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Technology Education and Modular Labs

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The field of technology education is changing very rapidly. Nationally, more and more middle and secondary schools are converting traditional industrial arts programs to contemporary technology education programs. One of the major changes is the use of *modular* technology systems, also called modular technology education environments. Modular technology systems are now used in many of the middle and secondary technology education programs throughout the United States. These systems use self-contained modular units of technology instruction in the classroom. For example, a typical unit in the area of fluid power would include a modular unit that has a hydraulic trainer, hydraulic valves, gauges, hydraulic circuit boards, and various consumable supplies, tools, and accessories including the main computer and associated software.

Students complete various assignments throughout the modular unit and continue to advance to higher level content. Various modular units are available for middle and secondary school programs. Some of the more popular modular technology units include aerodynamics, computer problem solving, fiber optics, computer graphics, flight simulation, electronic music, robotics, CAD/CAM technology, fluid power, computer integrated manufacturing, satellite communications, desktop publishing, virtual reality, biotechnology, video editing, CO^2 raceway, space and rocketry, air-track vehicle, radio broadcasting, artificial intelligence, and weather satellite.

Although not completely matched, each unit of instruction within a modular program can be linked to the *Standards for Technological Literacy* (International Technology Education Association [ITEA], 2000). The module areas or content are also related to accepted technology themes that have been established within the National Council for the Accreditation of Teacher Education (NCATE) and Council for Technology Teacher Education's (CTTE) technology education specialty area guidelines (ITEA, 1997).

Modular technology systems guide the student to conceptualize, experiment, and examine the principles of the major content themes of transportation, communications, construction, and manufacturing. They also incorporate a multilevel curriculum that promotes the development of critical skills of teamwork, decision making, critical thinking, logical reasoning, troubleshooting, problem solving, independent research, and career exploration. Modular technology instruction helps students understand and assess the impact of technology on society today in order to make informed decisions about how they will use, manage, and even create technologies for the future.

Why Talk About Modular Instruction?

There are several reasons for this exposition on modular technology and modular environments. First, there are many instructional strategies that can be used in the technology education classroom. Modular environments are one of many instructional strategies that could be used by the contemporary technology teacher. Second, in the past several years, modular technology has become more and more popular in middle and high school classrooms. Today's newly prepared technology teachers may very well accept a teaching position in a school that has a modular environment. Also, there seems to be somewhat of a limited research base concerning modular technology classrooms. And finally, there appears to be a direct link between the use of modular technology as an instructional strategy and the incorporation of the Standards for Technological Literacy (ITEA, 2000) in the technology classroom.

Consequently, how modular environments work and operate is reviewed. How to better prepare teachers in the field of technology education to teach successfully and thus accomplish the goals of a modular technology education environment is discussed. Additional life skills learning opportunities other than technology content as well as some of the advantages and disadvantages of teaching in modular laboratories are described. Finally, how modular technology environments help to meet the Standards for Technological Literacy is reviewed.

Program Characteristics and Operation

The characteristics and operation of modular technology environments will vary considerably depending upon the school. Variations will occur in the level of the program, the length of program, the number of modules available to the students, the academic level of the students, the number of students in class, and how the course operates among other things.

Modular technology classrooms exist in Grades 6 to 12, but most are found at the 6 to 9 grade level. Although there is modular technology equipment for senior high school, it tends to be more technically in-depth and in such areas as manufacturing or information technology. There seems to be more interest and excitement about modular classrooms at the middle school level.

The number of modules that a school offers will vary. Generally, schools have anywhere from 3 to 16 or more modules available for student use. For example, middle schools in some states have from three to four modules. When schools have only a few modules, the course curriculum is often supplemented with various types of additional technology education strategies and activities. For example, if a particular school had a module on a CO^2 car, the instructor may develop additional activities that parallel the module in such topics as friction, engines, thrust, and manufacturing.

In other cases, middle schools may have from 10 to 24 modules for the students to use. For example, in California, modular technology programs are designed so that there is one module for each of the 16 state standards (Schwaller, 2001).

