The development of a student-initiated, teacher-guided hypermedia program for automotive computer control systems

Dennis Raymond Korn

THE DEVELOPMENT OF A STUDENT-INITIATED, TEACHER-GUIDED HYPERMEDIA PROGRAM FOR AUTOMOTIVE COMPUTER CONTROL SYSTEMS

A Project
Presented to the
Faculty of
California State University,
San Bernardino

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts
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Approved by:

[redacted]
Dr. Rowena Santiago, First Reader   5/30/97
Date

[redacted]
Dr. Sylvester Robertson, Second Reader

ABSTRACT

To provide a proper amount of quality training for tomorrow's automotive technicians, it will be necessary to provide more time for training or to develop a more efficient means of training. This project uses a HyperCard-based program to provide a starting point in increasing efficiency in instructional delivery and continue to provide the skills necessary for a student to become a competent automotive technician.

The program "Automotive Computer Controls" is based on a modified version of Gagné and Briggs nine events of learning and their levels of complexity in intellectual skills that takes a learner from the lowest skill level of discrimination to the higher skill level of higher-order rules. The program then leads to the highest skill level of problem solving, which is accomplished through the use of lab worksheets on actual problem vehicles.

"Automotive Computer Controls" was designed to serve as a remedial tool, a classroom presentation tool and a subject reviewing tool, thus enriching the educational experience for both the student and the instructor.

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CHAPTER ONE

INTRODUCTION

The advances made in automotive technology have provided a challenge to training programs: the need to provide an extensive amount of complex technical information in a short amount of time. For example, in 1990 models, just 18 percent of a car's functional parts were controlled by a computer. Just four model years later, that figure has increased to about 83 percent (Mulford, 1994). This increased level of technology requires a greater amount of education time if students are going to be prepared to enter the work force, even in entry-level positions. At the moment, the amount of information presented versus the class time available does not allow the luxury of reviewing the material over and over again with students. Although reinforcement through the use of hands-on lab assignments is used, a student who misses lecture material is lost in the lab setting and at this point there is no adequate way of making up for the material missed. As electronic education and training technology expands and becomes more cost-effective (at the production end and the user end), it may become possible to offer a package which maximizes the use of highly proficient teachers, allows greater flexibility for the student, plus offers the added advantage for continued review and reuse (Cole & Prochazka-Dahl, 1996). This project provides the beginnings of an easily expandable program that can provide students with the opportunity to review material presented in class or receive a new lesson with limited instructor input and provide the instructor with a means to present material in class in a more timely, efficient and motivating manner.

The requirements for today's automotive technician (note that they are not considered mechanics anymore) has reached a point where only the best students have any chance of making a viable living the field. Twenty years ago a car mechanic needed to understand 5,000 pages of service manuals to fix any automobile on the road. The radio was about the only electronic component in cars then. Today's technicians must decipher more than 500,000 pages of text, and that number keeps increasing as manufacturers introduce new models (Sutphin, 1994). Current standards for material presented in automotive programs were established by NATEF (National Automotive Technicians Education Foundation), the educational arm of ASE (Automotive Service Excellence) which establishes program requirements for school certification. ASE also provides testing for technicians and instructors on a voluntary basis, but this standard is now providing minimum hire requirements for many automotive businesses. The material that must covered in an automotive training program, as established by NATEF, provides theory and practical application requirements to eight areas of the automotive field: engine repair, electrical, engine performance, brakes, steering and suspension, heating/air conditioning, standard transmissions and transaxles, and automatic transmissions and transaxles. NATEF's precise national standards determine the competencies students must master (Mulford, 1994). These requirements assist instructors in the formation of the automotive curriculum. If followed properly, students completing the program will have the skills necessary to enter the work force.

Standards have been set, curriculum has been developed, but still the students miss key points in lessons and find themselves lost as one point builds upon another to a greater understanding. Instructors are left with two choices: 1) take more time to review material over and over again to insure that all students fully understand, or 2) move ahead at a steady pace and those students that do not keep up get left behind. This would allow the very best to succeed, but would keep marginal students from completing the program satisfactorily. The nation is facing a shortage of about 60,000 auto technicians, according to the American Automobile Association (Mulford, 1994). This shortage will continue to grow as more vehicles are produced each year and training programs continue to provide inefficient training.

The problem is reduced to three not so simple items; 1) how do we train students in the most efficient manner?; 2) how do we provide a means for students to review material on their own so they will not fall behind?; and 3) how do we insure that all students are gaining the necessary skills to enter the work force?

An expandable HyperCard-based program that is part of the total curriculum plan and used as a presentation tool in the classroom as well as a follow-up tool by students would be one way to answer these questions. This program would need to provide a lesson, but not in a linear fashion. It should lead to an activity (see Appendix A) and take a student from the lower intellectual skill level of discrimination to the highest intellectual skill level of problem solving. The program should be easy to use, provide feedback, and not require extensive instructor assistance for students to use.

CHAPTER TWO

REVIEW OF LITERAUTRE

If you take your car into a shop to have the brakes fixed and the technician completed an occupational program with a 70 percent average, how would you feel about the repair job? Would you be concerned that the brakes might function correctly only 70 percent of the time, or that perhaps only 70 percent of this technician's repair jobs have been completed correctly in the past? Preparing individuals who can meet competency levels required in the workplace should be the concern of all educators (Luft, 1994). This implies that all education is vocational education, because the ultimate goal for all students is gainful employment.

With that goal in mind, this chapter will review literature on effective learning theories for automotive students, instructor productivity in the classroom, the trends in teaching automotive courses, the role of technology in the classroom, and multimedia and authoring tools.

Learning Events and Cognitive Constructivist

Learning is a complicated process, not easily understood, but studied for years. The development of an educational program, whether it is a computer-based program or simply a lecture on a body of material, requires an understanding and a basic belief in one or more of the numerous learning theories. Though all instructors may not readily admit to teaching per a given learning theory, they unknowingly subscribe to one or more of these learning theories and use them everyday.

Two learning theories evident in this project are the concept-learning hierarchies as described by Gagné and Briggs and cognitive constructivism as described by Piaget.

Gagné and Briggs describe instruction as "a human undertaking whose purpose is to help people learn." Five assumptions support the Gagné-Briggs concept of instruction design: first, instruction should facilitate the learning of an individual student; second, both intermediate and long-range phases should be planned; third, instruction should be precisely planned; fourth, instruction should be designed using the systems approach; fifth, instruction should be developed from knowledge about how humans learn (Gagné and Briggs, 1979).

The Gagné-Briggs theory postulates the information-processing model of learning and memory, as well as the need for reinforcement and feedback. Instruction is defined as a set of events that takes place in approximately the following sequence: (a) gaining attention, (b) informing the learner of the objective, (c) stimulating recall of prerequisites, (d) presenting the stimulus material, (e) providing "learning guidance," (f) eliciting the performance, (g) providing feedback, (h) assessing the performance, and (i) enhancing retention and transfer (Saettler, 1990).

Though the argument for or against these stages of learning development has centered on the child as a learner, the events of learning can also be applied to the education of adult learners. Adult learners range in age from 17 to 70+ years of age. They are self-motivated but generally require structure in their educational presentation. By basing a lesson on the events of learning as described by Gagné-Briggs, an instructor can provide all the necessary steps that the majority of students require to achieve their goals.

Matching adult learner characteristics or assets and the nine events of learning shows how effective this learning theory could be, especially when combined with multi-media instruction. To focus on these matched assets/learning events requires taking each one in turn (adapted from information developed by Ference & Vockell, 1994).

Learning Event	Adult Learning Asset
1. Gaining Attention	• Problem-centered • Skill-seeking • Task-centered • Value-driven

One way to gain learners' attention is by using multiple senses; e.g., using both sight and sound.

2. Activating Motivation (Informing the learner of the objective)	• Active learner • Externally motivated • Internally motivated • Life-centered • Problem-centered • Skill-seeking • Task-centered • Value-driven

It is important to provide learners with the rationale they need for engaging in the intended learning. Activities should not be so easy and mundane that the learner gets bored, nor so difficult that the task seems impossible to accomplish.

