K-12 Hands-on Science Education: A Small Business Proposal

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This is extracted from a proposal submitted to the Department of Education in 2000. The proposal required us to show long-term profitability once the DoEd funds ended. STI Inc., was the name chosen for this not-for-profit company. DoEd did not fund us We are passionate about developing it further if there is interest in collaborating with us / funding us. Do note that the proposal is based on a viable practical concept and has many useful references, but is verbose and needs trimming!

This was also a business plan developed for a course on Entrepreneurship that Dr. Shankar took as part of his Executive MBA, in 2000.

OVERVIEW

I hear, and I forget
I see, and I remember
I do, and I understand

--- A Chinese Proverb

Science Teachers Inc., (STI), is dedicated to enhancing the interest of K-12 students in science and engineering and to empower the teachers to participate in this process. Genomics, Information Technology, Internet, Software, and Microelectronics will drive the next millennium to unprecedented growth. A community that is well versed in science and engineering will dominate the international commerce and economics. The economic gap will be driven not by capital and natural resources, two traditional strengths of the U.S., but by scientific knowledge and the ability to translate that knowledge to commercial advantage. U.S., the traditional haven for innovation, will in all likelihood lose its preeminent status - the younger generation is falling far behind the students in other industrialized countries in both science and mathematics. STI wants to empower both the students and the teachers, by emphasizing the hands-on experiences in science and engineering,. Such an inquiry-centered approach has been well proven to be a good indicator of success. The society as a whole will grow and prosper. It is our intent to pave the path of success for the U.S. and other countries, and in turn benefit from this participation.

Science Teachers Inc., will develop and manufacture products for the school systems, both in the U.S., and abroad. There will be training and tutoring services associated with our products which may be contracted out. Our products will be PC-based software and hardware that together and in various combinations will be used by schools to set up customized curriculum for hands-on experience of the students. The home market for science kits is yet another market that can be addressed independently. We expect the concerned well-to-do parents to be the first ones to purchase our products.

Our conservative estimates indicate that the net profits would be $240,000 the first year of product introduction (Year 2 of our existence), increasing to $2.4 million in the third year, just from the U.S. sales alone. The figures may be expected to treble with exposure to other industrial countries and developing countries such as China and India. We estimate that a teacher with a new working innovation would net $60,000 to $120,000. We believe that the model has tremendous potential for growth and impact on the school system, not only in terms of better education, but also in terms of building an entrepreneurial atmosphere, and hopefully, many innovations in the future.

2. MISSION

2.1. Mission Statement

We believe that next century will bring enormous benefits to those who are ready and willing to exploit the technological and biological advances that will come our way. We want to prepare the world's young minds with sufficient insight and knowledge to be able to address the many scientific, technological, social, and environmental challenges and opportunities of the next century. We want to empower the teachers of the world to become entrepreneurial and participate in this wonderful opportunity to further their teaching mission, benefit economically, and contribute to the education of all the students around the world. We want to be a socially responsible company with dual goals, thought to be typically incompatible, of contributing to the enhancement of the standard of living of the participating communities, and an excellent return to the loyal and patient investors.

2.2. Significance

The Third International Mathematics and Science Study (TIMSS) released in June 1998 shows a dismal trend of science and math education in the U.S [TIMS98]. Out of 26 developed countries, our combined rankings moved from 7th for fourth graders to 12th for 8th graders to 25th for 12th graders, only ahead of Cyprus and South Africa by the senior year. As the ‘Popular Science’ magazine [Fish98] puts it, “Nothing less than our future is at stake. Our present world leadership in technology and economic well-being threatens to erode as we enter the 21st century, because our children are ill-prepared to compete in a global high technology marketplace.” Academics and politicians were understandably shocked at the seniors’ performance.

As grim as the situation seems, there is evidence that we already know how to fix the system. A group of US eighth graders did very well, being placed an impressive 2nd in

Science, second only to Singapore, while the official US ranking stood at 18th. These children, about 37,000 of them, belonged to 20 suburban Illinois school districts that joined together and entered the TIMSS test as a separate "country." The difference: Kids in this consortium learnt mostly through hands-on experiences, not the rote memorization that is still standard practice across most schools in the U.S.

Of course, these kids had the advantage that their upper middle class families could afford to provide the extras to their children and their schools to make a difference. "A major part of the national education problem consists of tears in the social fabric. One child in four lives in poverty, and many families - broken or otherwise - provide minimal support for and little expectation of a child's educational progress." [Fish98].

2.3 Products And Services Description:

1. Our main product will be a software and hardware kit that will turn a regular or a network PC into a lab unit. In our sales projections, we separate them so as to give the user more freedom in choosing the right combination. Thus, there may be as many as 5 different hardware platforms, 10 different hardware modules and 20 or more software modules.
2. We will also facilitate training of the teachers and tutoring of the students with the aid of these products. For the former, it is our intention to contract out the work to other teachers. For the latter, we will sell these units to private training institutes. It is not our intent to go into service business.
3. We will also sell a developer's kit to teachers and other interested parties to develop new innovative addition to the portfolio of experiments. To spur innovation, it is our intent to have generous terms with such teachers. We will provide prototyping help.

2.4 Innovation and Effectiveness

In our case, we propose to focus on the hands-on science experiments to give all the students and teachers the advantage of being taught, albeit indirectly, by the expert science teachers. While one can envision multi-media, Internet, and virtual reality experiences, our focus is NOT such software-only experiences. Studies show that today's children spend too much time in front of the PC screen and thus may be becoming more and more isolated and no longer socially adept.

Our approach will still use the PCs and Internet access that is becoming more and more common in schools, but in a different way, to provide hands-on experiments. An example of our approach is well illustrated in the $199 package sold by Lego-Mindstorms (see www.legomindstorms.com). This kit consists of robotics building blocks that can be assembled to perform various functions. Such systems can be programmed from the PC. We propose to adapt and significantly extend this concept to scientific experiments. Since children and adults alike learn better with more exposure and with familiar situations, we propose to develop experiments that mimic or relate to their experiences.

2. 5 Our Strengths

This effort needs a capability for developing the software and hardware modules and prototyping the system. This is the capability of the CAPE (Consortium for the advancement of product engineering) alliance described here. This collaboration involves three public / private higher education institutions with complementary strengths, (and a state-of-the-art infrastructure,) with regard to technical, academic and research capabilities. The consortium, in addition, has several business partners who bring in value-added to the alliance. The consortium has the modern infrastructure and the know-how for rapid prototyping of intelligent systems. An intelligent system, by modern definition, refers to a current or newly engineered system, which is made more powerful, optimized, flexible, and adaptable, with the aid of built-in computer software and hardware to act as its intelligence. The computer can store system pertinent historical information and help the system to be used better. The system, further, can now be remotely programmed, monitored, controlled and networked, to optimize its performance on a more global scale. Some common day examples are smart homes and modern automobiles. Both can have more than 10 to 12 such intelligent systems distributed physically / geographically, but networked and controlled perhaps by a central system, for smooth operation of the whole system. While the consortium's capabilities go far beyond the needs of this proposal, it is an industry and government sponsored resource that can aid in rapid prototyping of systems.

2.6 Uniqueness of Our Approach

Teachers, parents, and school administrators alike have voiced considerable support to our hands-on concept. Currently, several school districts are experimenting with the hands-on experience, albeit with stand-alone science kits. However, the availability of PCs and the Internet, provides one the ability to not only make the hands-on experiments more interactive, intelligent, intensive, and interesting, but also extensible, via Internet access, to other experiences and experiments. Further, the Internet provides one the ability to monitor and support the science teaching in geographically dispersed schools. The inquiry-centered science learning being promoted by the National Academy of Sciences [NAS96a] would have truly arrived.

Our approach is innovative - we will use the already existing PC-based laboratories and the ever-increasing Internet access, to provide not just a software (a virtual reality) experience, but a hands-on experience with scaled reconfigurable physical models of real-life situations. Such systems would be remotely controlled and monitored from the PC. Some examples might be: (1) Simple - electrocardiogram, traffic light controller, security alarm, electronic prism, and electronic tuning fork; (2) Intermediate: fractals, solar cells, germinating plant, and gear chain; (3) Advanced - heart and vascular system, auto fuel injection, radio, robotics, and thermoelectric devices.

A lower elementary school child (grades K-2) might simply observe and appreciate the phenomenon. Upper elementary (3-5) and middle school children (grades 6-8) would manipulate the experiment and estimate the result qualitatively and semi-quantitatively. On the other hand, the high school students (grades 9-12) would analyze, model and optimize the experiment and understand the theoretical and quantitative analysis better. The simple, intermediate, and advanced level experiments only differ in the level of complexity, and can be adapted to the various grade levels as needed.

We list above a representative set of examples only. Specifics for 5 prototypes are covered later. We expect to generate many more ideas not only from our own core group, but more importantly, from the many caring teachers who are experts in one or more fields. There will be close adherence to the Science Education Standards put forward by the National Academy of Standards [NAS96b] and the State of Florida Sunshine Science Standards [Flor96]. An entrepreneurial environment, with standardized interfaces and easy access to rapid prototyping, will be provided to both teachers and students to develop new experiments and ideas - some of which might indeed be breakthroughs.

3. MARKETING VALUES

3.1 Long-Term

1. An entrepreneurial management group that is not focused on immediate returns and understands the social responsibility of such an endeavor
2. Boards of teachers, administrators, parents, scientists and engineers that can determine the appropriate way to introduce concepts and products into the curriculum
3. A grass-root effort to recruit teachers with a strong interest and expertise in hands-on experimentation to campaign for change within the school systems and to contribute to new product development, with a fair return to the participating teachers, in appropriate form. The appropriate form may be monetary, recognition, promotion, or any combination there of.

3. 2. Strategic

1. A board of directors comprised of teachers, parents, and professional managers to help develop a strategy that understands the constraints of budgetary systems and hierarchical structured organizations of public and private educational entities. An example might be Internet based "software" module purchases, so the incremental cost is low and can be treated as an expense.
2. A consortium of research laboratories and companies that together have the infrastructure and the know-how to provide for rapid design, packaging and prototyping needed to introduce new products quickly. Such an infrastructure is unlikely to be achieved by a private start-up company soon. Engineers and students will be trained to utilize the resources and develop products, and the consortium paid on a contractual basis.
3. The trend towards fitting all schools with PCs and Internet access. More than half of the U.S. families will own a PC by the year 2000. There is also a trend to replace the

complicated general purpose PCs with network PCs, or Thin Clients, as supported by Citrix, to cut down the cost of maintenance in the long run, and to make such systems rugged for use by children.

3. 3. Tactical

1. Modular and electronically controllable scientific and engineering products that have a standardized interface so they can be interchanged fairly easily. Sufficient intelligence (with 4/8-bit microcontrollers) and wireless capability should be built into them so they can also have certain amount of self-alignment and distributed control.

2. An outstanding Graphical User Interface (GUI) that would make it easy for PC-wary elementary and middle school teachers to not only sign on, but also to use their imagination and expertise to further our and their mission in teaching for a better tomorrow.

3.4 Products and Services – Marketing Values

1. Our main product will be a software and hardware kit that will turn a regular or a network PC into a lab unit. We expect to develop three different hardware platforms for each science strand..This is done in order to incorporate the concept of modularity that will permit different schools to select the subset of modules that they wish to obtain.
2. We will also facilitate training of the teachers and tutoring of the students with the aid of these products. For the former, we will recruit the competent teachers. For the latter, we will sell these units to private training institutes.
3. We will also make available, a developer's kit to teachers and other interested parties to develop new innovative addition to the portfolio of experiments. To spur innovation, we will have generous terms for such teachers.

The project has a very strong plan for teacher preparation. Essentially, we plan to involve above-average teachers in the design phase, so better teaching and training material can be developed. In the subsequent phase, such teachers will train other teachers, with the aid of professionally developed interactive and Internet based material, and hands-on kits. In the evaluation phase, when the kits are introduced to kids in the classes, we will provide technical and pedagogical support on site and remotely via the web so the teachers will be able to perform science experiments. In the subsequent phase of regular usage, such teachers will be able to remotely monitor (and control, if needed) the class lab settings of many such classes simultaneously from a geographically remote site via the web. Further, these teachers will act as mentors for other teachers, who in turn can get trained this specific product or other products and become a mentor themselves. Our goal is to make the process viable and economically attractive for teachers. The goodwill and buy-in of the teachers will carry the company's objectives much farther than if we were to go at it alone.