Another interesting component concerning the operation of modular technology classrooms is the use of a "student expert." In many modular classrooms the technology teacher uses a student expert to help during the classroom period. Usually, the student expert has taken the class the previous year and is already very knowledgeable about the modular units and topics. In many cases the teacher has worked with the administration to allow such students to leave other classes and help out in the modular technology classroom. These student experts can help when current students have a problem with a module or have difficulty understanding the directions on how to use a module. In general, student experts help the teacher whenever they are needed.

There are many other characteristics of modular technology classrooms that help to explain their operation. One characteristic is the number of modular technology classroom sections being taught. The number of sections that are being taught in schools may range from one to six sections. In some cases teachers are responsible for six sections with 25 to 35 students in each section. In other cases the technology education teacher may teach fewer sections but often there still may be approximately 25 students in a section.

Another characteristic of a modular technology classroom is the length of the semester for a modular course. Modular courses can vary from 15 to 18 weeks of time, and it is important to have the right number of modules in relationship to the length of the course. To this end, often the modular technology education teacher will set up a rotation for the students. The length of time that each student rotates from one module to another will vary from 2 to 10 days. The exact number of days of rotation will depend upon the length of the semester and the number of modules that are available.

Most modular technology teachers set days aside between each rotation. Called discover days, creative days, problem time days, enrichment days, or catch-up days, these extra days may vary from one day to several weeks of time. For example, schools that have fewer modules may have 7 to 10 discovery or creative days for the students to work on other technology activities. On the other hand, in schools that have a greater number of modules, the teacher may only give the students one or two days for discovery and creative time. These discovery or creative days are very important because they give time for the students to internalize the module concepts and knowledge, and students are able to try out the module concepts learned by using other technology instructional strategies such as competition, design projects, and problem-solving activities.

Some of the more popular module suppliers and vendors include Lab-Volt Systems, Synergistics, Depco, Learning Labs (Applied Technology), and Scan Tech. There are also teacher-created modules. Rather than evaluating the suppliers or vendors in this

article, those procuring modular technology equipment are encouraged to become thoroughly familiar with each product. Some of the variations between vendors and companies include:

- The depth of the software—Some companies design their software with more technical depth while other companies have less technical depth to the software.
- The levels within the software—Some companies have only one level of depth while other companies have up to three levels of depth with the third level being oriented toward creative design within the content of the module.
- The quality of the physical equipment—It is very important for teachers to be familiar with the quality of the physical equipment of the module. Some companies have high quality while other companies have less quality built into the physical equipment that supplements the software.
- The ability to alter or change the software—Some suppliers of modular equipment allow technology teachers to alter and adjust the software to their particular course needs and instructional techniques.

Each modular course often has its own title. Course titles can vary across the spectrum. Some common titles include Technology I, Technology II, Applied Technology, Exploring Science and Technology, Technology Education, Technology Applications, and Technology Design. It is important that the course title be appropriate for the particular school as well as act as a marketing tool to draw students to the course.

Teacher Competencies Needed

New teachers and experienced technology teachers should possess the necessary classroom management competencies to be successful in a modular environment. The following shows a list of the most common teacher competencies needed to function successfully in a modular environment.

Teachers must know the equipment. It would be very difficult to instruct in a modular technology environment if the teacher did not have a working knowledge of the modules. This can often be accomplished by having colleges and universities offer courses on modular technology in an undergraduate or graduate program. As part of this experience, future teachers come to know and understand the depth that is programmed into the software for each module. Knowing this can help the teacher better plan the modular technology program, including the extra activities and discovery and creative days. Also, part of the cost of purchasing a modular laboratory includes teacher training on the modules.

