a time, opposite corners, are turned on.

An activity that flows naturally from this one is to allow the students to now connect a second motor in the same manner using the four remaining outgoing pins on the carrier. Adding another motor, and the corresponding code, would make the Stampmobile behave much like a tank in operation. Either side of the vehicle, and the directional control of the motor, makes for interesting movements. An elastic band, or fabric band, between the front and back set of wheels would give a better illusion of the tank nature of the student creation.

Using what has been taught in Project 2 and 3, students can now be challenged to design a vehicle that moves forward and back with a flashing light on it. A good title for the project might be "Invent a Police Car." Buzzers when the car is backing up, a crane or shovel scoop on the front, a BASIC Stamp Merry-Go-Round, and varying the speed of the invention might also be posed to the students. Once the basic skills are taught, applications that foster student creativity and problem solving skills will help them to see the value in multiple answers to a problem.

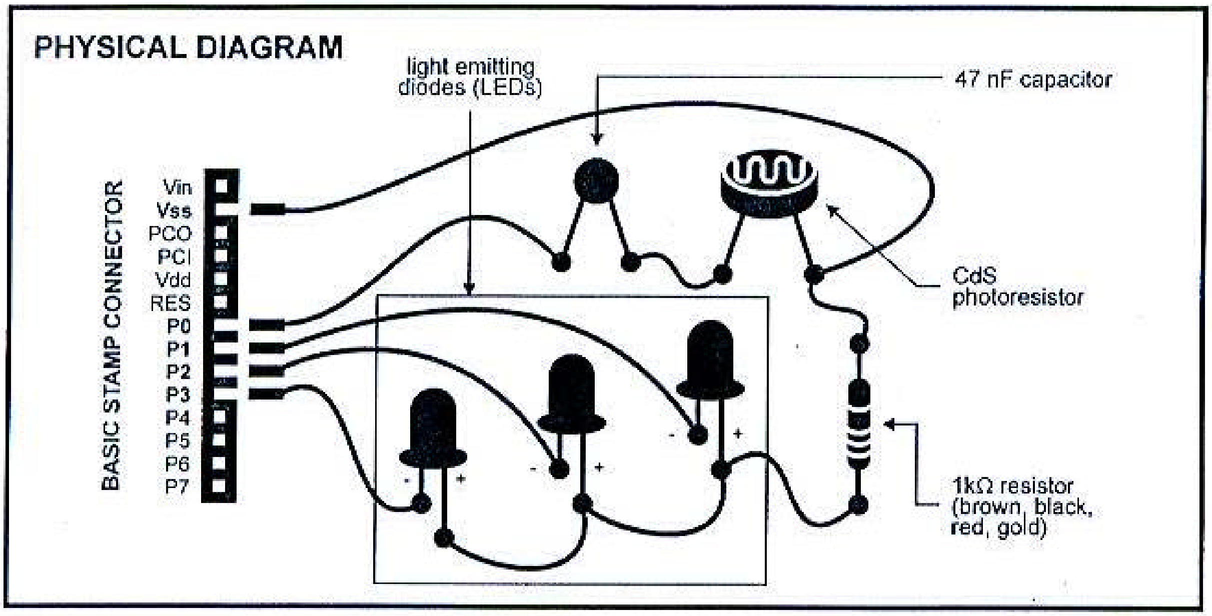
Project 4: Nite Lite

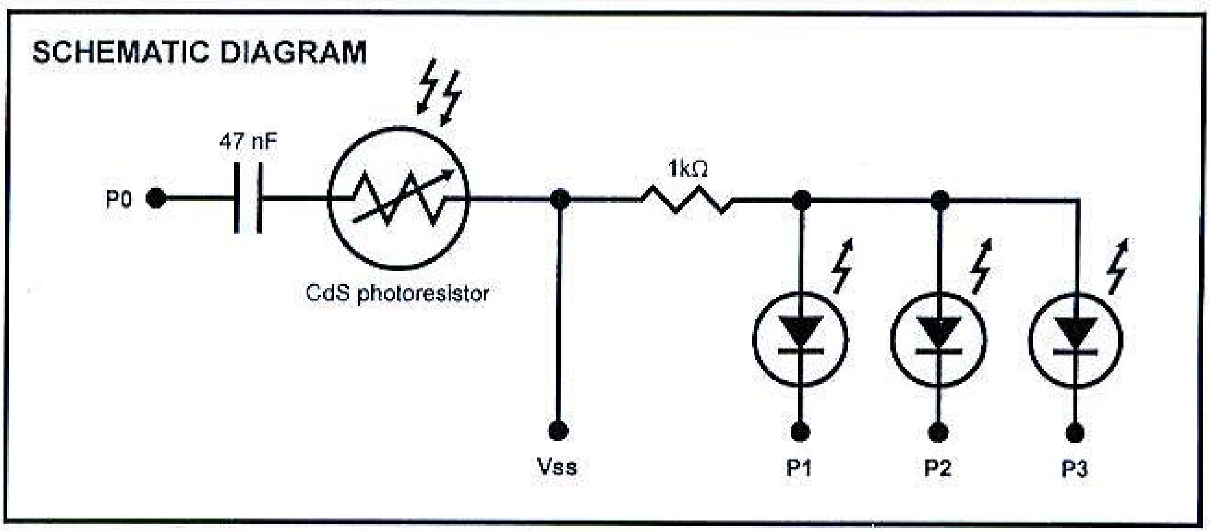
As a project for students, the Nite Light introduces the photoresistor as another tool in the creation of projects. When the light falling on the photoresistor decreases, for example when an opaque body moves over top of it, then the LED's light up sequentially. The dimmer the light the more LED's that turn on.

Combined with other mechanisms, such as the Stampmobile, this arrangement can be used to turn on the motor when the light level is low. Students can be given a problem of inventing an electrical burglar alarm. The answer to this question may range from a buzzer that sounds when the light turns on to a flag waving cart that scoots out into the street when it is disturbed.