3.5 Addressing the Professional Needs

There are specific improvements to science and math reform that can be implemented across the economic and social spectrum. Such reforms take the shape of curriculum reform and better trained teachers. While the media focuses on poorly performing teachers, an equal or higher number of teachers are average in performance, and a significant number of teachers might be construed to be both caring and experts in their fields of specialization. This begs a different perspective on the matter - that of mentoring the below average teachers and empowering the average teachers. Otherwise, there would be no way to get the most competent teachers to teach all the kids, nor is there any way to make the average and below average teachers good at these subjects overnight. We propose here a new concept, called "Network Enterprises" that recognize a two-tier organization. This concept is well described in a new best-selling book entitled "The Roaring 2000s" by Harry Dent Jr. [Dent98], as a business model. We fully recognize that education is not a business and should not be treated as such. This is our attempt, however, to adapt best practices elsewhere to our advantage.

In such a network organization, there are front end generalists (also called "browsers," coined in analogy to Internet Browsers) who understand the needs of the children they teach, and have enough resources at the back to teach the children effectively at their level of comprehension. The teacher in this model is not expected to know the material well, but should be sufficiently trained to access the appropriate information to help the students. This "appropriate" or expert information would come from the above-average teachers (also called "experts,"). Over a period of time, the non-expert teachers can be expected to gain knowledge and confidence to explore the subjects further.

We have planned much towards helping teachers prepare better for their science curriculum. A group of 30 to 120 teachers, who will participate in our pilot program, will first get to work with us in developing a prototype during a summer, followed by a 4 day workshop session in the fall, when they will learn about other prototypes from other teachers and our group. They will also get professionally prepared interactive and distance learning tools to support their preparation. A teacher leader will keep track of the progress of each individual teacher and help network as needed. During the spring, when the science kit will be introduced in the classes, a graduate student will stay with the teacher during the science lab sessions, to help as needed. We will also develop a remote monitoring and controlling center to assist the teacher in the class. This remote site will eventually be supported with a competent science teacher. We will continue to provide training sessions at nominal charge. We will also recruit corporate sponsors to go to classes and spend time helping with the kits.

3.6 Accountability

The Hands-On PC-Based Science Education project is wholly committed to accountability as an integral part of all of our processes and operations. We have two purposes for our accountability plans: (1) Evaluation that leads to improvement, and (2) Communication about our activities and accomplishments. The Executive Director, PI and co-PIs, as well as the major project sub groups collectively constitute the Project

Management Team. An independent advisory board, in collaboration with this team, will review on a semiannual basis, (1) whether the objectives of the project are compatible with the stated goals of the project, (2) how effectively and efficiently the project is meeting its objectives, (3) whether changes should be made to increase the effectiveness, efficiency and quality, and (4) what the impact of such changes would be on students and the teachers. and institute corrective actions if necessary.

3.7 Long Term Sustenance of Project

During the second year of our existence, we propose to develop a not-for-profit entity with the specific focus of providing hands-on science education. This not-for-profit entity will negotiate with Florida Atlantic University's Division of Sponsored Research for a blanket agreement enabling the not-for-profit entity to manage all aspects of the project including issues related to commercialization such as intellectual property/trademark protection, license, management of royalty/equity arrangements, etc. It is our strong commitment to make the products affordable for all and to continue to reduce cost, while improving the quality and content of the products, in the long run. Appropriate oversight committees will ensure that we adhere to the goals. We provide below information strictly from a business point of view. We have developed this model and completed a thorough business plan. We intend to develop a non-profit business model to sustain the initial advantage obtained through federal/private grants. Because of the preponderance of idealistic academicians and businessmen, we believe that we can make a success of our dual objectives: Of providing low cost education access to all; and Of being self-sufficient so we can continue to improve and make the systems more affordable, user-friendly and accessible to one and all. Figure 3.6.1 below captures the essence of our model.

4. BRAND DESCRIPTION

4.1 Products And Science Strands

Product Prototypes

We propose to develop three prototypes for each of the five following science strands: Force and Motion, Environment, Earth and Space, Life Processes, and Nature of Science. We will develop prototypes for other science strands after the completion of the work proposed here. We will develop all the prototypes during the first two years, and use them, first with the 3-5 and 6-8 grade groups, during the first two years. During the next two years, the prototypes will be extended to cover K-2 and 9-12 grades. The prototypes will be placed in all the four LEAs (a total of 9 schools that includes two magnet schools) and one private school, for a total of 10 schools. Over a period of two years, 6 PCs, suitably equipped, will be placed in each of these grade classes (one section per grade) in each of these schools. Over the next two years, the focus will be on K-2 and 9-12 grades. See Table 4. 2[1] for more info.

[1] Figures and Tables may be missing at present. To be added later.

We will provide certain common elements of the design flow here, by taking a specific example of a Force and Motion prototype that we have already designed and built. We call it the Ramp, Pulley, and Motor (RMP) prototype. Figure 4.1.1 shows the complete story of this prototype: from conceptualization to student use. Fig 4.1.1 (a) shows a 3-D depiction of the design entered in a mechanical CAD (Computer-Aided Design) package called ProEngineer. Many of the teachers and engineers involved in the project brainstormed and worked together on this design, while one of LIGI's engineers, ably manipulated the design in ProEngineer. The design so created was downloaded to LIGI's NC (numerical control) machines where the prototype was fabricated. The design process involved a total of 60 person-hours, spread over four weeks. The fabrication was scheduled for the run subsequent to that and was completed within two weeks after that and involved about 5 hours on the system. Subsequent manufacturing runs will be significantly faster. We will defer a discussion on the prototype's scientific and educational aspects to the specific section below.

The electronics was built with off-the-shelf components and basically interfaces and converts various sensor (electrical, mechanical, angular, and rotational) signals from the prototype to electrical signals that the computer can store and manipulate. The electronics board also accepts commands from the computer and translates them to electrical signals to control the mechanical prototype. In our simple prototype, the dc motor applied voltage can be controlled from the computer, thereby allowing the computer programmer to change the speed of the motor, and hence the speed of the pulley, and hence the speed of the load being pulled up. The electronics interfaces to the computer through wireless links as shown in Fig. 4.1.1 (b). The electronics fits under the platform of the mechanical prototype. The Laptop has software that will permit acquisition, manipulation and display of the data from the prototype. A Graphical User Interface, written in Java makes the experience more user friendly, so both teachers and students can feel at ease in using the system. See Figures 4.1.1 (c) & (d). The latter is a photoshot of the computer monitor screen. During this project and beyond, we will provide sufficient on-site technical and teaching support, with the aid of engineering and education majors at our universities.

This is a working prototype that is Java-based and is amenable for remote control and monitoring. The purpose of this will be described later.

Science Strand 1: Force and Motion

(a) Prototype 1: RPM

The Ramp, Pulley, and Motor prototype. We have provided the prototype details above. We briefly comment on the different types of sensor inputs to the computer from the prototype. The angle of the incline is converted into an electrical signal with the aid of a potentiometer. The optical detectors along the ramp provide a discrete measure (in terms of both distance and voltage level) of velocity and acceleration. The piezoelectric sensors placed across the ramp surface provide a change in electrical signal level whenever a load passes on the same – with higher loads giving more reliable response. The Infrared transmitter and receiver set up around the pulley on the incline will give a continuous, accurate measure of the speed of the pulley. The encoder coupled to the shaft of the dc motor will yield an 8-bit accurate signal on the speed and acceleration. The next paragraph will address the educational and scientific aspects of the prototype.

Figure 4.1.1 (b) shows a functional prototype next to a laptop. Essentially, it is an adjustable ramp, whose surface can be varied in terms of roughness, to pull up a load along the slanted edge of the ramp. Several measurement modalities (optical, piezoelectric, infrared, and dc motor speed) exist to measure the velocity and acceleration of the load. The dc motor can be run at different speeds, under computer control, to pull the load at different speeds. The string and load assembly can be decoupled from the dc motor, so younger kids can experience physical pulling. Mystery loads can be placed in the enclosed load box, or the load can be replaced with real quantifiable weights. The surface of the ramp can be varied by changing the mat, to mimic smooth to rough surfaces, and thus, change the coefficient of friction. The load can be placed on (different sized) wheels, to change the absolute amount of friction to the motion. The kids can conceivably explore whether square or circular wheels are preferable, as an example of open-ended explorations. A student would be able to let go of the weight from the top of the ramp and time the descent with a stop clock and compare with the computer estimate, and rationalize on the difference in the estimates. Advanced grade children would be able to build graphs of velocity (various estimates) , acceleration, weight, applied voltage to the dc motor, surface roughness, etc., against each other and seek explanations. Such experiments conducted anywhere the kits are placed could be documented and placed at an Internet site so all could benefit. A FAQ (Frequently Asked Questions) database could be evolved which will help whet the appetite of the kids and persuade them to try even "crazier" experiments. Finally, advanced grade children, could use mathematical formulations to compare and contrast the performance of the real system against the mathematical idealization, and ponder on the differences, if any. Lack of sufficient resolution could make the two sets of numbers match, which however could be a reason for further explorations: How to enhance the resolution of the real experiment? If there is a difference in the two sets, then, one can explore the possibility of using more complex mathematical expressions that considered more of the physical phenomenon. Thus, it must be clear that the hardware prototype, coupled with the PC hardware and software, and Internet, is a fantastic scientific experience that a pure hardware or pure software or pure Internet could not match. Once this is behind them, it becomes easier for the kids to visualize more complex scenarios and gain better insight in dealing with more complex systems, for all systems can be "divided and conquered" if only one knew how. On the other hand, if the student is not interested in a scientific pursuit, this hands-on process has made him or her at least more socially adept at understanding day-to-day phenomenon. As an example, we could place an accelerometer chip on the platform, at the point of contact of the load with the platform, to measure the number of "g"s of the load's descent. This will surprise and shock many – a car traveling at 20 mph that hits an immovable object will experience a force of 10 "g"s or more. Computer-based software can build on such hands-on experiences and relate them to real-world scenarios.

(b) Prototype 2: EMV

The Electricity, Magnetism, and Vibrations prototype: This prototype supports very simple to very complex experiments along these three lines of enquiry. Figure 4.1.1 (e) shows a 3-D rendition of the prototype, which has not been fabricated as yet.

Electricity-pertinent experiments are performed by placing in series or parallel a subset or complete set of the following: Batteries, Lamps, Bells, Resistors, Capacitors, Diodes, etc. All these elements are made modular so they can be substituted for each other easily. Connections are made with reliable connectors. Electronic chips under the platform are programmed to provide an open circuit between any two connection points and can be programmed by the computer to make any number of connections in any combination. It can also be programmed to accept or reject the physical connection made with the visible connectors. The dc battery can be replaced with a programmable signal wave-form generator so alternating signal (triangular, sinusoidal, square, etc.,) can be applied to the circuit. Voltages and wave-forms from the components can be acquired, displayed, manipulated, and analyzed, as with the first prototype. For the younger kids, the many LEDs can be used, under the control of the computer, or a local microcontroller, to show how the electrons go around the circuit loop. For younger kids, all the computer control can be disabled (the default state). Magnetism-relevant experiments are performed with the four building blocks of electromagnets shown on the right hand side – These units can be connected in serial, parallel, or any mixed combination, to see the net effect of varying the turns ratio, the current, and the core size, on the force produced. The students could use paper clips the way you have used in other experiments. However, now, they do not have to wrap the electromagnets, and concentrate on learning the concepts. The typical teacher now may feel comfortable enough with the kits provided to run the experiment in the class. Two major magnetic experiments have to do with magnetic levitation and plots of magnetic force lines. It is our intent to show 3-D magnetic lines with the aid of levitation. All the electromagnets can be controlled from the computer, by varying the amount of current flowing through them and also by automatically reconfiguring them from the PC. Vibrational experiments are performed with the guitar strings shown on the left front side. The microphones may be slid along the tracking unit and fixed in position (not designed yet). A student would typically pluck a string, and use the microphones to pick up the wave-form along the string. The microphone signals can then be displayed on the monitor as a three-dimensional plot of amplitude Vs time and position. The pitch of the wave-form depends upon the tension and the thickness of the string. We have provided three different thickness strings. The tension may be adjusted manually. A student may pluck more of the strings or at odd points along the strings to see how the waves travel and use mathematical analysis to understand the observations. One of the microphone outputs can also be fed to the PC’s Sound card, so music can be played. Multiplexing several of the microphone outputs and concurrent plucking would give a richer sound. Adding small “weights” to the strings can create different damping effects. Finally, unlike other kits, since there are many small objects in this experiment, we will provide a side drawer so the objects can be stored with the prototype. The computer can be used to aid in identifying the components needed for a given experiment, and even order them, on-line, if need be. It is easy to provide visual and audio prompts to remind the student or the teacher to put the items back into the drawer, when the prototype is not in use.