3. Stimulating recall of prerequisite material
   - Experienced-based
   - Life-centered

Adult learners bring to the classroom a vast amount of real-life experience in addition to formal education. They want to test newly acquired concepts and skills against their existing experience. As instructors of adults, teachers need to remember that adults place value on their previous experience and want others to value that experience. As instructors of adults, it is important to draw on the experience of the learner. Experience is so important to an individual that adults often feel rejected as persons when they perceive that their experience is being devalued or ignored.

4. Presenting stimulus material
   - Problem-centered
   - Skill-seeking
   - Value-driven

Clarity and relevance are the key principles in presenting information to adult learners. Clarity means that learners should be able to direct their attention exactly where it needs to go during the presentation. Relevance means that they should be able to see how what they are doing relates to the goals they have set for themselves. Do not confuse learners by giving them extraneous information. Focus their attention on the key elements. Since adults are often inclined to be independent learners, permit learners as much freedom as possible to work at their own pace and to adapt the instruction to their own goals and interests. Students should work with the instructor to establish reasonable goals and to insure understanding of the lesson objectives.

5. Providing learning guidance
   - Active learner
   - Expert
   - Externally motivated
   - Hands-on
   - Independent
   - Internally motivated
   - Self-directing
   - Task-centered

Adult learners are typically doers. They are active participants (task-centered) in the learning process and work effectively by doing and through discovery. The role of a facilitator of instruction is to guide the learning process. This can be accomplished through highlighting concepts, providing explanations, or demonstrating key procedures.

6. Eliciting performance
   - Externally motivated
   - Internally motivated
   - Life-centered
   - Problem-centered
   - Value-driven

The rationale for having the learners demonstrate that learning has taken place is twofold. First, if you discover that the learners have not gained the new skills as stated in the learning objectives, you will need to offer guidance to help them attain the objective. Second, if the learners satisfactorily demonstrate that they have acquired the new skills, you will want to proceed with the events of instruction by promoting retention of the skills and helping them transfer these skills to the real world. Comparisons can be made to a student's real life experiences and to situations they are likely to encounter in their life.

7. Providing feedback

- Action-oriented
- Life-centered
- Problem-centered
- Skill-seeking
- Solution-driven
- Task-centered

Providing feedback is a critical step in the training process. Feedback should be given frequently during the instruction. When learners master a small step, they should be made aware of their success and move on to the next step. For most adult learners, the simple awareness that performance is on target is usually sufficient to maintain motivation. When an error is made, learners should back up to an earlier event in instruction, determine what went wrong, acquire new information or skills, and try again.

8. Assessing performance

- Action-oriented
- Externally motivated
- Internally motivated
- Life-centered
- Problem-centered
- Self-directing
- Skill-seeking
- Solution-driven
- Value-driven

The difference between performance assessment and the feedback described in Step 7 is that performance assessment is more formal. Feedback occurs while learning is occurring. Performance assessment occurs after the learners think they have mastered a skill and want to demonstrate this mastery. This type of assessment typically requires a testing instrument such as a lab worksheet or live hands-on testing.

9. Promoting retention and transfer
   - Action-oriented
   - Externally motivated
   - Independent
   - Internally motivated
   - Life-centered
   - Problem-centered
   - Solution-driven
   - Task-centered
   - Value-driven

Newly acquired skills should not remain in the classroom. One of the main jobs of the instructor is to provide the learners with mental tools and techniques for retaining and effectively using these new skills.

As stated previously, adult learners are doers. For effective education of doers the instruction needs to allow the student to do something or perform a skill. This leads to the theory of constructivism.

A constructivist instructor creates a context for learning in which students can become engaged in the process of their own discoveries. The teacher creates an environment that generates problems, adventures, and challenges. Activities are rooted in meaningful situations that interest students and that have self-satisfying outcomes. Students work toward achieving goals meaningful to them and most commonly work in groups. This social interaction is vital in that it is a setting for cognitive conflict — or discussion, debate, exchange — to occur (Willis, Stephens, Matthew, 1996).

The theory behind constructivist thoughts was developed by Jean Piaget and forms the basis for another set of linear learning development stages. For Piaget, intellectual development cannot be pushed; it unfolds just as physical development does — naturally, at its own pace. All learners advance along stages regardless of cultural or societal differences. The Piaget teacher neither directs nor urges learning but, instead, takes the role of facilitator, assessing the stage at which the student is functioning and providing a learning environment that coincides with the stage of development of each student. By doing this, the teacher recognizes the students' natural curiosity and challenges their problem solving abilities (Willis, et.al., 1996).

Piaget's name is perhaps most often associated with the periods or stages of cognitive development: sensorimotor, concrete preoperational thinking, concrete operations, and formal operations (Willis, et.al, 1996). These four stages of learning take a learner from birth to the age of 15. How does this apply to adult learners?

Piaget's theory states that children construct knowledge about their world through their active level of cognitive development. He stresses that intelligence is a natural process that is continually unfolding. His genetic theory of cognitive development "above all sees knowledge as a continuous construction" (Willis, et.al, 1996). Though the formal stages Piaget describes may be completed by age 15, learning continues to take place and a review of the adult learning characteristics listed earlier shows a continued need and desire for knowledge, a curiosity that if tapped into properly can provide the vehicle for life-long learning to take place. This requires that instructors recognize the characteristics of their learners, continually challenge their desire to learn, and give the learner the means to continue the unfolding their natural processes.

The constructivist view, which undergrids the work of John Dewey, Lev Vygotsky, and Maria Montessori, holds that teachers should be facilitators who help students construct their own understandings and capabilities in carrying out challenging tasks. This view puts the emphasis on the activity of the student rather than on that of the teacher (Collins, 1991).

To take both Gagné-Briggs and Piaget theories and develop instruction for adults in a classroom through the use of technology requires a shift in the view of how instruction should take place; i.e, a shift from whole-class to small-group instruction; a shift in the instructor's role away from lecture and recitation and towards coaching; a shift from the instructor working primarily with better students to working with weaker students; a shift toward more engaged students; a shift from assessment based on test performance to assessment based on progress, products or effort; and a shift from a competitive to a cooperative social structure (Collins, 1991).

The basic goals of education - the retention, understanding and active use of knowledge - sound simple. But having and understanding knowledge and skills come to naught unless the learner actually makes active use of them later in life—in studying other subjects, shopping in the supermarket, getting a better job, casting a vote, or whatever other context (Perkins, 1991).

The conclusion reached from the research requires the combination of an understanding of adults by the instructor; that students in their classroom will be at various levels of learning development; that they will have individual learning styles; that the information and skills presented must be contextually based; and that through the use of technology as a tool it is possible to provide an interactive, contextual based learning path that leads to students constructing their own knowledge and is adaptable to a variety of students.

Instructor Productivity in the Classroom

It is particularly important that people in higher education seek ways to improve their productivity. Over the past two decades the cost of higher education has increased rapidly, but no evidence suggests that the outcomes for students have improved. In short, while other sectors of society have improved their productivity by the appropriate application of new technologies, productivity in higher education has suffered. Multimedia represents a potentially powerful technology for higher education that could, with proper use, increase productivity immensely (Falk & Carlson, 1995). At the same time one considers productivity in the classroom, thought must be given to the learners needs and how each student learns. One way to achieve this is through the use of an interactive multi-media program.

In 1990, Carlson and Falk outline two main types of interactive models available in multimedia that are still valid in the designing of multimedia programs today. One is an instructional system that gives correct information, tests, and remedials; here, the learner's interactivity involves regurgitating information given and responding to test items. The second is an instructional system in which the learner chooses what to learn and/or chooses how to learn the material; here, the instructional system acts interactively by providing content options and/or learning options. This project leans towards the instructional system that gives correct information, tests, and remedials, but the learner has an active role in navigating through the program to suit their individual needs. The reason for choosing this type of instructional system is the positive reinforcement qualities that this type of instruction provides. When dealing with highly technical information that easily becomes overwhelming, it is positive reinforcement (developed by educators like B.F. Skinner) that gives the student the encouragement to continue learning. Negative reinforcement also has a role in the learning process, but care must be used when applying this method. Knocking a student down only works if an instructor is sure that the student can get up again.