PROJECT 4

NITE LITE





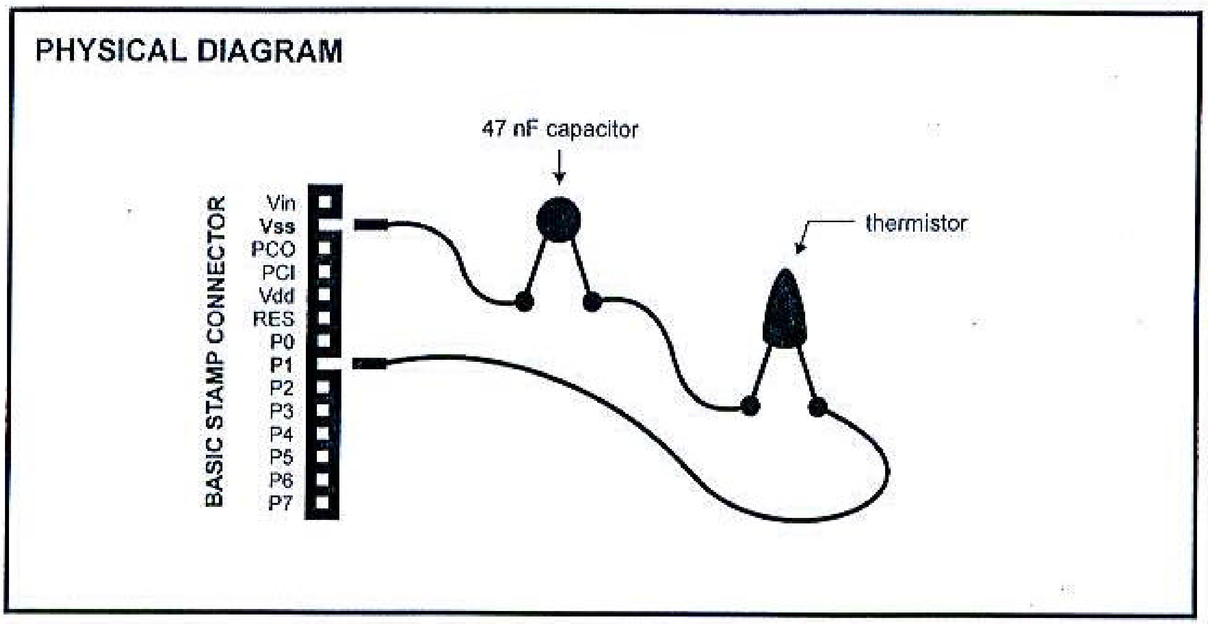
Project 5: Basic Thermistor

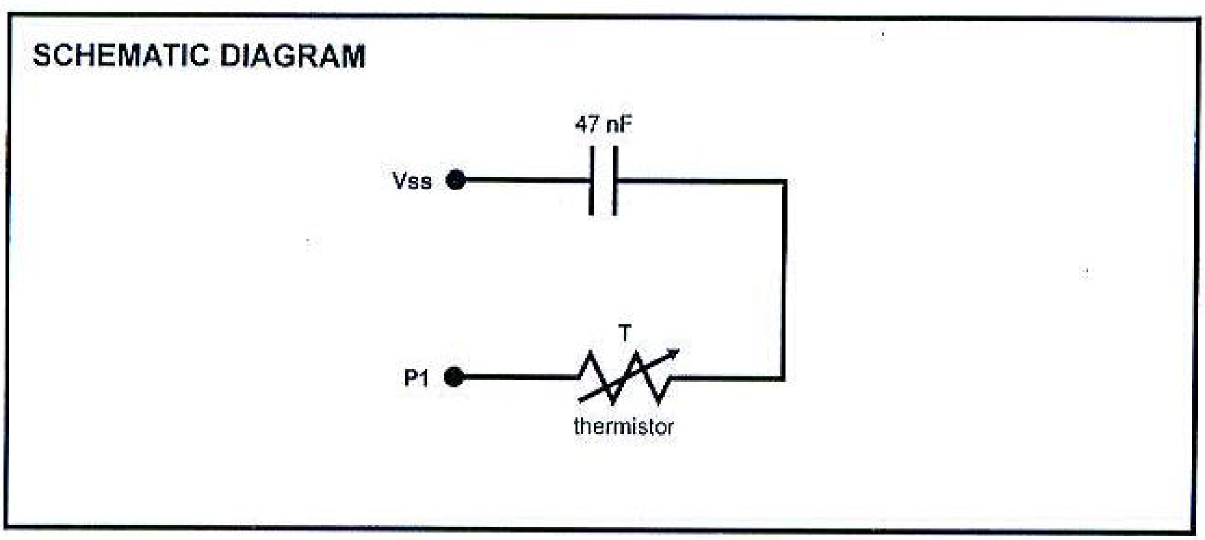
A thermistor operates on the same principle as a resistor. A thermistor resists the flow of electricity but that resistance is dependent on the temperature of the component. The Basic Stamp manual includes the design and instructions to create this device. Please note that the thermistor may vary from the one the software was written for and temperatures may not read true. Calibrating the thermistor is a complex process because of the relationship between the resistance and temperature is not linear. Therefore having students build the unit and download the software is sufficient.

The real application of this device comes in it's usage. Such a thermistor can become another lab tool for the accurate recording of temperatures where no person can be in order to read it, as in a closed refrigerator. Long term experiments can be recorded with the addition of the right code. Other challenges may include a body temperature measuring device while the participant is exercising, there would be no need to stop the test subject in order to take a temperature. With the right changes to the software, multiple thermistors can be connected to the same BASIC Stamp. A light can be signaled when a certain temperature is reached. Multiple thermistors can be placed around a room to measure heat as it circulates in a convection current. The usage of the device is endless, recycleable, and inexpensive.