(c) Prototype 3: ANV

We propose to use a programmable toy car, similar to lego Mindstorm kit, with road sensors such as velocity and acceleration to perform force-energy-motion experiments. By programming the car velocity, the radius of the turn and measuring accelerations and skid marks student will be able to design and perform experiments related to motion and friction. Moreover, recording the voltage and current of the car electric motor will allow student to relate the achieved motion to the amount of energy consumed by the system. A group at Florida Atlantic University has been funded by NSF to pursue research on computer-vision based driverless vehicle. We will use their expertise in evolving this prototype. We have not worked out the details at this point.

Adherence to the curriculum

Table 4.1 (a) and (b) below identify the concepts that are expected to be covered in K-12, as per the curriculum standards, and the match-up with the concepts covered by our three prototypes, for the Force and Motion science strand. Though the primary objective here is with regard to the Force-Motion strand, it is obvious that concepts in other science and math strands and state level Language and Math test (FCAT) are also covered. See below.

Science learning expectations

The prototypes provide open-ended challenging environment for further exploration, in addition to providing opportunities for analytical and critical thinking. The state of Florida recently started the administration of FCAT (Florida Comprehensive Accomplishment Test) in English in grade 4 and Mathematics in grade 4. Both the exams provide descriptive informational essays and the student is expected to comprehend the material and answer both multiple choice and essay type questions. Since the informational essays will be related to class material in Science, Social Studies, or Mathematics, the process of running such hands-on experiments provides for better comprehension of the problem posed.

Table 4.1 (a): Adherence of prototypes to the Force and Motion Science Strand

	Topics of the Force and Motion Science Trend	State of Florida Standards	American Assoc. for the Advancement of Science (AAAS) Benchmarks	National Science Education Standards	Prototype
K-2	Push/pull cognizance	P. 71, 296	P. 6, 10, 15, 89, 94, 298	P. 106, 109, 127, 138	RPM & EMV
	Sound & vibrations	P. 71, 296	P. 44, 89, 298	P. 106, 109, 127, 138	RPM
3-5	Simple Machines operated by gravity, magnetism & electrical forces	P. 72	P. 6, 11, 89, 299	P. 106, 109, 127, 138	RPM
	Varying effects of net force acting on object	P. 72, 296	P. 89, 299	P. 106, 109, 127, 138	RPM
	Effect of mass on a given force	P. 73	P. 89	P. 106, 109, 127, 138	RPM
	Effect of force on motion of object	P. 73	P. 44, 89, 299	P. 106, 109, 127, 138	RPM

6-8	Force/Distance Relationship Common contact forces Effects of multiple forces on an object Use of Simple Machines to change direction/size of force Cognizance of object in motion/object at rest Ability to demonstrate effect of net force on object Awareness of gravity's force on mass	P. 74 P. 74 P. 74 P. 74 P. 75 P. 75 P. 75	P, 7, 12, 95 P. 95 P. 95, 297 P. 46, 297 P. 56 P. 55, 297, 299 P. 55	P. 145, 165, 166 P. 148, 165, 166 P. 154, 165, 166 P. 154, 165, 166 P. 154, 165, 166 P. 154, 165, 166 P. 154, 165, 166	RPM RPM RPM RPM RPM RPM
9-12	Familiarity with acceleration due to gravitational force being proportional to mass and inversely proportional to the square of the	P. 76	P. 8, 13, 47, 57, 91, 92, 96, 97, 297, 300	P. 175, 176, 179, 180, 192, 193, 200, 201	RPM, EMV, & ANV

	distance between the objects Echoes				

Science Strand 2: Environment – How Living Things Interact With Their Environment

Grade	Math Topics	FCAT** Test	

The table above is incomplete.

Science Strand 2: Environment – How Living Things Interact With Their Environment

We have tentatively identified the following prototypes: Hydrology – movement of ground water flow using a dye – see Figure below; Ocean thermal energy conversion (OTEC) with Solar energy; and Energy efficiency in appliances (e.g., use of heat pump Vs an electric heater)[2].

Science Strand 3: Life Processes

We have identified as the following prototypes for this science strand: Electrocardiogram and cardiovascular system; Plant Growth, Genetics, and Bioinformatics; and Speech and Character Recognition. Drs. Shankar's research interest and expertise lie the area of biomedical engineering. Dr. Shankar has designed and developed massively parallel systems for character recognition. We can develop simpler prototypes from that experience.

Science Strand 4: Earth and Space

We have tentatively identified one prototype here: A Satellite and Communication Links prototype that is limited to Infrared, RF, Sonar and Visible spectrums.

Science Strand 5: Nature of Science

We have not finalized any prototypes under this science strand yet, with this strand scheduled to be addressed actively in only the second year of funding.

[2] Collaboration specifics have been deleted.

5. SITUATIONAL ANALYSIS

5.1. Company Analysis:

Our Company Summary:

Science Teachers Inc., was founded to promulgate the hands-on experience throughout the school system, both in the U.S., and outside. Considerable support has been voiced to this concept by teachers, parents, and school administrators alike. Currently, several school districts are experimenting with the hands-on experience, albeit with stand-alone science kits. However, the availability of PCs and the Internet, provides one the ability to not only make the hands-on experiments more interactive, intelligent, intensive, and interesting, but also extensible, via Internet access to others experiences and experiments. The inquiry-centered science learning being promoted by the National Academy of Sciences [NAS96a] would have truly arrived.

Our approach is innovative - we will use the already existing PC-based laboratories and the ever increasing Internet access, to provide not just a software (a virtual reality) experience, but a hands-on experience with scaled reconfigurable physical models of real-life situations. Such systems would be remotely controlled and monitored from the PC. Some examples might be: (1) Simple - electrocardiogram, traffic light controller, security alarm, electronic prism, and electronic tuning fork; (2) Intermediate: car crash test, fractals, solar cells, germinating plant, and gear chain; (3) Advanced - heart and vascular system, auto fuel injection, engineering signature analyzer, radio, robotics, and thermoelectric devices. An elementary school child (grades K-5) might simply observe and appreciate the phenomenon, while a middle school child (grades 6-8) would manipulate the experiment, and the high school students (grades 9-12) would analyze and optimize the experiment. The simple, intermediate, and advanced level experiments only differ in the level of complexity, and can be adapted to the various grade levels as needed.

We list above a representative set of examples only. The company expects to generate many more ideas not only from its own core group, but more importantly, from the many caring teachers who are experts in one or more fields. There will be close adherence to the Science Education Standards put forward by the National Academy of Standards [NAS96b]. An entrepreneurial environment, with standardized interfaces and easy access to rapid prototyping, will be provided to both teachers and students to develop new experiments and ideas - some of which might indeed be breakthroughs.

In U.S. alone, there are about 60 million K-12 students and 4 million teachers. Our efforts to introduce hands-on PC-based experiments into the curriculum will be smoother, given the current trends - there is heightened concern at federal, state and school district levels [Mcad98, USNW98a]. But we do not expect smooth sailing and the process will take anywhere from one to three years. In the meanwhile, enlightened parents, teachers and private tutoring agencies might be willing to introduce the products to the children on their own. We also expect the international sales to pick up and increase substantially after two years.

We believe that our core groups' competencies are not easily reproduced.

Our company’s business depends on the most recent trends in the computer and communication industry, and the school system. Our model also depends on the good news about the school system - while there are poor teachers everywhere, there are at least 30% good teachers in the system who care enough to teach well and who are resources to new products. We are unlike the other private educational enterprises which are focused on training, professional education, and distance learning. We are also unlike the edutainment software companies which are focused on a pure software-only approach. A closer match is seen in the recently released Lego's Mindstorms system [USNW98b]. However, Lego is strongly focused on the high end building toy and puzzle markets.

Ours is a company based on social responsibility and recognition of the intellectual asset that exists in teachers and other professionals. There will be strong economic return to not only the company but also the innovative teachers, who have been left out of the innovation waves in the U.S. The market's growth is enormous and almost endless. While this will attract other companies, only those that will build good rapport with the school systems and teachers will survive in the long run.

Our conservative estimates indicate that the net profits would be $240 K the first year of product introduction (Year 2 of our existence), increasing to $2.4 M in the third year, just from the U.S. sales alone. The corresponding sales figures would be $0.96 M and $9.6 M respectively. The figures may be expected to treble with exposure to other industrial countries and developing countries such as China and India. We estimate that a teacher with a new working innovation would net $60 K to $120 K. We believe that the model has tremendous potential for growth and impact on the school system, not only in terms of better education, but also in terms of building an entrepreneurial atmosphere, and hopefully, many innovations in the future. Many such innovations may go beyond the education market being addressed by our company. We would provide appropriate assistance as needed - such successes will only prove the power of our concept and establish us as strong leaders.

5.2 Environmental Analysis

The Third International Mathematics and Science Study (TIMSS) released in June 1998 shows a dismal trend of science and math education in the U.S [TIMS98]. Out of 26 developed countries, our combined rankings move from 7th for fourth graders to 12th for 8th graders to 25th for 12th graders, only ahead of Cyprus and South Africa by the senior year. As the ‘Popular Science’ magazine [PoSc98] puts it, “Nothing less than our future is at stake. Our present world leadership in technology and economic well-being threatens to erode as we enter the 21st century, because our children are ill-prepared to compete in a global high technology marketplace.” Academics and politicians were understandably shocked at the seniors’ performance.

As grim as the situation seems, there is evidence that we already know how to fix the system. A group of US eighth graders did very well, being placed an impressive 2nd in Science, second only to Singapore, while the official US ranking stood at 18th. These children, about 37,000 of them, belonged to 20 suburban Illinois school districts that joined together and entered the TIMSS test as a separate “country.” The difference: Kids in this consortium learnt mostly through hands-on experiences, not the rote memorization that is still standard practice across most schools in the U.S.

Of course, these kids had the advantage that their upper middle class families could afford to provide the extras to their children and their schools to make a difference. “A major part of the national education problem consists of tears in the social fabric. One child in four lives in poverty, and many families - broken or otherwise - provide minimal support for and little expectation of a child’s educational progress.” [PoSc98]. There are specific improvements to science and math reform that can be implemented across the economic and social spectrum.

Such reforms take the shape of curriculum reform and better trained teachers. While the media focuses on poorly performing teachers, an equal or higher number of teachers are average in performance, and a significant number of teachers might be construed to be both caring and experts in their fields of specialization. This begs a different perspective on the matter - that of mentoring the below average teachers and empowering the average teachers. There is no way to get the most competent teachers to teach all the kids, nor is there any way to make the average and below average teachers good at these subjects overnight. We propose here a new concept, called “Network Enterprises” that recognize a two-tier organization. This concept is well described in a new best-selling book entitled “The Roaring 2000s” by Harry Dent Jr. [Dent98].

In such a network organization, there are front end generalists (also called “browsers,” coined in analogy to Internet Browsers) who understand the needs of the children they teach, and have enough resources at the back to teach the children effectively at their level of comprehension. The teacher in this model is not expected to know the material well, but should be sufficiently trained to access the appropriate information to help the students. This “appropriate” or expert information would come from the above-average teachers (also called “experts,”). A competent and trained teacher at a centrally located remote site will be able to monitor all the classes through the web and provide monitoring/control/mentoring as needed.

In our case, we propose to focus on the hands-on science experiments to give all the students and teachers the advantage of being taught, albeit indirectly, by the expert science teachers. While one can envision multi-media and virtual reality experiences, our focus is NOT such software-only experiences. Studies show that today’s children spend too much time in front of the PC screen and thus are becoming more and more isolated and no longer socially adept.

Our approach will still use the PCs and Internet access that is becoming more and more common in schools, but in a different way, to provide hands-on experiments. An example of our approach is well illustrated in the $199 package sold by Lego-Mindstorms (see www.legomindstorms.com). This kit consists of robotics building blocks that can be assembled to perform various functions. Such systems can be programmed from the PC. We propose to adapt this concept to scientific experiments. Since children and adults alike learn better with more exposure and with familiar situations, we propose to develop experiments that mimic daily experiences and/or that they are exposed to many times.

This effort, a capability for developing the software and hardware modules and prototyping the system. This is the capability of the CRISP consortium described below.