Lucas (1992) echoes these models by describing an instructional technology in which the learner uses simple physical or cognitive manipulations to react to instruction (reactive model). She further describes instructional activities in which learners construct and deduce principles from their actions and experiences in a proactive manner. A third model, interactive, describes an environment in which the learner branches through a program based on responses to questions posed by the computer. Lucas maintains that each of the models has a specific purpose. The reactive model is useful in polishing a basic skill, the interactive model is appropriate for a novice learner of knowledge, and the proactive model is successfully used by those with some experience and knowledge in the subject. This project uses the interactive model which leads students to the proactive model during the performance-related module of the lesson.

Using multimedia and the interactive model as described by Lucas should provide the means to increase the productivity in learning. Considering the limited amount of time available to an instructor to provide one-on-one or small-group instruction and the amount of technical knowledge in the automotive field that needs to be acquired for basic job skill development, it becomes readily apparent that making use of any medium that takes advantage of the time available will increase productivity and increase student success.

Trends in Teaching Automotive Courses

This project is not the first computer-based instructional program to be developed for use in automotive training. Currently there are a number of program packages available for use by instructors. For example, Innovative Technologies in Education, an Orlando company, sells a computer-integrated technology lab that includes a personal computer, software packages that insert "faults" into a car's engine or electronic components to help students with troubleshooting problems and software-controlled simulators that depict lifelike examples of problems with a car's components (Mulford, 1994). This program, like many others, are costly and do not meet the specific needs of all instructors.

Another example of current offerings comes from a leader in educational training video production — Bergwall. Their latest offerings include CD-ROM programs covering various aspects of automotive training. But, where at first, this sounds like a new approach with a multimedia presentation, it is simply their video programs placed on CD-ROM. They are not making use of the new DVD (Digital Video Disk) format that would at least improve the quality of the video presentation over standard CD-ROM or video tape. These program packages are sold to schools which then have to adapt their curriculum to match the program, instead of the program be adapted to the curriculum.

The program developed for this project allows customizing to particular curriculum needs by allowing an instructor with the necessary skills to add information and lesson stacks. The necessary skills required to perform this operation are simply the ability to use the HyperCard program and HyperTalk programming language, two challenging skills well within the realm of possibility for many instructors.

The direction that a student's education takes usually begins on the high school level, where choices are supposedly offered and options discussed. In high schools today, students are being directed to four-year college educations. Counselors are being directed by school administrators, who are being pressured by parents, that all high school students need a four-year degree to be successful in today's society. Schools are not taking the time to research what industry requires in the form of job skills. Today's work place is full of technology and that technology demands workers who can analyze and solve problems quickly and efficiently. This type of training is being taught only at a few universities and in many cases is not incorporated into the vocational programs offered at the community college level. The United States needs to make a critical decision about what it means to be educated. America's fixation on preparing students solely for higher education is a primary cause of the inability of American students to apply the knowledge they have learned. It takes a great deal more time to teach applications than to deliver content to students. With the shortest school day and year in the industrialized world, the United States is at an obvious disadvantage (Daggett, 1994).

Specific requirements for the automotive trade have changed to the point where the vocational program should not be the dumping ground for those who have no direction. The automotive program course of study should be a directed career path starting at the high school level and moving into the community college with the possibility of advanced study at the university level. Each level should have basic entry level skill and exit skill requirements. This provides students the possibility of exiting the program at any level, gaining meaningful employment, and possibly rejoining the system at a later date for skill and job enhancement.

High school automotive programs should not attempt to teach the latest technology to their students, but instead should lay the foundations of knowledge for the next level of education. The community college automotive course should take the next step in the building of foundation skills by expanding the knowledge base and then providing problem-solving challenges to students. The current trend has been to provide information through lecture, lecture-demonstration, and hands-on approaches. These methods of instruction are still viable means of training automotive technicians, but multimedia possibilities provides another avenue of training. The use of multimedia is currently finding its way into automotive corporate training programs, designed for factory technicians, but has not seen extensive use in the community college or high school automotive training programs.

The new skill requirements for automotive technicians means students must be better prepared in reading, math (including applied geometry), and science (particularly physics and chemistry). High school students must read service manuals written at the 12th grade level. Instructors say many students struggle with academic requirements, but they are able to succeed on the strength of their own motivation and with the help of tech prep programs, individual attention from teachers and hands-on learning on high-tech training equipment (Mulford, 1994). These days computerization is going to be more useful to a technician than turning a screwdriver (Bamford, 1994).

Future technicians require courses and instruction that focus on hands-on or interactive types of learning. The use of the computer, not only as a technician's tool, but as a learning tool has a significant role in training automotive technicians. It is estimated that in three years every factory service technician will have a personal computer at their work station. This will be used for diagnostics, communications within the dealership and communication within the corporation that will give a technician quick access to technical data directly from the factory.

The future development of technology in the automotive field will not wait for training facilities to catch up, the technology will continue to increase the demands on technicians for update training. The life-long learning demanded of today's and tomorrow's technicians will require the use of technology to bring about effective training.

The Role of Technology in Instruction

The first teacher ever, that priest in preliterate Mesopotamia who sat down outside the temple with the kids and began to draw figures with a twig in the sand, would be perfectly at home in most classrooms in the world today. Of course, there is the blackboard (or white board), but otherwise there has been little change in tools and none in respect to methods. The one new teaching tool in the intervening 8,000 years has been the printed book. And that tool few teachers really know how to use—or else they would not continue to lecture on what is already in the book (Spotts, Bowman, 1995).

Technology has invaded our schools. Typical technology initiatives focus on teaching students how to interact with new equipment and how to use technology to improve learning of the traditional curriculum. While both of those goals are worthy of our attention, they fail to address the most fundamental challenge of our contemporary workplaces and society—teaching students the academic knowledge and skills that underpin present and future generations of technology. What good is it for students to know how to log on to the Internet, for example, if they cannot organize their thoughts to communicate coherently or think logically when something breaks down (Daggett, 1994)?

Instructors of the future will not be teaching information, they will be teaching students how to use information (Van Horn, 1991). The use of technology will not replace the instructor in the formative years of learning, but could replace the instructor in the life-long learning strategies used by adults. An example of a technology that could change the way we look at educational delivery is the CD-ROM (Compact Disc - Read Only Memory).

Automotive technicians are required to use factory or service manuals as part of their diagnostic routine. As recently as five years ago, this information was only available on printed page and would require an extensive library for the average technician to complete their job. Today it is possible to access a series of CD-ROMs that contain all the information that used to take up a bookcase of printed books. But that should be just the beginning.

Factory service manuals provide technicians with information. An additional major responsibility of automobile manufacturers is to provide training. When technicians must complete a diagnosis or repair they are unsure of or have never previously performed, training can be of vital importance. To have the desired impact on job performance, however, access to training must be at the point of need and at the time of need (what we call a teachable moment).

Implementation of CD-ROM technology allows the integration of information and training. Designing training that guides a technician through a series of diagnostic steps in which symptoms are related to causes can be integrated into the information presented on how to perform the steps. Combining information with training in this manner can prove particularly beneficial to learners facing unique problems.

As importantly, the technician has the option to repeat relevant information/training as often as necessary. This is a distinct advantage when the repair or diagnosis is complex or includes unusual or seldom-used skills. Enabling the technician to see the skills performed just prior to the actual on-the-job performance increases the chances the technician will do it correctly (Heideman, 1995).

The CD-ROM technology mentioned in the previous example replaces the older technology of video tape training. The results can be very similar, but the advantage of the new technology is the speed of access to specific points of training and instant access to support information.

Technology is a tool. And like a hammer is only an effective tool if the user grabs the correct end before trying to pound in a nail, technology will only be effective if the user realizes the limitations and challenges the current paradigm in teaching.

Studies have proven that students learn by various means and at different rates. The implications of these fundamental facts are that technology alone will not fix education; that the use of technology will not guarantee learning by all students; that some students will still demonstrate higher achievement through the lecture method; and that to ignore technology and its place as a tool in the classroom is comparable to not giving students access to the school library or pens and paper.