While classroom management is a competency all technology teachers should have, it takes on particular importance in a modular environment. The teacher must know how to manage a classroom with modular equipment and know how to keep all students challenged, on target, focused, and on task. The teacher must also know how to repair the equipment when broken and how to troubleshoot the software. When to add in the discovery or creative days, how to develop the creative activities, and how to keep each student challenged based upon the diversity within the classroom must also be managed. The management skills needed to teach modular technology tied with other instructional strategies help to develop an integrated learning system to teach technology.

Teachers who use modular technology must also be able to think in an interdisciplinary manner. Most of the modules that are sold today weave mathematics, reading, history, social studies, and science into the module software. This is especially true at the middle school level, where the modular technology teacher must have a "big" picture of technology. Modular technology at this level is very exploratory and not highly in-depth.

Computer literacy and program network competencies are also very important for modular teachers to possess. Since many of the companies that develop modular technology components use computers and networking for test-taking and grading purposes, these two competencies are very important. The teacher must be able to understand computer networks, troubleshoot problems in such systems, load software, and be comfortable with computer systems in general.

Teachers must also have a general knowledge in the technical area of each module. It is not necessary to have an in-depth technical knowledge in each of the module topics at the middle school level, but more

technical depth in the subject area of the modules would certainly be very helpful at the high school level.

The modular technology teacher must also have ability to repair the hardware of the module. As with any other type of laboratory situation, technology teachers are often called upon to repair the laboratory equipment. In this case, rather than repairing a production machine, the modular technology teacher may have to repair the physical hardware that is part of the module.

The teacher must also know how to get technical support quickly. In a modular environment, there are times when the teacher must contact the company or vendor for technical support, and often it is needed quickly. Thus, the teacher needs to have the ability to contact suppliers and vendors when a problem arises. If all the software, curriculum, and module equipment is obtained from the same company, repair of the modules and access to service personnel are greatly enhanced.

As with any other technology laboratory, the teacher must have an organized system for inventory control of the parts used on different modules. Depending upon the module, there may be different parts such as bolts, gears, valves, electrical components, weights, string, belts, and plastic stock that may be needed and which the instructor must organize as part of the inventory control system.

Lifelong Skills and Knowledge

Modular technology learning environments should include (a) the technology content delivered in a variety of instructional strategies and (b) modules representing a wide assortment of technology fields such as communications, construction, transportation, manufacturing, and bio-related systems. The modules should be designed to provide a contextual and relevant environment in which technical skills and knowledge and lifelong learning skills and knowledge are developed (Secretary's Commissionon Achieving Necessary Skills [SCANS], 1991). For example, since in all cases students work in groups, a great deal of cooperative learning is taking place and this helps to develop various social skills, including respect for and getting along with others. In the modular environment, students also learn how to be self-directed learners, a major skill for being successful in today's society. And time management skills, as part of self-directed learning, are also developed. These skills tend to develop an increased sense of responsibility within the students.

Other lifelong learning skills that may be developed in a typical modular laboratory include accountability (getting things done on time), staying on task (making sure to finish the module), computer literacy (familiarity with computer software), research skills (especially true in the high school modules), problem solving (students often must solve module problem by themselves), and respect of technological equipment.

Advantages

Modular learning systems have several advantages. The design of the software and its content allow students to see technology as a very broad field that ties directly to the *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000). There are several standards that deal with technology from a very broad point of view. For example, Standard 1, The Characteristics and Scope of Technology; Standard 2, The Core Concepts of Technology; and Standard 3, Relationships Among Technology and the Connections Between Technology and Other Fields all emphasize the broad nature of technology. Standards 4, 5, 6, and 7, which deal with Technology and Society, also emphasize the broad nature of technology.

Students also learn a variety of technical topics in the field of technology. Depending upon the number of modules, students can learn exploratory content in the areas of manufacturing, transportation, construction, communications, energy, and bio-technology, all of which are part of the Standards for Technological Literacy (ITEA, 2000)

Learning can also be more efficient in a modular laboratory environment as compared to the traditional laboratories. In a survey done by Schwaller (2001), teachers indicated that students could learn in one week what it took six weeks to learn before. One of the reasons for decreased learning time is that the software used in modules and the instructional strategies have been carefully and deliberately designed by technology education experts in the field.