An Existing Resource: Consortium For Intelligent Systems Prototyping

This collaboration involves four non-profit / private institutions with complementary strengths, with regard to technical, academic and research capabilities[3]. The consortium has the modern infrastructure and the know-how for rapid prototyping of intelligent systems. An intelligent system, by modern definition, refers to a current or newly engineered system which is made more powerful, optimized, flexible, and adaptable, with the aid of built-in computer software and hardware to act as its intelligence. The computer can store system pertinent historical information and help the system to be used better. The system, further, can now be remotely programmed, monitored, controlled and networked, to optimize its performance on a more global scale. Some common day examples are: smart homes and modern automobiles. Both can have more than 10 to 12 such intelligent systems distributed geographically, but networked and controlled perhaps by a central system, for smooth operation of the whole system. While the consortium's capabilities go far beyond the needs of STI, it is an industry and government sponsored resource that can aid in rapid prototyping of systems. STI's credibility will also be enhanced.

It is our intent to draw skilled professionals from this consortium to develop our products

5.3 Market Planning

Market Analysis Summary

Public and private expenditure for education and corporate training reached almost $550 billion in 1995, or approximately 7.5 % of the gross domestic product (GDP). In that year, almost 7 million people were employed in education [USIT98]. The total number of K-12 students will increase from 54 million today at an annual growth rate of 1% through the year 2000. During the same period, the growth of expenditure will rise by 4 to 5 % annually. The relative return (salary) of a college education has increased over the past 25

[3] This consortium does not exist at present; however, the activity can be duplicated by partners with similar strengths.

years, from a 24% premium to a 52% increase, when compared to one with a high school diploma. Between 1970 and 1990, when overall enrollment remained at a flat 60 million or so students, the cost of educational services increased significantly. The average per student cost, adjusted for inflation, for a public school education (K - 12) has gone from $4,421 in 1980 to $6,121 in 1995, an increase of 38%. Cost increases are largely the result of higher salaries, capital costs and monies for special services.

With regard to corporate training, a total of $29 billion was spent in training of their employees. Most of the training was related to use of the equipment and tools of the job, problem solving, customer service, or computer usage. Despite positive effects of employee training and education on productivity improvements, U.S. companies appear to offer significantly less training than those in Europe and Japan. In addition, Japan and Germany have a much more formalized system of training.

In 1994, over 1 billion students were enrolled in schools around the world [Snyd97]. Of these students, 639 million were in elementary-level programs, 351 million were in secondary programs, and 77 million were in higher education programs. In 1995, the school age population around the world averaged around 11% of the country's population for 5 to 13 year olds, and 5% for 14 to 17 year olds. Pupil/teacher ratios in elementary and secondary schools varied considerably: from a low of 10.2 in Italy to 27.4 in Turkey and 24.3 in Ireland.

TIMSS is the largest, most comprehensive comparative study of education that has ever been undertaken, testing a one-half million students. For undergraduate degrees awarded in science and engineering fields, among the OECD (Organization for Economic Cooperation and Development) countries, rates varied from 14 to 54 % of the total graduates, with Japan highest at 54%, Germany at 30%, and the U.S. at 14%. National investment in education in 1994, in OECD countries, ranged from 3.3% of GDP in Turkey to 7.6% in Norway [Synd97].

There has been widespread introduction of computers into the U.S. schools in recent years. In 1995, the average public school contained 72 computers. The number of schools with Internet access has increased rapidly from 35% in 1994 to 50% in 1995, to 60% in 1996. Of the schools which had Internet access in 1995, more than one third had access at only one computer, and another one-third had access at 2 to 5 computers. The total computer usage rate of students at school increased from 43% in 1989 to 59% in 1993. In 1993, about 25% of elementary school children used computers at home and about 11% used them for schoolwork. In general, students in higher income families were more likely to use computers at home and use them for schoolwork than students from lower income families [Snyd97]. About 13% of the high school students in the $25K to $30 K household income group used computers at home for school work compared to 45% in the $75K and over income group. More frequent use of computers was associated with higher levels of education and higher incomes.

Elementary and secondary teachers were less likely to use computers than persons employed in other managerial or professional fields [Snyd97].

Almost half of U.S. homes, i.e., 50 million, will have a PC by the year 2000, up 20% in 2 years. About 95% of them will be connected to an online service provider, up 60% in 2 years. During the same period, global annual shipments will exceed 120 million PC units by the year 2000.

The average middle-class household in North America has an estimated 35 microprocessors in it - not counting the microprocessors in the PC. These microprocessors would be found in common consumer items such as VCRs, telephones, TV sets, thermostats, security alarms, appliances, pagers and cell phones, etc. Many such products will have a low end 4-bit or 8-bit microcontroller embedded in them. Such low end microcontrollers are shipped in millions of units per month. Motorola, for example, shipped its two-billionth 68HC05 microcontroller in April of 1997 [Turl97].

6. Marketing Challenges and Issues

6.1. Market Segmentation

Revenue Sources

We divide this into four primary categories: U.S. School Districts; Global School Systems; Teacher Training and Student Tutoring Service; and Home Hobby Market.

U.S. School Districts: The total number of K-12 students will increase from 54 million today at an annual growth rate of 1% through the year 2000. During the same period, the growth of expenditure will rise by 4 to 5 % annually. The relative return (salary) of a college education has increased over the past 25 years, from a 24% premium to a 52% increase, when compared to one with a high school diploma. Between 1970 and 1990, when overall enrollment remained at a flat 60 million or so students, the cost of educational services increased significantly. The average per student cost, adjusted for inflation, for a public school education (K - 12) has gone from $4,421 in 1980 to $6,121 in 1995, an increase of 38%. Cost increases are largely the result of higher salaries, capital costs and monies for special services.

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Global School Systems: In 1994, over 1 billion students were enrolled in schools around the world [Snyd97]. Of these students, 639 million were in elementary-level programs, 351 million were in secondary programs, and 77 million were in higher education programs. In 1995, the school age population around the world averaged around 11% of the country's population for 5 to 13 year olds, and 5% for 14 to 17 year olds. Pupil/teacher ratios in elementary and secondary schools varied considerably: from a low of 10.2 in Italy to 27.4 in Turkey and 24.3 in Ireland.

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Teacher Training and Student Tutoring Service: Public and private expenditure for education and corporate training reached almost $550 billion in 1995, or approximately 7.5 % of the gross domestic product (GDP). In that year, almost 7 million people were employed in education [USIT98]. With regard to corporate training, a total of $29 billion was spent in training of their employees. Most of the training was related to use of the equipment and tools of the job, problem solving, customer service, or computer usage. Despite positive effects of employee training and education on productivity improvements, U.S. companies appear to offer significantly less training than those in Europe and Japan. In addition, Japan and Germany have a much more formalized system of training.

Home Hobby Market: Almost half of U.S. homes, i.e., 50 million, will have a PC by the year 2000, up 20% in 2 years. About 95% of them will be connected to an online service provider, up 60% in 2 years. During the same period, global annual shipments will exceed 120 million PC units by the year 2000.

6.2 Industry Substitute Products

School Suppliers: The leaders in book publishing companies that are publicly traded are John Wiley and Sons, Advanced Marketing Services, McGraw- Hill, American Educational Products, IDG Books Worldwide, Houghton Mifflin, Thomas Nelson, Scholastic, Harcourt General, School Specialty, and others [IBD98b]. Some of the other companies, with a stronger focus on technology publications are: AIMS, Claris Corporation, Computer Curriculum Corporation, Broderbund, Creative Wonders, Davidson and Associates, EduQuest/IBM, Gamco, KidSoft, Microsoft, Minscape, National Geographic Educational Services, Videodiscovery, and so on [Teac96].

Training Services: The leaders in the publicly held category are: Appolo Group Inc., Devry Inc., ITT Educational Svcs, Childline Learning Ctrs, New Horizons Worldwide, Bright Horizons Family Solutions, Career Education Corp., and others [IBD98]. (The University of Phoenix is a privately held company which has been one of the handful companies that have struck it rich in recent years by offering college degrees for working adults [Stam98].)

Toy Makers: Mattel, Hasbro, Nintendo, and Sony are the leaders here

6.3. Competitors and Possible Alliance Partners

Lego Mindstorms: This is a recent entry into the market. They have incorporated much of the technological sophistication that we propose here, i.e., PC-based, programmable systems whose hardware modules are rugged and safe. The software programming environment is user friendly and easy to get started with. The advanced user will be able to customize the software so the programmable and re-configurable robots can be made to be extremely “intelligent” in the long run. See www.legomindstorms.com. There is much to be learnt from this introduction, which is a joint effort of Lego company and MIT Media Laboratory. The first kit, introduced during the holiday season of 1998, sells for $199. We would have similar technological sophistication and user-friendliness, but our products will be geared to address basis science strands of the school system. Our systems, unlike their system, will have to provide two way links to the PC, so as to provide both observability and controllability. It is quite possible that our first product would build on the Robotics kit - for the science strand of ‘Force and Motion.’ We would have to build in sensors and a bi-directional IR link, and upgrade the software. Since Lego Mindstorms does provide software development kit, this is a viable option. However, they have strong restrictions on commercialization of any such developments. This needs to be resolved.

FischerTechnik: This German company provided robotic kits that were extensively used in the U.S. during the peak of Robotics era, 1980-1990. These kits could be used to build robots, however, they were not programmable or monitorable from the PCs. The company may not be in existence anymore. There are other companies that supply lab kits to engineering colleges. However, they are very expensive (due to the smallness of the volume) and tend to break down, even under more careful usage by college students. Their educational content is also different and targeted to more mature courses and students.

BroderBund: Broderbund is the leading software maker with an edutainment emphasis. They have integrated multi-media in a very sophisticated manner into the education software. They have no hardware or school curriculum experience. Collaborations with a company such as BroderBund will be of immense value to us and them.

RadioShack: Radioshack has had the unique opportunity to integrate PCs with electronics, thus paving the way for programmable hobby kits. They have not done this. However, they can be expected to enter this market. Many toy makers introduced this holiday season PC programmable toys. Radioshack may be expected to jump into the fray. However, their stand-alone hardware kits are less than rugged and leave much to be desired with regard to help in building any thing meaningful. But we believe they have some of the technology to be a force in the market.

6.4 Competitive Analysis

We list below both companies that have competing products and companies that have building blocks (often developed with federal and private foundation grants) that would be useful to realize our vision:

- The Edutainment companies, such as BroderBund, The Learning Company, and others are pure software oriented companies. There is no hands-on experience involved in this.

- Lego makes major building block type systems. Their recent Lego Mindstorms system is already in the market at $199 and is very powerful. They have set up an Internet website and intend to take full advantage of the one of a kind of introduction that they have provided. Their focus is on the high end of the "puzzles" market and it is not clear that they ever have had a strategy to address education and curriculum issues directly. Our systems would look similar to Lego, but will be much less complicated, will be made up of simpler building blocks, and will emphasize staged learning and analysis in K-12.

- The pure hardware company products come from Radio Shack, Texas Instruments Inc., Heath Kit, and others. Such systems are not programmable and lose their usefulness very quickly. Also, many of these hardware systems, in an attempt to give the students a complete experience, make the system less than reliable for kids' usage, rendering such systems useless soon after their purchase. Our products will be well sealed and reusable - the intent is not to externalize the whole design to the student, but show how to build more powerful things with pre-designed building blocks.

- Two companies provide science kits that are being used in many school systems: 1. Full Option Science System (FOSS) developed at the University of California, Berkeley, is distributed by Delta Education Systems, Berkeley, CA. See www.lhs.berkeley.edu/foss/ foss.html. The kits, for any given grade (1-6), sell for $300 to $500 and will support 32 students for 2 repetitions. The Palm Beach County School System uses FOSS; 2. Carolina Biological Supply Company, Burlington, NC, distributes the Science and Technology for Children (STC) kits developed at Smithsonian Institution, Washington, D.C. There are four STC kits for each grade (1-6) that together sells for about $1400 and will support 30 students.

- PC-Programmable toys are the new rage this holiday season. These seem to be the low end of toys, but can be expected to get more sophisticated quickly.

- Web-Based Lessons from Frontliners, as disseminated by the CyberBee magazine from Ohio State University, Columbus, OH. OSU is one of the 16 in the ERIC (Educational Resources Information Center) system, supported by the U.S.

Department of Education. ERIC collects, catalogs, and provides access to educational materials, and has a strong focus on science, mathematics, and environmental education. See www.ericse.org. A lesson on Circulatory System is particularly illustrative on how SciTeach can help. The web lesson is interactive and hands-on, and has the students draw and label parts of the heart and the vascular system, measure the amount of the blood in the body, find heart rate, discuss ways to exercise the heart, and use a stethoscope to listen to heart. Much of this can be made a truly remarkable experience with a simple electro-cardiogram amplifier, an electronic sound amplifier and multi-media display on the PC. Another lesson refers to the Food Pyramid. An extension would be electronically monitored and controlled plant growth and measures to estimate calorie and nutrition content of foods. Two other efforts that are active and complementary: The Annenberg/CPB Math and Science Project: see www.learner.org. Several S. Florida school systems and other educational entities, such as the Museum of Science in Miami, FL, are involved in this project; Eisenhower National Clearinghouse for Mathematics and Science Education: see www.enc.org.