Multimedia and Authoring Tools

This project is a HyperCard-based combination of stacks incorporating images, sound, and graphics to provide the external events required for learning to take place. It is an authoring tool, but is it a hypertext, hypermedia, or multimedia tool used to produce original computer programs? Hypertext is a collection of textual information on a specific topic featuring highlighted words known as "hot spots" which can be activated by touch. When activated, they branch the user to additional information, such as definitions, elaborations, or related material (Sweeters, 1994). Since it is possible to have text in a HyperCard highlighted and activated by touch for branching, then HyperCard can be considered a form of Hypertext. Hypermedia is a multi-voice medium. The material can include text, static and animated graphics, voice, sound and music. . . . well designed systems allow learners to link information, create their own paths . . . annotate, and literally construct webs of information (Gay, G., Trumbull, D., & Mazur, J., 1991). Since HyperCard can include the elements of animated graphics, still pictures and a variety of sounds, it must also be considered Hypermedia. Multimedia is described by Weiner (Tolhurst, 1995), as ". . . the powerful combination of text, graphics, sound, animation and video under computer control." The current versions of HyperCard can be used to control video disc, other programs, sound generators, and access graphics and animation or video from CD-ROM. This makes HyperCard a multi-level authoring device that allows the user to choose the extent of program. A user could make a program purely Hypertext or include pictures and animation to make it Hypermedia. But with the advancements in today's technology it is easier to make HyperCard a complete multimedia presentation and learning tool by making use of the best components of all the available resources.

HyperCard is a tool that can be used at various levels (Hypertext, Hypermedia, or Multimedia) that provides a means for users to branch out as they explore in ways very similar to the way the human brain actually functions. This makes learning fun, interactive, and exciting for both the educated and the educator.

So what can be concluded about this authoring tool HyperCard? It was designed by individuals who wanted to provide a means for anyone to develop programs they could use without extensive training. It is a tool that provides various levels of activity from basic text manipulation to multimedia access and retrieval of information. It has no real limits except those placed on it by the user or equipment available. It can be used in a classroom or outside the classroom (the principle might use it or the librarian). It can be both teacher-centered and/or student-centered. It is a program designed for use today and tomorrow by any who desire to keep pace and make easy use of the advancements in technology. It is almost ten years old, yet it is as fresh as the day it was introduced. For educators it is a program that is both timely and timeless.

HyperCard was chosen more for familiarity reasons then for technical reasons. There are many authoring programs on the market today and most allow an individual to provide instruction in ways that make learning fun, effective and productive. In the past HyperCard did not make use of color, but the newer version (v2.3) allows the use of color in creating the card backgrounds, buttons and fields. The use of color in this project will be limited to backgrounds or buttons because color, while gaining attention, can also be distracting. The use of color must be for a specific reason, not just to provide some flash. Extensive use is made of actual photographs taken of automotive components on and off the vehicle. These are in color and pasted to the appropriate cards in the various stacks. Hidden buttons under specific items in the pictures will allow students to click on the picture and be transported to another stack or card for further information or insight into a subject.

This project has elements of teacher-centered activity (when used as a presentation tool), and student-centered activity (when used by students in groups or individually). There has been a recent emphasis in educational journals and university education classes to provide for "learner-control" in designing programs for instructional use. The reasons for this include increased student motivation, to develop self-learning ability, and, consequently, to yield the best learning achievement. But, there is limited empirical evidence to suggest that "learner-controlled" instruction is the best way to go, especially in a computer-based instruction model. Important reasons as to why the learner-control principle is not effective for instruction are: (a) the student usually does not have sufficient knowledge about the content to be learned, and therefore cannot make appropriate decisions in the selection of learning content and strategies; (b) the student may not have the the metacognitive ability to accurately assess and predict his or her own learning progress; and (c) the student may not have the appropriate cognitive strategies for applying his or her experience and knowledge in the learning process (Park, 1991). A majority of adults learners have arrived at the post-secondary education level without the proper tools for learning. The cause of this inadequacy can be due to the amount of time between the student's secondary and post-secondary education, the inability of secondary education to provide these tools or the students inability to acquire these tools at that time in their lives. By developing a program that is instructor-guided but learner-operated, it is one of the goals of this project to provide the pre-knowledge necessary for students to begin the development of cognitive strategies for life-long learning. This requires the use of an authoring program that is both easy to develop material on, easy to operate by students and will meet the requirements of available delivery systems.

CHAPTER THREE

OBJECTIVES

It is the goal of this project to develop a computer-based instructional material that in combination with laboratory worksheets will assist students in developing their higher-order thinking skills. These skills should be developed in the context of the subject matter they study. Higher-order thinking requires students to apply, analyze, synthesize, or evaluate information. In essence, higher-order thinking occurs when students are able to use what they learn to deal with real-world problems and situations (Miller, 1990). This will require taking students from the lowest intellectual skill level of discrimination to the higher-order intellectual skill level of problem solving.

The goal of taking students from the lowest skill level of discrimination to the highest skill level of problem solving does not necessarily need to be accomplished within a single medium. The ability to combine media delivery systems to provide the proper environment for raising a student's skill levels is one of the goals in making educational delivery more efficient. By combining a computer based learning element with actual hands-on experience in a lab environment will provide the means for taking a student from discrimination to problem-solving in a timely manner.

Based on the problems identified and the instructional goals of this project, the following objectives have been established for this project:

1. Provide an expandable program that can be used as a presentation tool and as a student directed learning tool.
2. Within the program, provide a lesson on one automotive computer control sensor with support material.
3. Increase productivity in the classroom through the use of this program.

The instructional material presented in the project has objectives that must be met through the use of the project program and student activity in the automotive shop environment. These objectives are:

1. Given pictures of sensor scope pattern, students will be able to distinguish a problem pattern from a good pattern with 100% accuracy.
2. Given the proper test equipment at the completion of the program students will be able to generate a solution to a vehicle problem using the hands-on worksheet with 100% accuracy.
3. Given a technical description, students will be able to distinguish between the two types of oxygen sensors with 100% accuracy.

CHAPTER FOUR

DESIGN AND DEVELOPMENT

Content Area

The specific subject matter chosen for this project originated from a study of the program requirements for training automotive technicians as prescribed by NATEF (National Automotive Technicians Education Foundation), and observations from instructors on student skill levels upon completion of the program. Though a large amount of material could be presented in a computer program, it was decided that concentration should be given to specific goals in one aspect of the curriculum to test the viability and validity of the program. The one aspect chosen is the automotive oxygen sensor and the specific goal is to develop the skill in solving automotive diagnostic problems based on oxygen sensor readings.

Audience

The audience for this project is composed of community college students taking the Automotive Tune-up, Fuel, Electrical and Emissions class. The following is an overall description of the learners:

a. Range in age from 17 to 70+ years old.

b. Have limited background in automotive technology, i.e. no high school automotive class, no previous college automotive classes.

c. Range in learning style from those who learn best through visual or auditory means to those who can learn quickly by just reading written text.

d. Students in the automotive programs have traditionally learned best through hands-on experiences, so assignments in the shop are used in combination with the project.

e. Majority of students are self-motivated. Those who require external motivation to complete assignments or work usually do not complete the program.

Structure

The program (see Appendix B) is divided into five main areas. These areas are Test Equipment, Inputs/Sensors, Outputs/Actuators, Questions/Quizzes, and References. Each area is sub-divided based on the content included. The Test Equipment area offers options on studying about Digital Volt-Ohm Meters (DVOM), Digital Storage Oscilloscopes (DSO), or Scanners (Figure 1). The Input/Sensors area separates the available options by the type signals an automotive sensor may produce.

The three types of sensor signals are DC Voltage, AC Voltage and Variable Frequency (Figure 2). Each of these types of sensor signals are further divided by actual sensor names listed under each type of sensor signal. For example the "Oxygen Sensor" would be found under the sensor signal type DC Voltage. The particular lesson on oxygen sensors presented in the program is a self-contained stack that provides a series of cards presenting various facts and procedures required to perform oxygen sensor tests in the laboratory.