PROJECT 5

BASIC THERMISTOR





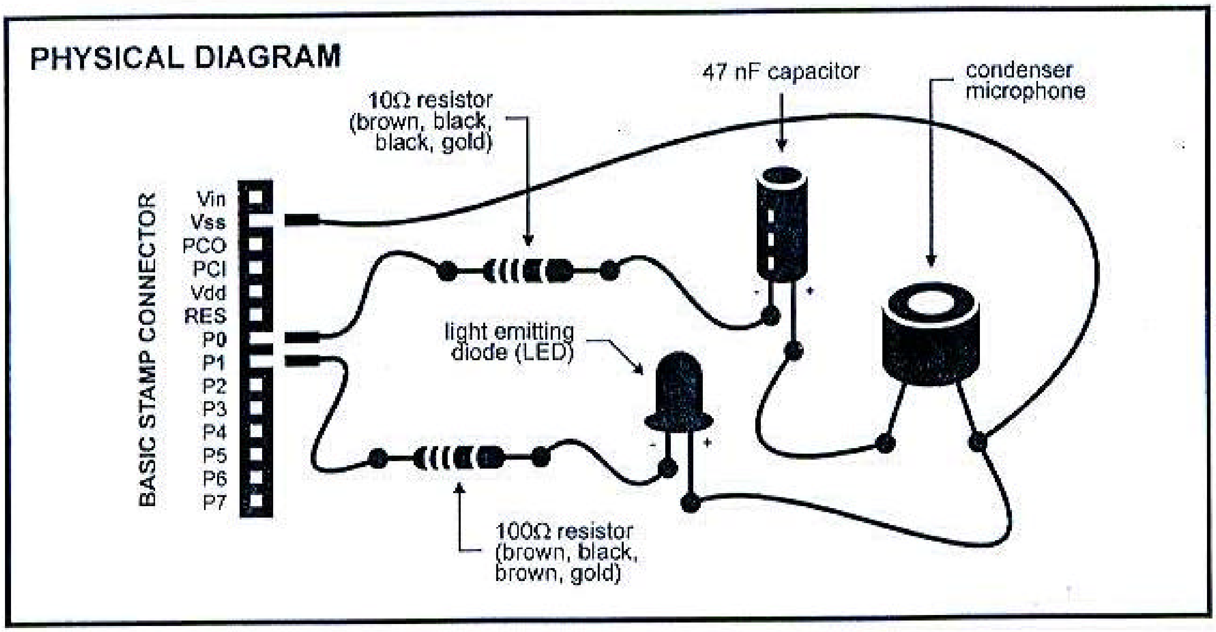
Project 6: The Clapper

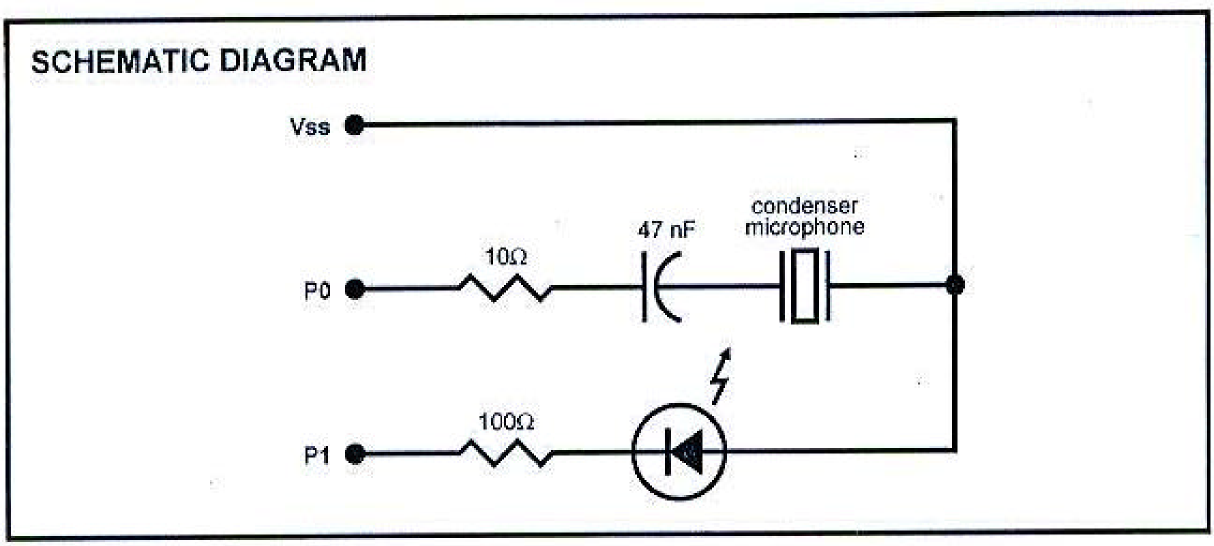
Naming this project became a fun activity, initially called the Stamp Detector the name was changed to the Clap Detector with some reservation of calling it the Clap or Stomp Detector. Regardless of the name the intent was to use the electrical signal coming from a condenser microphone to act as a switch. When an audio peak is reached the BASIC Stamp takes the input as a signal to do something. In the case of the Black Line Master, a loud noise will trigger the light to turn on or off whichever is the opposite of what it currently registers.