6.5 Differentiation and Positioning Analysis

The primary market we will address is the U.S. K-12 schools. There are 120,000 schools in the U.S., subdivided into approximately 2000 school districts, with 60 schools per school district. S. Florida has some of the largest school districts. This, however, is not the norm. We also have a distinct advantage in having such large school districts in our area. By working with local schools and proving the efficacy of the program, we would not only have convinced some of the largest school districts, but also used the same to convince the smaller ones elsewhere to purchase our systems.

In U.S., there are about 54 million school going children (K-12) and 4 million teachers. The U.S. schools have an average of 72 computers and most of them have Internet connection, thanks to the initiatives at the federal level. The school going population will increase roughly at the rate of 1% annually, while the education expenditure will increase by 4 to 5%. Public and private expenditure for education and corporate training reached almost $550 billion in 1995, or approximately 7.5 % of the gross domestic product (GDP). The average per student cost, adjusted for inflation, for a public school education (K - 12) has gone from $4,421 in 1980 to $6,121 in 1995, an increase of 38%. There has been a heightened concern for student education over the past 15 years or so. Public and private expenditure for education and corporate training reached almost $550 billion in 1995, or approximately 7.5 % of the gross domestic product (GDP). Today, there is much concern about the dismal performance of our high school seniors in science and mathematics, and many remedial suggestions are being made, with significant opportunities for funding from federal and private sources. Our approach would be to obtain such public funds to develop some of the pedagogy and initial developmental work involved in our work. The results will be widely disseminated, which will prove of value when our products are marketed eventually.

We have not found any equivalent PC-based kits that address science education. Our pricing compares very favorably with the stand-alone kits offered by one of the two major suppliers of science kits today. Thus, there is a major opportunity for growth. The school districts are no longer isolated in their curriculum, because of the push for national standards. Thus successful experiments in one area will be much better accepted, and even mandated, elsewhere. We project that, in year 2, when we release our first product, roughly 1% of the school districts will purchase, with adoption rate going up to 10% by year 3. The systems will last at least 5 years, and will be constantly upgraded with more integrated and different hardware modules, so there will be a variety of products that the schools will be able to choose from. Our goal is also to have flexible manufacturing to address custom needs.

We will address the international market subsequent to the U.S. market. There are about 1 billion school-going children around the world today. Most of the industrialized nations did better in the science and math tests at the senior level, as compared to the U.S., but may lag behind in terms of PC usage. But we expect that there will be widespread usage of PCs and Internet throughout the world, by the year 2000. Thus, our strategy is to introduce our products outside of the U.S., after having learnt from our experiences. Moreover, there is also the need to customize the setups for use elsewhere.

The third market to address is the teacher training and private tutoring. We expect to contract this out. Corporate spending has increased significantly over the past ten years. But it is not clear how much is for retraining educators. Since schools cannot afford significant funds for training, we may need combination of distance-learning/ Internet-based learning, free training seminars at conferences, etc. Thus, it is not a major source of revenue. We, however, need to perform this as a service to ensure better acceptance of our products by teachers.

The fourth market to address is the hobby / home education market. Roughly 50% of the U.S. households today have PCs and the home Internet usage will increase to 95% from the current 65% within the next two years. Because of heightened concerns with regard to education, we expect the parents in the middle and upper-classes to opt to encourage their children to study more at home and/or with private tutoring agencies. In addition, they will also look ways to combine education with entertainment. We will have to be creative in combining the two. There are many software companies doing precisely that today. However, our challenge is to orchestrate software and hardware to be educational and entertaining at the same time. We believe that this is doable.

Additional market opportunities will be identified through a technology niche analysis (TNA), during years 2 and 3 of the project. A more refined commercialization strategy will be developed from the TNA to sustain funding (cash flow) in out years. TNA uses a mode of logic called coherence. Coherence evaluates information and options in terms of their goodness of fit with a pattern. We take the technology being commercialized and the goals and capabilities of our customer as given. We then look for strategies, tactics, and targets that mesh strongly with these factors, given other elements (application for the technology, market, etc.) that constrain commercialization strategy options. The result will be a solution which, to use Herbert Simon's terminology, "satisfices" rather than optimizes. Through this effort, we will not be seeking to provide a "best possible" or "optimal" strategy -- just one we believe will have a good probability of working based on the data we could find and analyze. In addition, we intend to leverage the SBIR and STTR programs to obtain funding to further develop our prototypes to get them "market ready". This strategy will further enhance commercialization opportunities and program funding in out years.

6.6 Competition and Buying Patterns

The buying patterns may be considered to be similar to those for books, with the distinction that we will be the first ones into the market. However, it is to be expected that others will follow within an year of our product introduction. Both elementary and high school books take an average of five years to develop and are subject to the whims of school districts. The loser in the race to sell a district a new text absorbs the investment. Industry wide, returns average around 30%, as per the Association of American Publishers [IBD98b]. As of this year, large bookstore chains had 50% of the market. Such superstores sell more, but also run leaner inventories. That forces publishers to hold more inventory. Many superstores also sell magazines, software, stationery and coffee. Our products would compete with these products for the impulse buy. Another approach that is being increasingly tried is the web site. Publishers offer book excerpts and point users to Amazon.com or other online book retailers.

Nation wide, the K-12 school population is expected to climb from 52.7 million in '97 - '98 to 54.3 million, a 3% jump by '98. The well-to-do Baby Boomer parents will want to educate their children in the best way possible, with the most hands-on influence. This set of prototypes will provide that.

6.7 Trends, challenges, and issues

This has been explained above.

6.8 Long-term implications

We envision the company as being a solutions provider, with a focus on innovation and service. We anticipate that the hardware and software modules will be constantly improved, either by the company or the small support companies that might spring up. The manufacture of the products will be contracted out. Training, similarly, will be contracted out. Franchisee-based Training institutes will be allowed. Remote monitoring sites with resident science teachers is yet another business that would get started. It is not our desire to try and conduct all these different types of businesses under one roof. We would like to coordinate and ensure the success of these activities. Quality control measures will have to be incorporated to ensure that the products will meet the specifications. Education will continue to dominate the public's interest. Innovation is sorely needed in the education field. If the market is carefully cultivated, the home educational toy business and the Training Institute business might outpace the school business segment. However, neither of the other two will really take off without the endorsements of school districts and successes there.

6.9 Short-term implications

We will face enormous difficulty in acceptance of the concept. Having been part of an education system, some of us can envision all the checks and balances in the system that can slow down the acceptance. We will need to be very patient as we wait out the slow process of acceptance. However, the same product introduced elsewhere in countries that value education the utmost, such as Japan, Singapore, and others, may catch on fairly quickly. However, we will have to prove quite convincingly that the method did indeed help students do better in their FCAT/SAT/Pre-SAT tests. It may be a few years before such proof will evolve. Until then, we may have to invest time and effort in selling elsewhere and enlisting Training Institutes to offer these courses. More brainstorming is needed to decide how to proceed.

7. TECHNOLOGY

Thin Client models will become increasingly popular. Thin Clients are PCs with no movable parts, such as CDROM, hard disk, and Floppy drives. Consequently, they are much thinner, lighter, and more rugged. They are ideally suited for student and class use. Such Thin Clients will be connected to a central server which will host all the software that can be downloaded as needed. Citrix Inc., Ft. Lauderdale, is a phenomenal success in S. Florida that provides software in support of this model. Many Application Service Providers (ASP) have sprung up to support this model. Our business can fully take advantage of this model. A central server either for each school or a set of schools (to start with) coupled with such Thin Clients would be the beginning point. The students could be assigned these units to use throughout the school year and could take them home for continuing the work started at school. They could also be allowed to access the school server from home. Further, many of support ASP companies are located in S. Florida and it should be possible for us to involve them in this civic minded project.

A related trend that is taking place now are the Net Appliances. Many companies, such as Gateway and AOL are strongly pushing the state-of-the-art. Our units could be used as Net Appliances, perhaps for team projects or games.

However, it should be noted that many schools still have the old 286-based PCs and that will not change quickly. It is not clear to us that we wish to support such old technology. We might be unable to justify it based on economic considerations. We hope that the US government will upgrade the PCs in the schools. If not, an approach might be to get ASP companies to develop a plan to support schools, similar to what Apple and Microsoft have done over the years. That was behind the re-birth of Apple and will continue to generate much revenue for Microsoft in the years to come. Local ASP providers might be willing to participate from that perspective.

8. GOALS AND OBJECTIVES

8.1 Key Objectives

A. Long-Term Goals: To provide PC-based hands-on type science and engineering experiments that can be observed (grades K - 5), manipulated (grades 6 - 8), and modeled and optimized (grades 9 - 12). To support teachers with training, well-documented material and repeatable experiments so they feel comfortable in leading hands-on experimentation. To provide enough problem-solving opportunities and to help students evolve their own creative solutions.

B. Strategic Goals: To encourage participation of teachers and other knowledgeable sources in developing experiments to address the needs of various groups. The initial focus will be to teach fundamental physics, chemistry and biology principles, though developments related to mathematics, language, and physical manipulation skills will also be encouraged.

C. Tactical Objectives: To develop software and hardware modules that are easy to use, assemble and maintain, to run different types of experiments, with as few prototype boards as possible and with as few disposable items as possible. To keep the cost of ownership, maintenance and training low so all children and teachers can benefit. To provide free software and shareware so all can benefit from each other’s innovations.

8.2 Long Term Goals

1. To work with school districts in translating their vision to reality and in incorporating our methodology into their curriculum. Further, to facilitate the work of some teachers to develop hands-on experiments as envisioned here. To supplement and extend further the inquiry-centered science initiatives practiced at many school districts.

2. To provide for highest level of quality control and strict adherence to federal laws with regard to children's and adult's safety. To rate the systems on their appropriateness for use at various grade levels.

3. To provide a nurturing environment for both teachers and students so they can become less inhibited in performing hands-on experiments. To also help a subset of them to become entrepreneurial and translate their ideas to products to gain economically.

8.3 Strategic Goals

1. To leverage and learn from the initiatives of the federal government (for e.g., TIMSS) and private sources, to enhance education in Science and Mathematics. To gain access to funds, databases of the few successful ventures (for e.g., FOSS and STC), and experts.

2. To provide a website for not only on-line purchase of our and other products, but also to provide a forum for discussion and innovation.

3. To host regular conferences and contests to encourage teachers and students alike to explore their creativity and perhaps benefit economically.

4. To develop a corps of expert science teachers who can monitor several class lab experiments simultaneously from a lab site and provide hands-on or hands-off advice to the students and teachers in these classes. Extend that to remote support via a web site.

8.4 Tactical Objectives:

1. To develop a system that will be user-friendly and that will consist of icon-based GUI (graphical user interface) to assemble, in software, the hands-on experiment that will be performed. All the hardware modules will have intelligence built in to accept the signals from the PC and elsewhere, and to configure themselves accordingly. In addition, they will have a standard interface for inputs, outputs, and power supply connections.

2. To develop Printed Circuit Boards / Hardware Platforms that will be multi-functional and that will be able to support electronic, electrical, mechanical, biological, thermal, optical, structural, physiological and other experiments. To encourage thin-client /network computer systems to reduce maintenance cost, enhance field activity, and reduce computer down-time at schools. To provide Internet-based support for free software, maintenance, training, and exchange of ideas among teachers.

3. To provide analytical and modeling software so modeling and simulation is recognized as part of the experience in optimized design. To use industry standard languages, tools, and interfaces, so open standards can develop which in turn will lead to proliferation of new ideas and products.

4. To develop Remote monitoring and on-demand control mechanisms so a science "expert" teacher can monitor the lab activities of various class rooms and provide expert advice to the science teacher in the class and/or remote control the experiment (either partially or fully) as needed.

9. PRODUCT POLICY

9.1 Product Manufacturing Policies

- The new hardware platforms, to be fashioned after the currently existing PC boards, will be manufactured by contractors in Latin America, Puerto Rico and S. Florida. Initial arrangement will be with a Puerto Rican company owned by one of the founders.

- The hardware modules will be manufactured and assembled at one of the following places: LigiTools Inc., Pompano Beach, FL, for electromechanical systems; SMT Lab, PUPR, PR, for assembly of electronic, sensor, optical and thermal sub units.