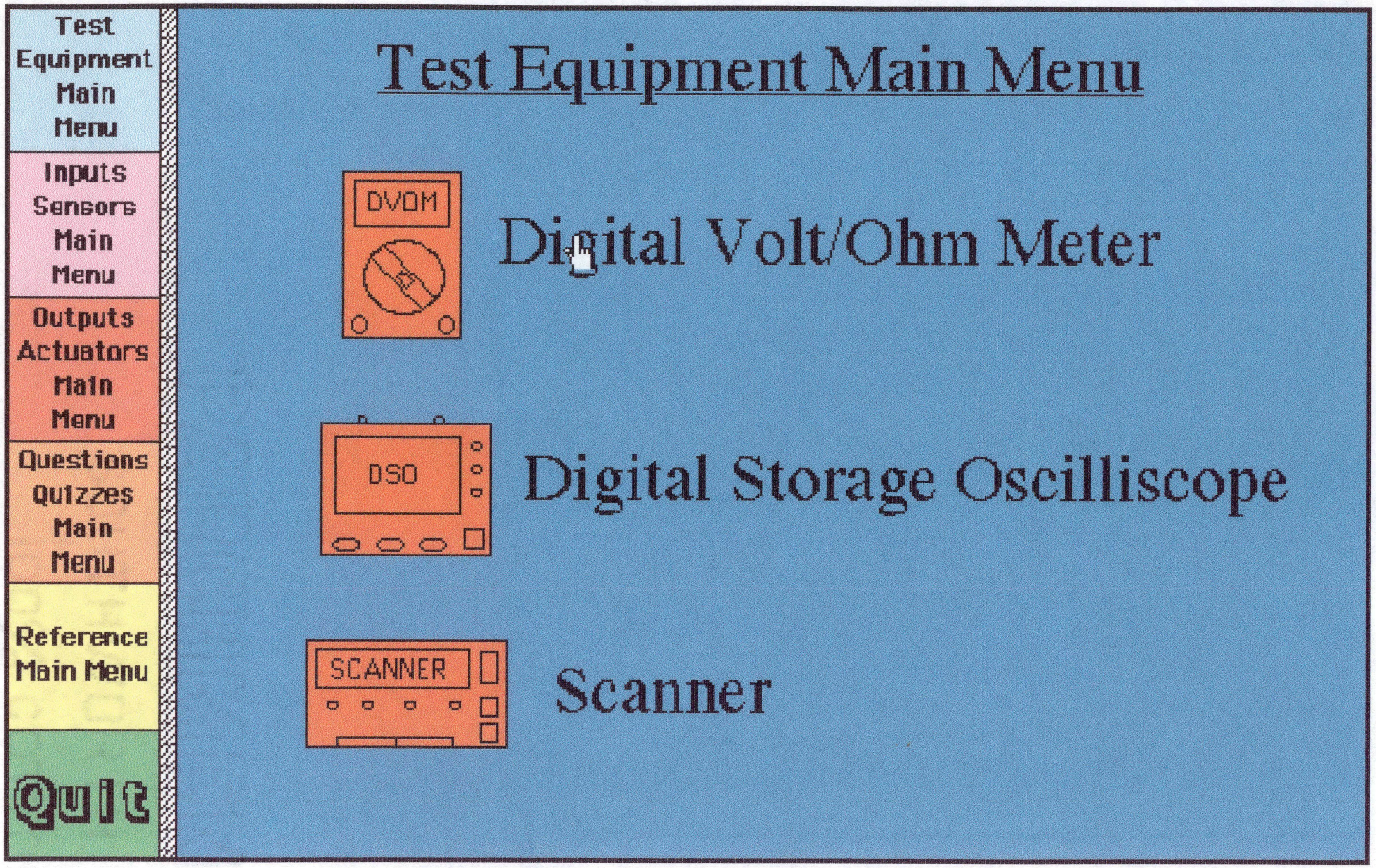

Figure 1. Test Equipment Main Menu

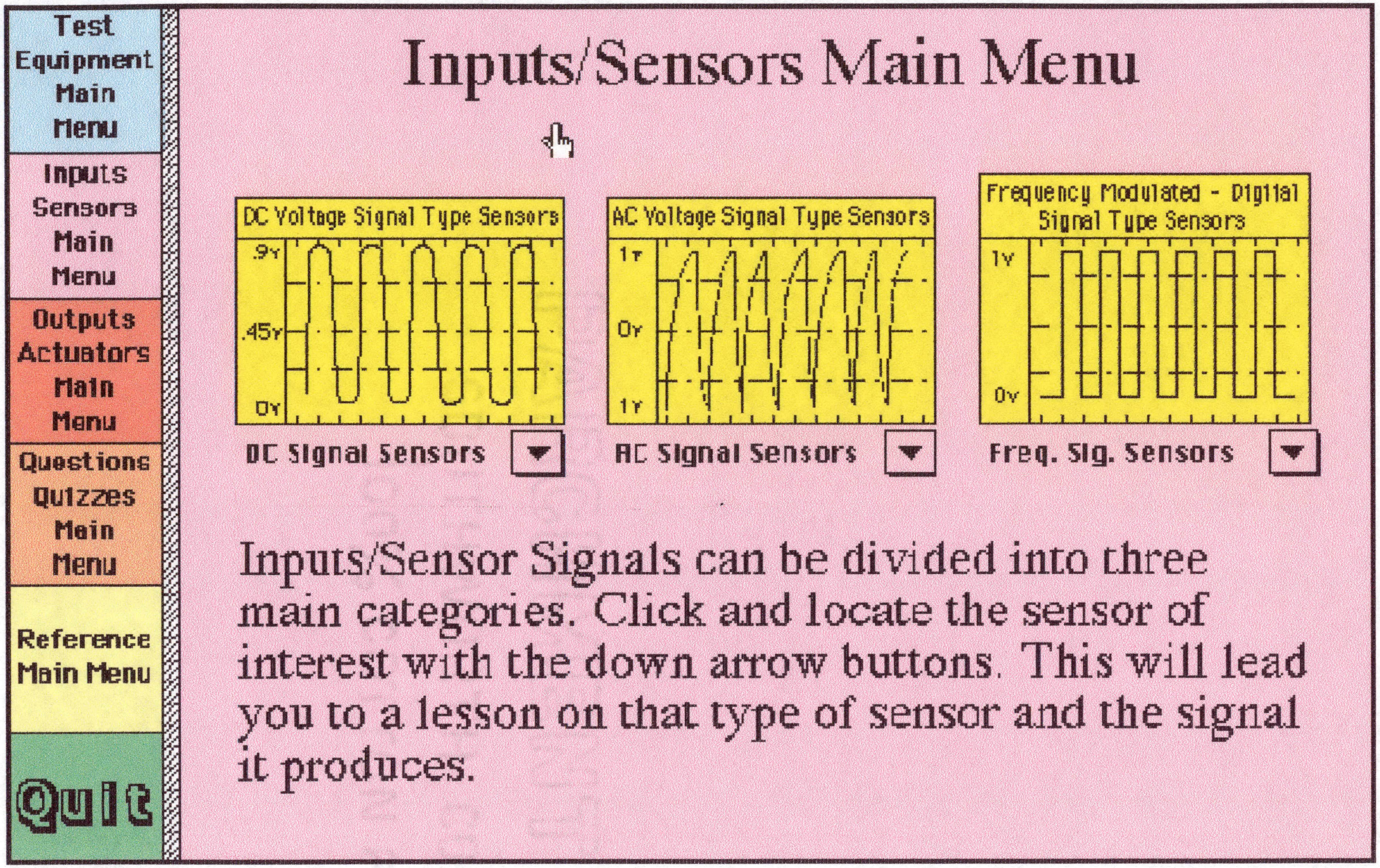

Figure 2. Inputs/Sensors Main Menu

The Outputs/Actuators area would follow the same format as the Inputs/Sensors when it is fully developed. The Questions/Quizzes area would provide a main menu of subject headings listing various sensors, actuators, or types of test equipment, each leading to a variety of quizzes for student evaluation. The Reference area is separated into a dictionary portion, both English and Spanish sections are under development, and a sensor pattern sampler from a digital storage oscilloscope. This would provide quick access to terms not defined in pop-up fields and a ready source of known good scope patterns for comparison with laboratory worksheet results.