Adding another option for components students can use, displayed in a manner that simply explains it's usage, allows for a very broad spectrum of outcomes when future scientific investigations arise. If students are provided with this and the other activities as learning experiences, then new problems may result in solutions that include a technological answer as often as a more traditional physical response.

PROJECT 6

THE CLAPPER





C. Results of the Test Lessons

Once developed and tested it is natural to evaluate the success of any learning tool. The above lessons provide only snapshots as to the total usage possible for the BASIC Stamp. Evaluation the initial success of these lessons needs to be considered in light of the conditions under which the testing occurred. There was only a small group of selected students eager to try out the new resource. Teachers who used the Stamp were also science teachers who ranged in understanding of electrical components, however all had a basic understanding of the principles of electrical devices. Therefore, testing on a larger scale with a full classroom of regular students, and selected group of teachers who have varying understanding of electronics, would be needed to validate any unit materials that are distributed. Many other activity ideas were proposed, solutions to all are believed to be possible but have not been acted upon. Some of those ideas include:

experiment timer
tick-tack-toe board
measure pulse rate, sphygmomanometer
breathing rate or number recorded, using chest strap
soil moisture measurement
wind speed anemometer
electronic rain gauge
pressure receptor
water quality indicator (conductivity or pH)
material tester for wet cell construction
mimic the electronic control in simple household appliance
measure the transfer of heat by radiant energy (infra red)
insulation tester for model home
manipulate the conditions for plant growth over long period
photogate to measure velocity
water pressure gauge
measure earthquake activity, electronic seismograph
scale tones for music
robotic brain

In general, it can be stated that the BASIC Stamp micro-computer offered potentially stimulating, challenging, and relevant experiences within the context of the Alberta curriculum. Students would benefit greatly from having resources such as these made available to teachers within the province. Implications for the students include increased understanding of electrical principles, electrical devices, computer hardware, software, programming skills, problem solving skills, and an appreciation for the work of engineers. This learning combined with information on the related scientific fields of study can only increase the potential of bringing young males and females to science and technology careers. If the resources are presented along with rudimentary explanations of the electrical components, graphical representations of the circuit layouts, and all for an economical price, many teachers would be pleased to plan lessons around their own curriculum in order to incorporate this new teaching tool.

6. Future Science and "Non-Traditional" units

A. Identification of Future Units

Given the vast array of possible routes into the curriculum, and manners of instructing with this tool, possible routes to success have been postulated for each grade grouping. The question is -- if future study units are to be developed with grade level and subject in mind, what subjects may be most successful. To begin we have to make assumptions about the nature of planning for these units. Planning done well is the craft of an experienced curriculum developer or teacher. It is always best to focus on the strengths of those working with you to maximize your returns. Therefore, a mathematics teacher would not be chosen to develop a unit for a social studies curriculum. The assumption here is that these unit choices are made without consideration of who would be doing the development. Another assumption is that the curriculum will not change drastically from the general format that is suggested by these units. And finally, we need to also assume that the teachers at these grade levels will welcome the materials and activity to their teaching. Often in school settings there are curricular areas that are overburdened with excess mandatory student learning outcomes in contrast to resource poor programs. As you read the following three suggested groupings, please consider these and other implications of taking them to completion.

B. Proposed Future Units

With the establishment of the flexibility of this tool for education it becomes almost impossible to suggest the best course of action for launching it into the classroom setting. The following suggestions are provided to help those wishing to focus on natural connections. These recommendations presume that units where electricity is a prime focus would be the best connection for such a device. Secondly, these suggestions explore the question of if there are best-fit units in other disciplines, where the Stamp would not be presumed to be a required resource, what would those units be?

Elementary, Division I, is such an important grade for basic literacy and numeracy skills that this paper recommends the BASIC Stamp not be introduced. Although an argument can be made that the students at this level would understand it, the question is one gaining prerequisite skills to a level of proficiency that they become transparent to newer experiences.