- Software will be downloadable from our Internet Site which will also act as a central clearing house for new product ideas, new use ideas, etc.

- Documents and on-line manuals will also be downloadable from our website. We expect a training company such as JHL Inc., to be responsible for developing documents and training material.

- Development Kits will also be purchasable from the website. They would be shipped by UPS or another major carrier under various currently existing plans.

- Maintenance will be offered on turn-around periods of one day to one week. This will be coordinated with the Internet site and live technicians/operators.

- Training and tutoring will be contracted out to teachers and private training institutes. An example of such an institution is Helen Gimore Learning Center, founded by Dr. H. Gilmore.

9.2 Product Importance to the Firm

- Our primary focus is Hands-on Science. This could be the launching pad for bringing about many other products to support science education and training, or for developing alliances with entities such as Scientific American, Science Museums, etc., for mutual benefits.

- We also wish to support innovation in science by teachers and students alike. This may help launch new related or unrelated products. We primarily see ourselves as facilitators in rapid prototyping the designs so the innovators can convince venture capitalists to invest. We would have take an equity position.

9.3 Research and Development Activities

We take an offbeat approach for this, since there is much R&D involved in this project. Besides, we are serious about sustenance beyond the funding period and we care about successful outcome for this initiative. We use a methodology developed by Jolly [Joll97] to delineate what already exists and what has been accomplished already, so it is clear what lies ahead. Dr. Jolly does this for technological commercialization and we pursue the same approach here. For the long-term sustenance of these concepts, we need to approach the issue as one of commercialization, to keep the cost down and encourage widespread ownership and usage.

The process of technology commercialization [Joll97] in successful companies does NOT follow the traditional linear view of innovation, which is given in the figure below: The successful strategy is rather a segmented, value build-up view of commercialization. We adapt the same here for successful introduction and adoption of our products in the school environment. The stages are as follows:

Conceptualization	Develop the dual (techno-market) insight
Incubation	Define success factors (address low cost, school need, & support to be provided)
Demonstration	Develop contextuality in products and processes (Evaluation phase)
Dissemination	Encourage adoption
Sustenance	"Commercialization" (provide low cost, technology and training support)

Though segmented, the stages require bridges to satisfy and mobilize stakeholders at each stage. Clearly, all this needs a multifunctional approach :

Our team has the necessary expertise to cover all these stages. We briefly describe the many issues involved at each of the segmented stages and identify contributions needed from us to move forward. We will also identify the technologies that exist or might be reasonably expected to exist soon.

Conceptualization:

- Evaluate the need - an informal survey of teachers, administrators and principals indicates a strong need for such products. The PC and Internet trends, globalization and high tech trends in all the industries, the growing gap between the haves and have-nots, concerns of the Governments, communities and concerns for better educated younger population, are all positive trends for our proposal.

- Evolve an approach - Hands-on Science experiments with PCs is the next step in the evolution. Much literature and experience exists with regard to stand-alone science kits and educational / lab experiences as described in K-12 science textbooks. Use of PCs for remote programmability of systems, as with Toys, is a trend that has begun. Remote programmability with Infrared [IRDA99] and RF technology [Blue99] has become a reality.

- Identify trends and solutions -   The science and technology are moving towards micro-miniaturization. The fields will become elitist and will discourage students from entering. Yet, the concepts used are not that difficult to comprehend, if externalized. This, however, is possible only if a love for science and engineering is cultivated from early formative years. Hence our proposal to develop a set of PC-based scientific experiments that are compatible with the curriculum needs of the U.S. educational system.

A Figure that compares the traditional model and a new model [Joll97] for success is missing

Traditional Model A Model for Success

Incubation

- Several popular books exist that help build simple to complex science and engineering experiments. See the references listed at the end [Rora95, Iann87, Horn95, Shal81, Vecc94]. Our initial focus will be strictly the needs as defined by the national and FL curriculum.

- In the microelectronics industry, development of electronic experiments for K-12 is fairly straight forward. There are companies such as TERC Works which do exactly that. However, Science is more than just electronics.

- Prototyping of mechanical and other engineering components, such as gears, motors, robotic arms, etc., in various materials is accomplished at companies such as Ligi Tool in S. Florida. There are very few such companies and the mechanical prototyping is not inexpensive, but feasible. The challenge here is to identify a subset of building block elements that can be inexpensively produced and electronically controlled.

- We expect to use currently existing software and hardware standards, so that it will be easy for all to develop compatible products and to ensure maximum portability of our products. Embedded Java [Wind98, Cole98a] as the real-time distributed operating system seems to be the ideal choice. WinCE and Epoch2 are strong contenders for this [Cole98b]. Citrix' Thin clients may need the use of WinCE and are finding increasing application in the education market [AOL98]. We also need a good GUI (graphical user interface). Much free software is available. See the list of GUI web sites listed below [GUI98].

- We will use an infrared wireless link and protocol, for communication between the hardware platform and the PC. Motorola makes microprocessors with built-in support for this. IR does not pose any health concerns and is appropriate for use at schools. See www.irda.org [Hous97].

Demonstration

- Full electronic / medical instrumentation type setups are easily developed and prototyped. Examples are: Electrocardiogram Amplifier and Solar Powered systems. Systems for image and speech recognition are also prototyped easily. Electro-mechanical transducers are also available at low cost. Prototypes based on them can be developed by a mechanical prototyping company such as Ligi Tool. Since the prototypes may not be complicated, and may not need expensive materials, cost may be held low.

- A software program and a staged educational approach to experimentation would have to be developed for a subset of these experiments.

We sketch in section 4 possible sets of experiments in five specific science areas, for grades K-12, as recommended by the national and state level entities [NAS97, Flor96]. Please consider section 4 as proprietary.

Dissemination

- The company's school board will have to study the curriculum needs and offer our vision to various school districts early on, to get beta test sites for evaluation, to seek additional simple ideas from teachers for prototyping, and to get feedback on making user-friendly, useful and rugged prototype systems.

- Our group's education panel has studied the curriculum needs and offered our group's vision to various school districts early on, to incorporate the experiments in the classrooms and obtain evaluation, to seek additional simple ideas from teachers for prototyping, and to get feedback on making user-friendly, useful and rugged prototype systems. Four school districts are partners to this proposal.

- County and State level TEC (Technology Education Conference) are held on an annual basis and are well attended by teachers. Workshops and presentations at such sites will be conducted.

- There are many national conferences relevant to our needs. Our approach so highly integrates the stake holders, school districts, technology and business, that several conferences become sites for workshops, presentations, and buy-in. Examples are: Association of American Publishers (February), American Association of School Administrators (February), National Association of Independent Schools (February), The Education Show (March), Microcomputers in Education Conference (March), National Science Teachers Association Conference (March), National Business Education Association (March), National School Boards Association (April), National Association of Educational Buyers (April), Learning Curve Conference (June), Innovations (June), National Education Association Annual Meeting (July), National Association of Biology Teachers (October), and National Association of Gifted Children (November).

- Dissemination will also take the shape of journal and book publications as well as on the Internet. Further, workshops for teacher training will be conducted in the fall at the four LEA sites.

Sustenance

- The teachers support is critical for the administrators to approve the switch, if any, from the stand-alone kits, to our PC-based approach. Informal surveys of teachers to better understand possible reasons for non-use of our systems have been conducted. Some schools have invested in kits [FOSS99, CARO99, AIMS91], but do not use them, due to lack of time and teacher preparation.

- We will work with Industrial engineers and business majors to evolve low cost and high value added approach in developing and refining our products.

- We will hold conferences and contests, with the intent to invite teachers and students to develop new and useful products for schools.

- Patent rights and royalties for any inventions developed as a result of our project efforts will be held by the not-for-profit corporation to be formed during the course of the second year of the project. This arrangement has to be worked out with Florida Atlantic University, who will initially hold all rights to inventions and trademarks.

9.4 Physical Design

This has been explained in section 4.

9.5 Features, Benefits and Attributes

This has been explained in section 4.

9.6 Product Life Cycle Stage

The first prototype (RPM) has been developed and is fully functional.

9.7 Package Specifications

See the RPM figure in section 4. Further details have not been worked out.

9.8 Guarantee

The hardware will be sold at a low price and will be replaced if any defect is found. Software upgrades will be provided on a regular basis, either with licensing or for an additional fees.

9.9 Future Products and Services

Here is our vision for the future:

- Years 1 and 2: Develop and demonstrate prototypes for two Science strands in the U.S. curriculum. Sell them from Years 3 in the U.S. Obtain SBIR (Small Business Innovation Research) Grants/ OERI (Office for Educational Research and Improvement) of Department of Education/ Semiconductor Industry Association (SIA)/Private Foundation grants by Year 2. Negotiate arrangements with CRISP partnering institutes.

- Years 3 and 4: Accelerate the prototyping process to include all the remaining Science strands. Sell them ASAP. If SBIR recipient, submit Phase 2 proposal.

- Year 3 and 4: Adapt the prototypes for the global market. Sell the U.S. products abroad. Develop new ones for the market abroad.

- Year 5 and 6: Develop home-oriented / hobby products. Integrate more functionality into the modules.

9.10 Quality Strategy

We will take into account the feedback from the teachers and students in designing better systems. There are several industrial engineers in the group who will ensure that the quality will be built into the product.

10 DISTRIBUTION POLICY

1. The Kits could be distributed through local educational book stores, such as PTA Store, EduTeach, and ACE center. However, we did not observe that the store clerks were knowledgeable in the products they carried.

2. The best alternative may be the establishment of demo sites in private training centers such as the Helene Gilmore Learning Center, in Lantana, FL. Dr. Gilmore is aware of a national network of such centers and would be willing to coordinate such an effort.

3. Equally good may be an arrangement for some schools to carry our products free of charge, in return for demonstration to other schools.

4. Media advertisements with toll-free numbers and web site store might be other options.

11 PRICE STRATEGY

1. Hardware will be given away for a low price. We expect to make money in software (downloadable from the web), licensing fees, and service fees in terms of supporting science education with teacher mentors and remote monitoring of class experiments.

2. Training Institutes will be owned by Franchisees. A licensing fee will be collected. We do not know the details. Experts in appropriate areas will be recruited. Because of the social impact of the project, we might be able to attract certain retired well-connected executives.

3. Home units will be priced higher. Home sales are only possible if we have good endorsements from the schools.

4. International Sales will also be priced higher (list price) relative to US Schools, primarily because most other countries have uniform education policies throughout the country and the large volume sales will require a major discount.

5. Third-party company sponsorship in equipping the classes in minority schools. Our systems may be purchased by company sponsors and provided to these schools. We do not know what the pricing strategy should be.

12 PROMOTIONAL POLICY

1. School-based evaluation studies of students' test scores with and without these lab experiments will be a powerful message. These require much effort, time, money, and support from the school county officials. It could take as much as 2 years to complete a reasonably complete project.

2. Such endorsements will indeed spur sales.

3. Contests on product related innovation.

4. Demonstrations at Conferences. Dr. Gilmore has agreed to be responsible for this.

5. Promotion of economic and innovative successes of teachers, as a result of participation in this program.

13 ADVERTISING POLICY AND CAMPAIGN STRATEGY

Advertisement policy will depend upon appeal to the parents to ensure good science education at schools and home, pointing out the TIMSS study results and economic benefits to self and the country with scientific innovation. Campaign will focus on using endorsements, easily available Virtual Reality models on the Web, Real-life large size hardware models at Museums, and Free CDROM with software that run a software version of the software.

14 CONSUMER SALES PROMOTION

This has not been given much thought to, at present.

15 MARKETING AND PUBLIC RELATIONS

Public relations would follow the following lines of action: Lectures at schools on the importance of science education; school sponsorship by companies so the schools can obtain our products; Sponsorship of Science Fairs; Free one day seminars on Innovation and Science; Success stories of teachers in terms of innovation, teaching excellence, and financial gain/rewards.; and Our positioning as a non-profit entity.

16 PERSONAL SELLING AND SALES MANAGEMENT

This has not been given much thought to, at present.

17 DIRECT MARKETING POLICY

This has not been given much thought to, at present.

18 . ORGANIZATION

18.1 Company Ownership

Science Teachers Inc., will be incorporated in the State of Florida. Dr. Ravi Shankar will be the founder and part-owner of the corporation. Below in section 18.3, we list all the key members who have expressed their desire to participate, along with their possible roles. No cash contributions and equity positions have been discussed at this point. These issues will be addressed at a later date in a meeting of the group. This section will be updated upon further consultations.