Instructional Design

The instructional strategy that was used to achieve the stated objectives makes use of a learner-centered computer-based module of instruction, entitled "Automotive Computer Controls". Each section of this module includes a means to direct the attention of the students to the subject matter through the use of icons or graphical pictures that represent the subject matter. Each module informs the student of their objectives through the use of text fields and provides a stimulus for continued student involvement through the use of pictures, student activated buttons and student control of the lesson pace. A computer-based lesson is new and exciting for many students and makes learning a fun experience. The design of the program eliminates frustration through the use of easy navigational tools such as arrow buttons located at the bottom of each card. These buttons can be used for basic linear progression or retreat through the stack, but students have the option of choosing one particular part of a stack through the main menu for each particular stack (i.e. Oxygen Sensor Main Menu, Figure 3). Ready access to any part of the program is provided through buttons located along the left edge of each card. These buttons are color coded for easy recognition and provide students a means to move from lesson material to reference material to support material with ease. Review of the material in the program is provided through multiple answer questions. An incorrect answer leads the user to the opportunity to go back and review the relevant material or to continue. A correct answer is rewarded with positive feedback. Long-term memory skills are tested through the use of laboratory assignments linked to the computer-based lesson by having the student access the worksheet through a word-processing program and print out a copy to be completed in the lab and turned in for evaluation and feedback by the instructor.

The individual lessons are presented through the use of stacks that includes an introduction card for orientation and provides a means for student control over the lesson's direction. The lesson is self-paced, non-linear, and user-friendly. Self-pacing is achieved through the use of HyperCard as the authoring tool. Students are able to move at any given pace without timer restrictions. The non-linear aspect of the module is achieved through careful mapping and card linking that allows a student to move to any section of the module with a few mouse clicks. With proper design of

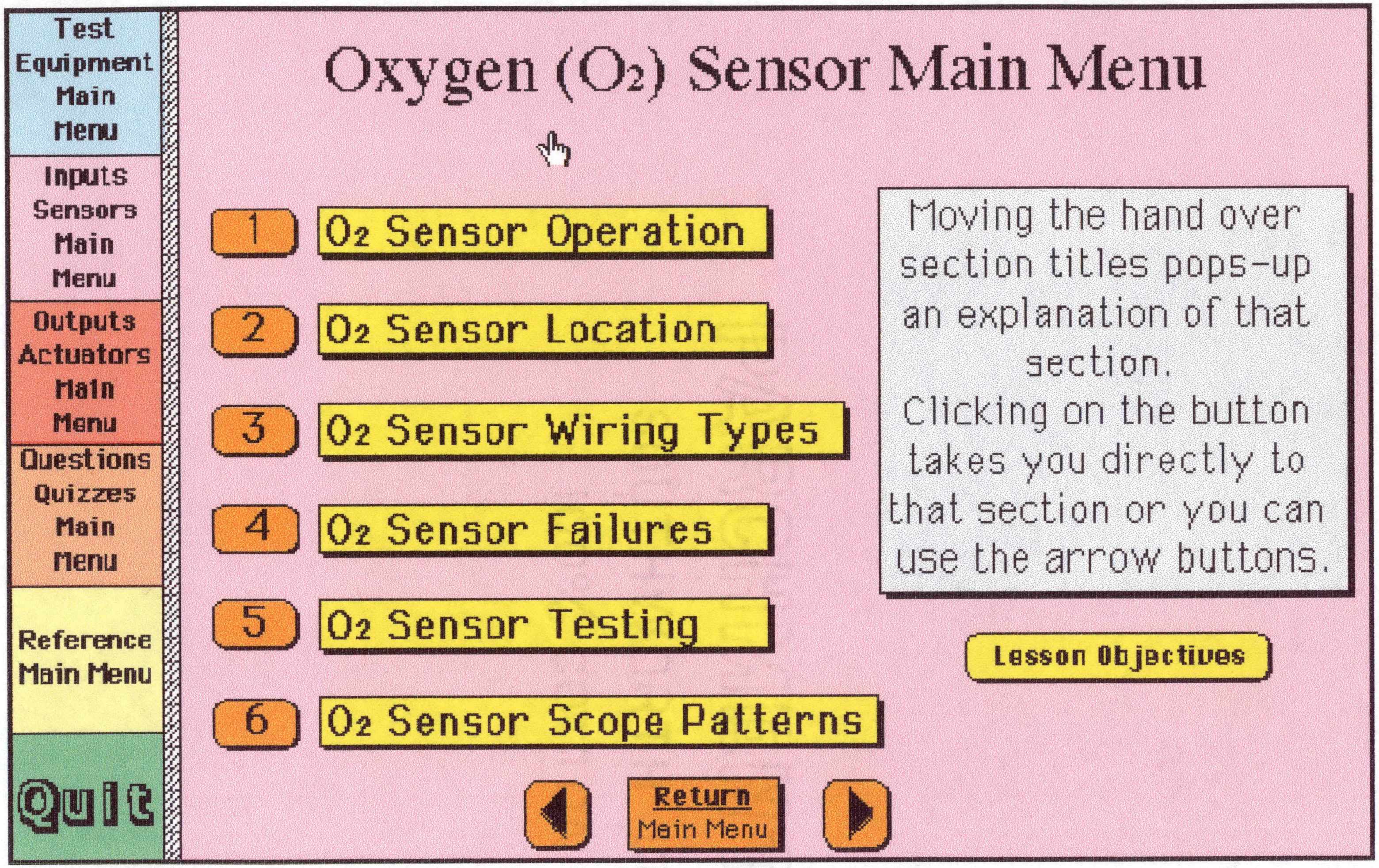

Figure 3. Oxygen Sensor Main Menu

buttons and card linkage the module is user-friendly and avoids frustrating the students and causing them to give up.

Screen Design

HyperCard version v2.3 is used as it provides for the incorporation of color into the cards and the placement of pictures saved as PICT files. This provides a substantial improvement over earlier versions of HyperCard that did not include color capability.

The use of color on the cards is purposeful. Each section of the program has a particular color associated with it: Test Equipment, blue; Inputs/Sensors, purple; Outputs/Actuators, red; Questions/Quizzes, orange; References, yellow; and Quit, green. This color theme is carried into the stack for each section. All cards in the Test Equipment stack have a blue background for example. Those in the Inputs/Sensors stack have a purple background. This gives the user a means of recognizing what section they are working in through the association with the colors. A complementing color is used for graphic backgrounds to provide contrast. Text is either shown on the background card color or more typically on a gray background.

The basic card design has main menu buttons located along the left side of each card. The card provides buttons on the bottom of the card for movement through any particular stack. There is extensive use of pop-up fields which provide information about various objects represented by artwork on the card. Main movement buttons are typically colored in orange or a simple arrow device is used (the use of various types of arrows has provided a means to test the effectiveness of each type).

The artwork on the cards are original drawings executed in Aldus SuperPaint 3.5 and imported to the HyperCard stack (Figure 4). HyperCard v2.3 allows the coloring of the these drawings once they are imported. Photographs incorporated into the program are original photos taken by the author and processed by Seattle Film Works. This processing includes providing the photos on disk, which allows importing to HyperCard. This is a multiple-step process that involves saving the picture as a PICT file, converting the picture to a GIF file with a graphic converter program, opening the picture up in ClarisWorks as a GIF file, performing any color changes, adding lettering or titles and then saving again as a PICT file. The final version can then be imported into the HyperCard stack where buttons or fields can be placed on top of the picture for navigation or informational purposes.

Navigational Design

The basic card design provides easy access to all parts of the program through menu buttons along the left side of the card (Figure 5). This allows flexibility in the way the program can be used by the learner. The card provides buttons on the bottom of the card for movement through the particular stack. These buttons can be used for basic linear progression or retreat through the stack, but students have the option of choosing one particular part of a stack through the main menu for each particular area (i.e. Oxygen Sensor Main Menu).