Elementary, Division II, Grade 4, Topic C. Building Devices and Vehicles that Move, and Grade 5, Topic B. Mechanisms Using Electricity are both Problem Solving through Technology based units hat would be a wonderful match. As well mathematics would benefit form simple LED switching exercises linked to student created software that includes operations. While the elementary grades offer the most hope for a thematic unit based on the BASIC Stamp that would incorporate all the core academic subjects as well as the fine arts and option classes.

Junior High, Division III, Grade 9, Unit 4, Electromagnetic Systems is a technology based unit with potential for the most impact on learning of any grade. In Career and Technology Studies the Electro-technologies module and the Information Processing module both offer introductory, intermediate, and advanced opportunities to explore several themes ideally suited to the use and understanding of the BASIC Stamp.

Senior High, Division IV, Science 30, Unit 3, Electromagnetic Energy and Physics 30, Unit 2, Electrical forces and fields, both take a deeper look at the physical and theoretical nature of electrical transmission. Fine Arts, specifically Art and Drama would be interesting places to introduce an intelligent component to the creation process.

7. Final Comments

I have seen many teaching tool enter the classroom only to become dust collectors. Those curricular resources that change as the curriculum changes survive. These materials that are easily understood by the teacher using them, and has text resources with it that will be assessable to any new teacher who comes upon it, will survive. Education of our youth is a daunting task to put before any individual, however with the proper resources and training, we can give the students of today more than knowledge -- we can give them the skills they will need to acquire their own knowledge and invent a future for themselves.

Referential Material

Alberta Education. (1990). Learning Contexts for Junior High School Science, Alberta Education, Curriculum Standards Branch. (various years). Programs of Studies

Mims, Forrest M. III. (1986), Engineer's Mini-Notebook: Optoelectronic Circuits 1st Edition

Siliconcepts Book, Archer (Radio Shack): USA.

Mims, Forrest M. III. (1990) Engineer's Mini-Notebook: Science Projects

Siliconcepts Book, Archer (Radio Shack): USA.

Parallax, Inc. (1995). Basic Stamp: Stamp-Sized Computer Runs BASIC, Version 1.2, Parallax, Inc. Rocklin, CA.

Raizen, Senta, et. al., (1995)., Technology Education in the Classroom: Understanding the Designed World, Jossey-Bass Publishers: San Francisco.

Reynolds, Karen E., and Barba, Robertta H., (1996), Technology for the Teaching and Learning of Science

Allyn and Bacon: Boston.Sharp, Vicki. (1996). Computer Education For Teachers. Second Edition, Brown & Benchmark: Dubuque IA.

Weeks, Ronald C. (1997). The Child's World of Science & Technoloy: A book for teachers, Prentice-Hall Canada: Ontario.

Internet Sites

http://piglet.cs.umass.edu:4321/robotics.html
Robotics Internet Resources

http://www.inel.gov/robotics/index.html
INEL's Robotics Program

http://www.robotics.com
Arrick Robotics

http://ppl.mines.colorado.edu/inel.dir/main.html
Parallel Computing Applied to Robotics and Computer Vision

http://www.engin.umich.edu/~johannb
J Borenstein's Mobile Robots, Obstacle Aviodance, Dead-Reckoning, Positioning

http://www.jpl.nasa.gov http://robotics.jpl.nasa.gov/robitcs.html
NASA Jet Propulsion Lab

http://www.urich.edu/~ed344/summer/Shannon/web.html
"The First-Year Science Teacher's Guide to Sanity" -- lessons, facts, connections.

http://www.teachnet.org
"BluePlate Special" lesson plans and links to other resources.

http://www.ase.org.uk/safe.html
"The Association for Science Education: Safety Files" -- hazards and safety solutions.

http://www.neat-schoolhouse.org/lesson.html
Awesome Library -- K-12 Lesson Plans (Lesson plans and links to more sites).

http://www.ericsp.org
ERIC Clearinghouse on Teaching and Teacher Education (Planning help for teachers)

http://www.ed.gov/pubs/parents/Science/
"U.S. Department of Education: Helping your children learn science" -- teaching at home.