Certain gaps exist in the expertise represented by the above group. We will recruit well regarded individuals in these areas: Legal (Corporations and Patenting); Production; Sales & Marketing; and Finances. A technical board will be formed that is comprised of teachers, engineers and scientists to develop standards and identify products to develop. A school board will be formed that is comprised of teachers, parents and community leaders to address school and community pertinent issues. A business board will be formed that is comprised of leaders in the various fields to advise and set long term strategic directions.

18.2. Management Summary

The management group has the necessary expertise and background to address this field with vigor and confidence. The group is illustrious and is made up of outstanding individuals in their own right. They have been brought together by a common vision of making a difference to the national debate on science education. Many of the partners are successful businessmen, underlying the important fact that they see market potential for this concept. But more importantly, they also see how they can share their expertise and wisdom in a collective way to make a better society. Many of the founders have been active in the dialog on enhancing high tech base in our local regions, since the ensuing high paying jobs will enhance the local economy, the education system, and the industry base.

Specifically, Shankar will act to coordinate the peer group. Gilmore will ensure that our products will meet the needs of the school systems, and will articulate our vision to the schools, teachers, and parents. Masory will be responsible for product development, while Cruz for prototyping the same. Mucciacciaro will coordinate manufacturing and mechanical prototyping. Ueltzen will help coordinate administration, finances and operations. We do not have any legal representation on the group. We will address this soon.

There will be three boards, as detailed below that have responsibilities to address the curriculum, engineering and business issues, on an individual basis. *This chart is missing.*

18.3 Management Team

18.4 Project management Structure

Given below are the names of project personnel and their responsibilities.

Principal Investigator: R. Shankar

Co-Principal Investigators:

Site Coordination: An Academic Coordinator in the school system
Curriculum Coordination: An Education Professor
Engineering: O. Masory;
Strategic Coordination: R. Ueltzen;
Dissemination: H. Gilmore

Project Director :   R. Krishnaiyer

Activity Monitoring Panels and Boards (To provide checks and balances):

We provided here details of personnel on 4 panels/boards: Education, Technical, and Business panels, and an Advisory Board.

There will be three working groups or panels, as detailed above that have responsibilities to address the curriculum, engineering and business issues, on an individualized basis. A 19 member advisory or accountability board, comprised of school administrators (3), businesses (3), community leaders and parents (3), teachers (4), universities (3), and school board members (3), has also been formed.

Short Biographical Sketches of some of the founding members:

Ravi Shankar, holds a Ph.D. from the University of Wisconsin, Madison, WI, and is a registered professional engineer in the state of Florida. He is currently a Professor in the college of Engineering at Florida Atlantic University, and is the director of a modern industry funded facility where electronic systems can be designed. This center is part of the CAPE consortium (see below). Shankar has 3 U.S patents in the biomedical area. A company in Miami recently filed for FDA approval to market a product based on these patents. Shankar has brought in close to $2.6 M in cash and grants to the university. Shankar also coordinates a four university consortium, called CAPE (Consortium for the advancement of product engineering) that brings together expertise in hardware and software design, packaging and prototyping at the four universities so one can rapidly prototype products similar to the ones proposed by STI. CAPE boasts of a modern infrastructure and industry-relevant research.

Oren Masory, holds a Ph.D. from the Technion University, Israel. He is at present a professor in the college of engineering and the director of Robotics Center, at Florida Atlantic University. Considered by his colleagues as the best mechanical engineer around, Dr. Masory exhibits a love for the hands-on experimentation that is exemplary. He has developed many PC-based Robotics and System Design course at the university.

Roger Ueltzen, is the president of a non-profit company called Joint Venture South Florida (JVSF) that is focused on enhancing the high tech industry base in S. Florida. JVSF is fashioned to emulate the activities of the very successful Joint Venture Silicon Valley. Mr. Ueltzen was a high level PC manager with HP, Colorado, and is today a VP at Cylex Systems, Inc., in Boca Raton, FL. He has been a major force behind he current discussions among the four S. Florida Universities to conduct collaborative research that recognizes each others strengths and does not waste scarce resources in duplication.

Ramesh Krishnaiyer serves as the Director of New Research Initiatives in the College of Engineering at Florida Atlantic University, Boca Raton, FL. Prior to this position, for 18 years, he served as the Associate Director of the NASA Southeast Regional Technology Transfer Center. In this capacity, he was engaged in the effective transfer and commercialization of federal government/university developed technologies through licensing, joint venturing and other means. Approximately half of his 33-year professional career was spent in the private sector in various technical, marketing and administrative capacities. He received a Masters degree in electrical engineering from the Illinois Institute of Technology and an MBA from the University of Wisconsin, Whitewater. His private sector R&D and marketing experience in the areas of building automation, security systems, telecommunication and fluidics has resulted in six U.S. patent awards, more than 30 company proprietary research reports, 10 prototype systems and four commercial products. He has authored 17 technical and 3 business oriented papers. Krishnaiyer has a successful track record of developing competitive proposals targeted at state and federal agencies. In this decade, he has been part of proposal teams that have been successful in winning more than $30 million in technology development and deployment related federal awards. He has participated in screening proposals from Florida high tech entrepreneurs in order to recommend funding from the Florida High Technology Innovation Research and Development Board. He has organized and participated in over thirty NASA Industrial Outreach Seminars intended to educate and establish linkages to transfer NASA technology to small and medium size companies and to help commercialize it. He served as the Telecommunication Technology champion for NASA at the Technology 2006 Conference and Exposition held in Anaheim, CA in October 1996. As the technology champion, he was responsible to select and showcase 15 telecommunication technologies that had the best commercialization potential from all ten NASA field centers. He has also served as a proposal reviewer for federal technology funding programs such as the NASA Small Business Innovation Research (SBIR), NASA Small Business Technology Transfer (STTR), the NIST Advanced Technology Program (ATP) and the Florida Space Grant Consortium. He is a senior member of the Institute of Electrical and Electronics Engineers (IEEE) and a Registered Professional Engineer. He serves on the boards of several locally based technical and entrepreneurial assistance organizations such as the Florida Venture Forum (a South Florida based not-for-profit organization that showcases fast growth potential small businesses in front of the venture capital and private investor communities) and the South Florida Manufacturing Technology Center (a NIST funded manufacturing technology assistance provider). To date, more than $99 million in equity financing has been raised by the presenting companies. Each year, he has served in an advisory capacity to one or more of the presenting firms to develop and streamline their business plan including equity financing strategy and conference presentation strategies. He also serves on the board of directors of the Space Communication Technology Center (SCTC), Boca Raton, FL. The SCTC is a NASA Center for the Commercial Development of Space engaged in the development and commercialization of terrestrial and space based communication technologies.

Helen M. Gilmore, Ed.D. with more than 35 years' experience in the education profession, owns the Helen Gilmore Learning Center at 510 West Lantana Road, Lantana, Florida 33462. In operation for ten years, the Learning Center provides a full range of enrichment and remedial tutoring services, preschool to adults, for any subject, and consulting services for schools and agencies. The retail store, housed at the center, carries unique educational games, toys, books, and software. With a doctorate in Early Childhood, a Master's in Curriculum and Instruction and a Bachelor's degree in Elementary Education, Dr. Gilmore has served as an adjunct professor at Nova

Southeastern University for the past 17 years. Among the many courses taught at the graduate level are Elementary Science and Creative Problem Solving in the Elementary Curriculum. The last eight years of her 20 year tenure with the Palm Beach County Schools were spent as Program Specialist for Gifted Education for the district's K-12 program. More than 2700 students were served. She designed and was the recipient of several Florida state grants for gifted children. Dr. Gilmore is past-president of the National Association for Women Business Owners, Palm Beach Chapter, and of the American Association of University Women, Palm Beach Branch. Hobbies include piloting aircraft and staying involved in her community.

18.5 Management Gaps

We see a major gap in the legal area. We expect to hire consultants to fill the void. Later on, we need to identify personnel to head finances and manufacturing.

19 FACILITIES, TECHNOLOGY AND EQUIPMENT

19. 1 Company Locations And Facilities

The company will not have a physical location to start with. The R&D work will be performed in Shankar's home office, with the prototyping undertaken at Ligi Tools and PUPR's rapid prototyping facilities. Once the market dynamics are better established, we may need to rent space for inventory storage as well as an office. This will be addressed later on.

Our consortium consists of pro-active members of various stakeholder communities, who primarily came together to make a difference to the education infrastructure. They, however, also see an avenue to sustain the business model once the federal funding ends. Our group consists of engineers, teachers, school administrators, concerned parents, management professionals, corporate sponsors, and small businesses. The core capability that facilitated the formation of this consortium is a loosely formed consortium we call as CAPE. The CAPE consortium that consists of three research centers at Florida Atlantic University, Boca Raton, FL; Florida International University, Miami, FL; and Polytechnic University of Puerto Rico, San Juan, PR; Our group has state-of-the-art facilities to design and rapidly prototype a low cost fully engineered system. More information may be had from www.cvsi.fau.edu. Full CAPE facilities may not be needed to start with, but would be invaluable in the long run, as more functionality is integrated into our hardware modules. This will be needed to keep cost down and make the products affordable by all the schools. Our intent is to reduce the cost of ownership on a consecutive basis, i.e., year to year. In addition to reducing our own cost, we will also work with local companies to incorporate their thin-client and intelligent communication technology in place of the current PCs which are old, slow, top-heavy (in terms of software overhead), difficult to maintain, and difficult to network.

The extended group has the necessary expertise and background to address this field with vigor and confidence. The group is illustrious and is made up of outstanding individuals in their own right. They have been brought together by a common vision of making a difference to the national debate on science education. Many of the partners are successful business people, underlying the important fact that they see market potential for this concept. But more importantly, they also see how they can share their expertise and wisdom in a collective way to make a better society. Many of our core group of professionals have been active in the dialog on enhancing high tech base in our local regions, since the ensuing high paying jobs will enhance the local economy, the education system, and the industry base.

20 BUDGETS

20.1 Start-Up Summary

Our start-up costs come to $ 59,000. A major part of this is the R&D cost associated with developing and prototyping simple, albeit standardized, products as our first introductions. The start-up costs are to be financed by investment of owners and other interested parties. The parties have already contributed close to $150,000 in personal and machine time.

21 ACTION PLANS AND SCHEDULES

21.1 Milestones

Here we provide specifics:

7/1/00 Group meeting to evolve organizational details and responsibilities.

8/1/00 Incorporate STI. Focus on one science strand and design prototype

12/1/00 Develop prototype, software, manual and GUI. Arrangement with CRISP/CAPE institutions. Demonstrate to local schools.

3/1/01 SBIR/OERI/SIA proposals submitted. Summer student feedback Determine a tie-in with Lego Mindstorms. Refine the first prototype

7/1/01 Second strand system is ready. Endorsements and promotion started.

12/1/01 Second prototype refined. Marketing to schools started. First Conference in Florida. Teacher feedback. UL and safety endorsements obtained.

3/1/02 Prototype runs at PUPR and Ligi Tools in full swing. Delivery date to schools: 4/1/00. Global marketing efforts initiated.

5/1/02 Teacher Training at our expense. Incorporate teacher feedback.

8/1/02 First two science strands incorporated in some school systems. Kits released to home hobby market. Teacher Training and student tutoring contracted out. Teacher Development Kit developed. Start tracking student performance.

1/1/03 Second Conference in Florida. Teacher feedback and contests. Surveys.

8/1/03 Four more science strands incorporated in school systems. Hobby Kits developed. Adapt the kits for international use, with experiences relevant to kids in those areas. Focus on two regions at a time.

8/1/04 Final two science strands incorporated in school systems. Global product developments continued. Focus on more regions.

22 FINANCIAL STATEMENTS

22.1 Financial Plan

During the first 18 months, we do not anticipate much sales revenue. We, however, strongly believe that, given the concerns of the federal government and the industry for better K-12 education in science and math, we would be able to obtain federal grants from NSF and /or the Department of Education. Another possible source is the Semiconductor Industry Association [Bell98]. Thus, some of the initial effort will be spent in putting together a viable prototype and further development plans and submitting the same for funding by one of the above specified agencies.