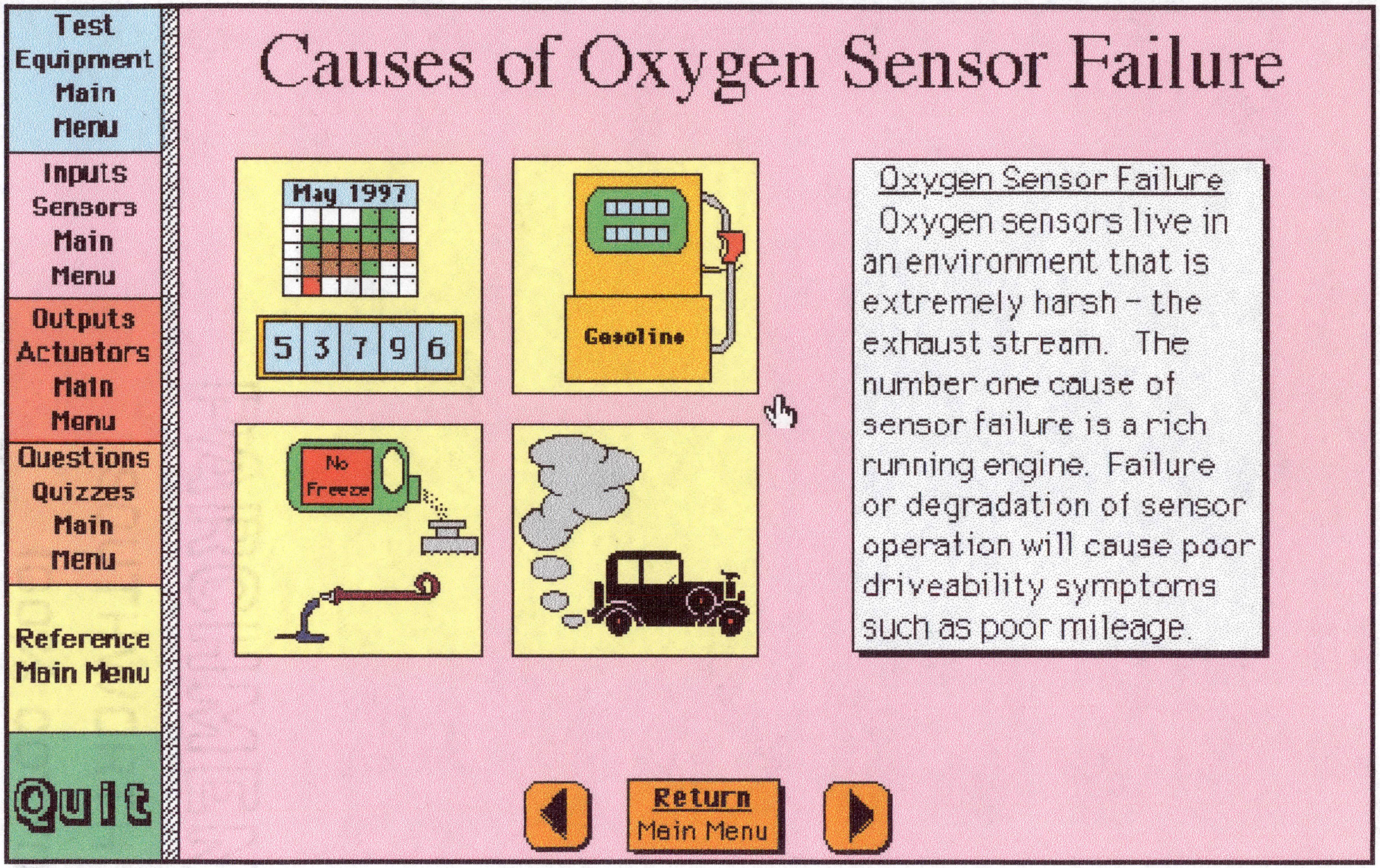

Figure 4. Oxygen Sensor Failures

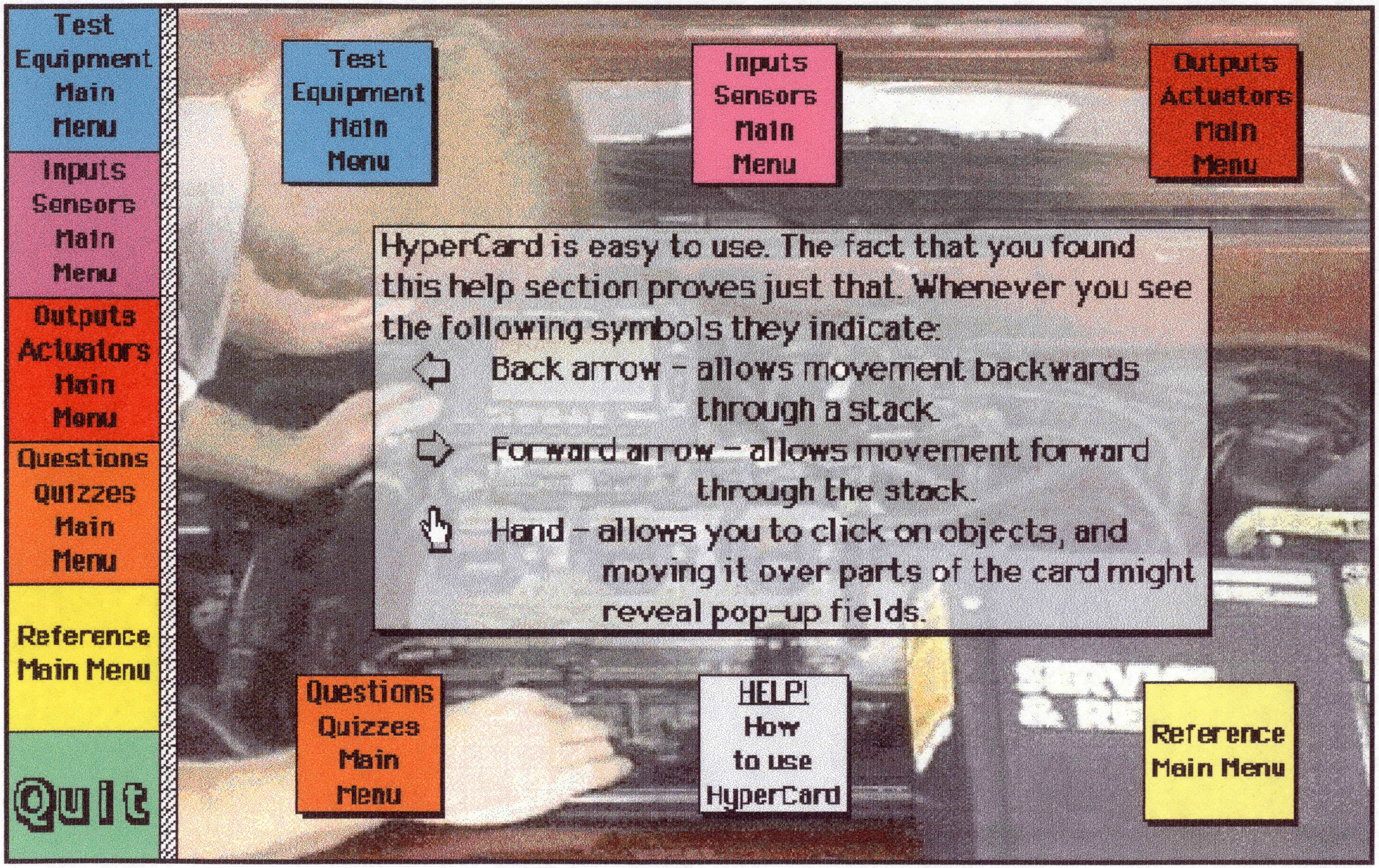

Figure 5. Title Card and Introduction

There is extensive use of pop-up fields which provide information about various objects represented by artwork on the card. ClickText is used to provide definitions to new terms or expressions. Main movement buttons are typically colored in orange or a simple arrow device is used (the use of various types of arrows has provided a means to test the effectiveness of each type).

Technological Requirements

The project is designed around the use of a PowerBook computer, therefore the card size is 640 by 400 pixels in size. This is the standard size for display on a PowerBook 10.5″ screen. This size card and display allows an instructor to use a PowerBook for classroom presentations (when connected to a projection device) or the use of any size monitor from 10.5″ and up. This provides a full range of use for both classroom presentation and computer labs for the students.

The specific hardware requirements for delivery of this program by an instructor in the classroom or use by an individual student includes the use of a Macintosh computer with a minimum of 16MB of RAM, adequate hard drive space for the program or the access to a Zip-drive, a 10″ or larger monitor, a projection system if the program will be used as a presentation tool, 66Mhz minimum speed, and HyperCard reader installed. The program in its initial development stages is not overly large, but further development will require the use of a CD-ROM or larger storage device for adequate use. The monitor requirements are a minimum of 10.5″ effective viewing area. A mouse is used for navigation purposes. At the end of a particular lesson the student is instructed to print out a worksheet to be used in the shop for practical application and evaluation of the lesson's effectiveness. This will require the proper software for the worksheet (i.e. WriteNow, SuperPaint, or MacWrite II) and a printer (preferably a laser printer).

Further development of the program requires the same basic hardware and software used for delivery purposes. Additional hardware or software requirements depends on the features that a developer would want to include in the program. To make use of video would require a video camera, video player and video editing machine. To convert to a format usable by the program would require the proper software to produce QuickTime movies. Additional pictures can be incorporated through the use of a variety of painting programs. Which one to use depends on personal availability and the programs ability to save an image as a PICT file. Inclusion of more sound requires recording and playback equipment, but HyperCard allows for easy incorporation of sound through the basic hardware and software that operates the program.

Formative Evaluation

The evaluation process used for this project included three separate means of testing its validity as a teaching tool. The process received approval from the Instructional Review Board of California State University in San Bernardino (see Appendix C).The first involved a group of college students in a classroom setting who were shown the computer program as it would used in the classroom presentation mood. Feedback was then solicited from the students on the effectiveness of the presentation. These students were chosen at random from a pool of students attending the Tune-up, Electrical, Fuel & Emissions class at Citrus College. The second group involved individual students from the same pool who were given the opportunity to try the program on a one-on-one basis. After each student used the program for 20 minutes they were interviewed for their perception on the effectiveness of the program as a learning tool, what they gained from the program and what they felt was lacking in the program. The last group who tested the program were automotive instructors at Citrus College who checked the program for technical errors.

Initial feedback from students in the first two groups provided interesting comments. The majority of the students felt the sound incorporated in the original was not needed. That it tended to take up time and became annoying after awhile. This was most evident in the classroom presentation group, where the sounds used interfered with the presentation timing. These sounds were subsequently removed. The sound retained in the program provides feedback during review sessions and came as pleasant surprises to the students and helped to retain interest in trying another section of the program.

The overall response from the students was positive in nature. Those students identified as needing the greatest amount of extra assistance in their automotive studies felt that the program did indeed provide another perspective and gave them the time to study the material for as long as required for retention of the material to take place. Since the majority of the students who evaluated the program had no previous experience with this type of program, it was new and exciting to them. But, as expected, once they began to explore they wanted more. Similar to the constantly changing landscape of automotive technology, this program will be a continuously evolving program. This means this program can never really be considered complete, but would have a new look each time it undergoes an update.

The evaluation for technical accuracy by associates in the automotive technology department provided helpful insights into the material presented. Though these insights were minor in nature (determination of proper composition of zirconium dioxide vs titania oxide in comparison to various technical sources) they were incorporated immediately and any expansion of the program would go through a similar review process to maintain its technical accuracy.

Strengths and Limitations of Project

The strengths of this project are the ease of use for students in accomplishing the stated objectives. This is achieved through a program design that concentrates on an in-depth lesson on a single subject (oxygen sensor) with support material (digital storage oscilloscope) and not on a quantity of material to fill up space. An in-depth approach provides a quality educational experience for the student, but creates the format for easy expansion of the program. The power of the project as a presentation tool for use in the classroom will provide the instructor will a means to present material in a timely manner, while maintaining instructional quality and interest. The possibility for easy expansion through the addition of linked stacks allows this project to grow with the instructor needs and the program requirements. The use of technology in education should be looked at as one more tool that should be used effectively, as a technician would use a wrench or a screwdriver, in the training of students for gainful employment in the automotive trade. This project is just another tool of many that makes use of technology to provide a more effective, efficient means of serving the needs of the students.

As an interactive program the project involves the student in their own learning while at the same time getting them involved in using computer technology. This not only provides a successful means of presenting material, but prepares these students for the future of the their chosen profession. Soon all technicians will have a computer in their service bay that they can use to access information, send messages to the factory or interact with a customer vehicle.

Limitations of the project start with the sections that will undergo further development. With a design that concentrated on an in-depth approach to a single subject matter left many sections at the initial stages of development. Further limitations of the project deal more with the lack of higher-end multimedia features that would further enhance the program. For example, the use of QuickTime movies to show the action of the "Check Engine" light would improve the end product.

The use of sound could be increased with the addition of more surprises as the student makes their way through the program. Additional sounds need to be original and will require production by the author of the program. Caution should be taken, however, not to distract users with too much sound. Also an increase in the use of pictures of actual objects would enhance the program. This requires copyright permissions or creating original source materials, made on location to fit the exact needs of the program. Sources for sound, pictures or movies related to the automotive field — applicable to this project — that are available royalty free do not exist at this time. Sound, graphic and video enhancement is possible as proven by the ability of this project's original features that exactly meet the needs of the learner. However, generous time allotments for such enhancements need to be committed to the project development process.

As for delivery methods, this project would serve the needs of a greater number of students if it could also be made available in an IBM compatible format as well as a Macintosh format. Multiple platforms would allow more students to take the program home for study. These limitations, though minor in scope, encompass the possibility of greatly improving the project. They also lead to recommendations for future projects.

Recommendations for Future Projects

Recommendations for future projects include the following thoughts and ideas:

1. Development of the remaining sections in the project in the same in-depth manner as the current program and supplement the reference material with the latest technical terms and information.
2. The inclusion of video interviews of actual technicians in the field and simulated problem solving such as animated and full 3D interaction that would allow students to zoom in and find components on a pictured vehicle and then connect a test instrument and access the results of the tests.
3. Adapting the program over to SuperCard or other software program that would allow presentation of the material on both Apple MacIntosh and IBM compatible machines.
4. Additional projects could be developed covering other areas in the automotive field. For example, engine rebuilding, brakes, or basic electrical theory.

APPENDIX A: Oxygen Sensor Worksheet

DSO O2 Sensor Testing Worksheet - Propane Method

Complete all the vehicle information in the spaces provided and perform the test per the checklist. Draw the resulting waveform in the space provided. Include appropriate voltage markings on left side of waveform.

Draw waveform result of test below	Vehicle Information	
	Year:	______________
	Make:	______________
	Engine:	______________
	Fuel Sys:	______________
	VIN:	______________
	PCM-PIN:	______________
	Status:	______________
	RPM:	______________
	Engine Temp:	______________
	Vacuum:	______________
	Mileage:	______________

Voltage Scale: ________ Time Scale: ________

- ❑ Connect propane bottle to a good vacuum source. (not the fuel pressure regulator or the MAP sensor hose)
- ❑ Let the engine idle. (<u>You must complete this test within 30 seconds to produce accurate amplitude and response time results</u>)
- ❑ Slowly add propane until the O2 sensor signal goes high, or rich.
- ❑ Keep adding propane slowly until the system loses its ability to compensate for the rich mixture. Continue to add propane until the engine speed drops a few hundred rpm. (<u>This richening procedure should take about 20-25 seconds</u>)
- ❑ Quickly pull the propane line off the vacuum source, to create a huge vacuum leak. (<u>If the engine dies, it is okay</u>)
- ❑ **<u>Turn propane bottle off</u>.**
- ❑ Wait until the drop in the waveform moves to about the center of the DSO display and press the RUN/HOLD button.
- ❑ Examine the waveform against sample provided and draw your waveform result in the space provided.
- ❑ Test parameter checklist:

  Maximum voltage (above 850mV) good ____ bad ____

  Minimum voltage (<150 mV, > 0 v) good ____ bad ____

  Maximum allowable response time (rich/lean) <100 ms, (between 300 mV and 600 mV = straight) good ____ bad ____

APPENDIX B: Program Disk