There are three major customers / partners in this venture: schools, teachers and investors/founders. At present, schools could spend on an annual basis, about $1,000 for a comprehensive grade 1 kit that can be used twice during the year for up to 32 students, perhaps teamed two per team. This kit comes from Delta Education Systems from Berkeley. Extrapolating, over a 5 year period, if the school wished to support hands-on science, the Berkeley kit would cost them, for 4 grades, with 4 sections per grade, a total of $1,000 * 4 * 4*5 = $80,000. While this may be a more typical situation, consider a smaller country school with one grade and one section per grade. The Berkeley kit would cost such a smaller school an amount of $1,000 * 4 * 5 = $20,000. Assume that each school will purchase all the 16 kits from us, one for each science objective, at $300 each (each kit will have one hardware platform and 5 hardware modules, with software provided free), along with 5 additional hardware modules at $40 each. Further assume that all these will last for 5 years, and can be used/reused by all grades and sections. Then the total cost to the school = ($300 + $200) * 16 = $8,000. We would be priced at less than half of the lowest cost school system. Thus, our goals of affordability and accessibility by all the schools will be met.

Now, let us consider how much a teacher who develops an innovation would benefit. We propose to pay such an innovator up to 20% of the net income. With the hardware modules priced at $40 each, and a potential annual market share of 5%, the net income (with 25% margin) , over 10 years, to the company from this innovation would be: $40 * 0.05 * 120,000 * 0.25 * 10 = $640 K. Return to the innovator would be a maximum of $128 K over 10 years. A student, on the other hand, working with a teacher, might share part of the teacher's income, say 20% of that, at $25.6 K. Thus, our goal to encourage innovation by teachers and students alike will be met.

Finally, let us look at the investors and founders. In three years, with international sales included, the net income would be $7.2 M. Assuming an IRR of 20%, the NPV of the company in three years could be estimated as $14.4 M. Let us assume for simplicity sake that each of the founders invests $100K in cash, time, and / or facilities, during the formative period, in return for 5% of the equity. This would mean a return of $0.72 M after a further 3 years on an investment of $100 K, an annualized return of about 180%. Thus, our goal to provide a fair return for the founders and investors is also met.

Continued growth beyond the first five years will come from introduction of more types of science strand kits, the home hobby market, and training. We expect the company to have a net income of $ 20 M in year 5, under a very conservative estimate that our U.S. market will stabilize at 30% of the overall U.S. market, and that the overall international market will only amount to the equivalent of an additional 60% of the overall U.S. market. In the long run, the company has potential to be a major force in shaping the innovation in science and engineering and influencing the discussion on science and engineering education.

22.2 Important Assumptions

- There will be one hardware platform for each of the 16 science strand objectives. This will cover the 8 science strands (with two objectives per strand) of: Matter, Energy, Force and Motion, Earth Processes, Life Processes, Environment, and Nature of Science. Each kit will consist of one hardware platform, any 5 hardware modules, and PC software. These kits will sell for $300 each.

- There will be up to 10 additional hardware modules for each of the science strands. These modules will cost $40 each.

- Software for the modules, written in Java, will be free and downloadable from the Internet. Users can post their software and /or modifications to these module software at the website. Others can use them at their own risk. These upgrades will be suitably, but nominally rewarded, if incorporated in future releases. If a new hardware module is released as a consequence of the input of a teacher or student, then, the return to the innovator will be higher, at up to 20 % of the net income, depending upon the innovator's involvement in the product development process.

22.3 Projected Cash Flow

Assume, as a simple example, that we will sell two kits (one hardware platform, any five hardware modules) priced at $300 each, and with 5 additional modules on each of the platforms, priced at $40 each, coupled with free software for the modules and the platform. Assume the profit margin to be 25%, in line with that for text book publishers and much less than for typical high tech product, since our primary targeted market is cash-strapped school systems. Assume that we will be able to penetrate 1 % of the US school market (at 60 schools per school district, this works out to 20 school districts) in the first year of product introduction, which we project will increase to 10% in the third year of product introduction. The total number of schools in the U.S. is around 120,000, with an average of 5 PCs per school.

We estimate that the net profit would be $ 240 K the first year of product introduction, increasing to $2.4 M in the third year, just from the U.S. sales alone. The corresponding sales figures would be $0.96 M and $9.6 M respectively. The figures may be expected to treble with exposure to other industrial countries and developing countries such as China and India. (We estimate that a teacher with a new working innovation would net $60 K to $120 K, over a 10 year span.) We believe that the model has tremendous potential for growth and impact on the school system, not only in terms of better education, but also in terms of building an entrepreneurial atmosphere, and hopefully, many innovations in the future. Many such innovations may go beyond the education market being addressed by our company. We would provide appropriate assistance as needed - such successes will only prove the power of our concept and establish us as strong leaders.

23 CONTROL PLAN AND CONTINUAL IMPROVEMENT PROCEDURES

23.1 Evaluation Plan

Each prototype development plan will be evaluated at least semiannually, at a review of project activities in conjunction with the Board of Advisor's meetings. The Executive Director, the four major subgroups (Education Stakeholders, Prototype Development, Business and Marketing, External Communications) and the Principal and co-Principal investigators will consider three major aspects of the project at these reviews: technical performance, budget, and project status relative to the schedule milestones. If the progress on the project is unsatisfactory, the Executive Director can recommend a review by the Advisory Board, and the Advisory Board will decide on the continuation of any particular aspect of the project (such as specific prototype development). The Advisory Board will also determine the points at which each sub project (prototype development) is ready to proceed through various stages of development from laboratory prototype to field test units. The Executive Director will issue an annual report containing summaries of the progress to date of each sub project.

23.2 Evaluation Overview

A professor in the college of education will be the team leader for the evaluation component of the project. The project leader's role will be that of overseeing the progress of the evaluation, and coordinating the collaboration of all team members.

23.3 Evaluation Approach

To ensure that the objectives are met, formative evaluation will be conducted throughout the design, development and implementation phases of the project—i.e. conceptualization, incubation, and demonstration. Findings from each stage of the evaluation will be fed back to participants, informing them of the effectiveness of their recent choices, and guiding them in future decisions. Therefore, it will be essential to use a participatory evaluation approach (Patton, 1986, 1981; Worthen & Sanders, 1987) that involves project members in the evaluation process itself, thereby ensuring that the findings will be relevant, constructive, and user-friendly. This approach will also enable participants to gain needed evaluation expertise to help them integrate evaluation into the project throughout its lifetime. And finally, it will place the evaluation within a naturalistic framework of inquiry that will mesh well with the constructivist paradigm of learning, and that will allow for emergent design, and multiple viewpoints from a variety of stakeholders (Guba & Lincoln, 1981; Lincoln & Guba, 1985; Worthen & Sanders, 1987). Within this paradigm of evaluation, however, both qualitative and quantitative methodologies will be used to provide a well-rounded depiction of the project's effectiveness. Primary data collection methods will include: focus groups, interviews, and surveys. During the dissemination and sustenance phases, summative evaluation will be used. Using Flagg's (1990, p. 5) model for the formative evaluation of educational technology, the evaluation will have the following four major stages (see Table 2).

23.4 Preliminary Evaluation Questions:

Based upon the identified objectives (1.3), the following preliminary evaluation questions have been identified. During the planning phase, these questions will be refined, expanded, validated, or eliminated. Additionally, new ones will be generated. The end result will be a core set of primary questions that will guide the data collection and analysis process.

Formative Evaluation Questions:

A. Curriculum:

- To what extent do teachers and students find the hands-on experiments to be engaging?
- To what extent do students lead hands-on experiments?
- To what extent do students evolve their own creative solutions?
- To what degree are the experiments aligned with the Sunshine State and the National Science Education Standards?
- Can students grades K-5 observe and manipulate the experiments?
- Can students grades 6-8 analyze and semi-quantify the experiments?
- Can students grades 9 - 12 model and optimize the experiments?

B. PC-Pertinent:

- Are the software and hardware modules easy to use, assemble and maintain?
- Does this technology have the capacity to run several types of experiments?
- To what extent does the technology allow students and teachers to share each other's innovations?
- Is technical support provided in an effective manner?

Summative Evaluation Questions:

C. Strategic Objectives:

- To what extent did students achieve the Sunshine State and National Science Education Standards?
- To what extent did teachers participate?Was teacher training and professional development effective?
- To what extent did business/company volunteers become mentors/trainers for the professional development of teachers?
- Is the cost of ownership, maintenance and training within reason, thereby ensuring that all children and teachers, within this project, can benefit?
- Was the prototype production completed with as few storyboards as possible?

23.5 Dissemination Strategy

A. Our group's education panel has studied the curriculum needs and offered our group's vision to various school districts early on, to incorporate the experiments in the classrooms and obtain evaluation, to seek additional simple ideas from teachers for prototyping, and to get feedback on making user-friendly, useful and rugged prototype systems. Four school districts are partners to this proposal.

B. County and State level TEC (Technology Education Conference) are held on an annual basis and are well attended by teachers. Workshops and presentations at such sites will be conducted

C. There are many national conferences relevant to our needs. Our approach so highly integrates the stake holders, school districts, technology and business, that several conferences become sites for workshops, presentations, and buy-in. Examples are: Association of American Publishers (February), American Association of School Administrators (February), National Association of Independent Schools (February), The Education Show (March), Microcomputers in Education Conference (March), National Science Teachers Association Conference (March), National Business Education Association (March), National School Boards Association (April), National Association of Educational Buyers (April), Learning Curve Conference (June), Innovations (June), National Education Association Annual Meeting (July), National Association of Biology Teachers (October), and National Association of Gifted Children (November).

D. Dissemination will also take the shape of journal and book publications as well as on the Internet. Further, workshops for teacher training will be conducted in the fall at the four LEA sites.

Table 2: Evaluation Phases

Table 2: Evaluation Phases

Program Development Phase	Evaluation Phase
Phase 1: Planning (1/99 to 6/99)	A needs assessment was already conducted through an informal survey, through analysis of curriculum needs, and through informal interviews with four school districts. Next, the evaluation system will be refined, resulting in a clearly defined evaluation purpose, target audience, guiding questions, methods, and detailed timeline.
Phase 2: Design (Summer '99) Formative Evaluation	Prototype conceptualizations will be presented to the target audience (students and possibly administrators) for feedback. Inquiry will focus on whether students find the concepts to be engaging, fun, and challenging; and on whether administrators see them as meeting learning standards. Methodology may include a survey, interviews or focus groups. Findings will serve as input for the prototype production phase.
Phase 3: Production (Fall '99) Formative Evaluation	During production, initial prototype designs will be shared with the target audience and subject matter experts through focus groups, interviews, and/or surveys. Teachers will review the prototypes one Saturday each month. Findings will be incorporated into the subsequent drafts of the prototype to ensure usability.
Phase 4: Implementation (Spring/Summer '00) Formative and Summative	Throughout the implementation, and directly afterwards, evaluation will be used to assess the effectiveness of the prototype as used in educational settings. Teachers, administrators, students, and consortium members will participate. Implementation findings will be used to refine the prototypes and will feed in to the following

Evaluation	year of design and development.

23.6 Plan for Replication

The proposed Hands-On PC-Based Science Education initiative will address the needs of the science teachers at all grade levels with appropriate “user friendly” tools. It seeks to capitalize on the fact that market-pull factors often influence the willingness of educators to “pull” technology from a viable outside source to improve their own teaching subject content and delivery skills. This will enhance their own effectiveness, resulting in motivating students to be more skilled and creative in science subjects. It should be noted that market pull factors often shape the technology needs of the science educator. Our understanding of market pull factors as applied to the education environment, and how they influence technology innovation and needs of the science teacher will be incorporated into an effective delivery and commercialization program, applied through a strategic network of committed consortium partners. The design, delivery and commercialization approach of this science education initiative is developed to meet the needs of the Florida public and private school science teachers. The collective experience of our consortium members in science teacher needs assessment, technology identification, science prototype design/development/construction, training resource mobilization, commercialization skills, and project management, when applied through the innovative approach described in this proposal will make our proposed technology innovation implementation process in science education in schools dynamic, cost-effective and responsive. When the project is completed, we would have demonstrated a comprehensive approach to harness the best talents available to focus on technology innovation, deployment and training with respect to school science education which can be replicated in a variety of locales and environment.

24 CONTINGENCY PLAN

We have not given much thought to this at this point.

25 GLOSSARY OF TERMS

FCAT Florida Comprehensive Assessment Test
GDP Gross Domestic Product
IRR Internal Rate of Return
K-12 Kindergarten (pre-grade 1) to Grade 12, typical U.S. School program

NPV Net Present Value
SMT Surface Mount Technology, a modern electronic board production technology
STI Science Teachers Inc.,
Thin-Client A new portable scaled down version of a PC with no movable components
TIMSS Third International Mathematics and Science Study

26 DEVELOPMENT EFFORTS – DOCUMENTATION

Our prototype development work is fully documented above. We now have a functional RPM prototype that has a Java-based GUI, allowing the prototype to be, potentially, controlled from a remote site.

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