Modular technology has a variety of other strengths. For example, there are always times

set aside for creativity in the discovery time, which students enjoy and learn a great deal. Also, the creative or discovery time gives students the ability to try out new concepts just learned in the module. It should be noted that the teacher must facilitate this creative or discovery time very carefully. Such time should not be "down time," but a time in which the student can engage in higher order thinking skills concerning the content of the module. What is said about creative or discovery time in modular technology instruction also applies to other excellent instructional strategies that should be integrated.

That parents are often impressed with modular learning environments is another advantage. When parents enter a laboratory during parent/teacher conferences, for example, they see that technology instruction is much broader than previously thought. This can change the parents' perception concerning their definition of technology education to a positive and contemporary image.

Software and network systems in some modular technology classrooms use the computer to select student groups. This allows the teacher to be objective about how groups are selected, which in turn encourages collaborative work as well as group dynamics skills.

Limitations

As with any existing technology education program, there are also limitations. Equipment breakdown is probably the biggest limitation of modular technology. This is true whether it be a traditional, contemporary, or modular technology laboratory. When equipment breaks down or a module is no longer usable, this causes a serious change in the organizational structure and management of the course. Since the students are on a rotation, it becomes necessary for the teacher to readjust the rotation when a module fails. In many cases, however, a teacher will plan for this by having one or two additional modules to help offset the problem.

Another limitation when using a modular environment concerns the discovery days. Without the discovery days, students tend to become bored with the continuing process of rotating from one module to another. We must remember that modular technology is not designed to do all the teaching. It must be an integrated system. The teacher must still be a facilitator and design meaningful creative and discovery times for the students. As already indicated, some schools maximize the creative and discovery times and use modules to supplement the discovery days.

If the modular laboratory is equipped with modules from several vendors, the teacher must learn the software depth, equipment, and operation of each company's products. Among other things, this means more preparation time for the teacher before the class begins.

When grouping students (usually two students per module), there may be a limitation if the students are at different academic levels. For example, if an academically bright student is paired with an academically slower student, the brighter student might be held back while the slower student might learn more. On the other hand, this type of problem causes students to develop leadership and social skills as well. Often this type of grouping occurs in the real world and, thus, can be used as an advantage for the academically brighter student.

Other limitations deserve mention:

- There needs to be continued administrative support from the school district including additional money to keep the module software up-to-date.
- The average costs of a modular laboratory will range from $80,000 to $125,000. Although this may appear to be a disadvantage, there seems to be little problem getting the administrative support for such a classroom.
- There needs to be improved follow-up in the senior high school. Often there is not an articulated system for students moving from the middle school to the high school. However, some vendors have developed more in-depth modules and more problem-solving exercises and activities to help offset this problem.

Modular Technology and the Standards for Technological Literacy

I predict that the *Standards for Technological Literacy; Content for the Study of Technology* (ITEA, 2000) will change the field of technology education dramatically. This is also true with any type of instructional strategy. Schwaller (2001) conducted a survey to determine the relationship between modular technology instruction at the middle school and the Standards for Technological Literacy. This survey tapped the opinions of 20 modular

technology teachers regarding the amount of learning taking place in reference to the Standards for Technological Literacy. Using a bi-polar scale from 1 to 5, with 5 representing *a great deal of learning in their classroom* and 1 representing *no learning in their classroom,* each teacher was asked to respond to a 20-question survey. To aid the teacher in this process, the question was asked how much learning is taking place (in their opinion) concerning each of the Standards for Technological Literacy. The results are shown in Table 1.

Although not without problems, modular technology continues to expand into more and more middle schools throughout the United States. The survey results and other professional experiences suggest:

- Modular classrooms and environments work well if used as one of many instructional strategies in the classroom.
- Modular systems should be considered an integrated system. It should not be considered the one and only way to teach technology education.
- Before teachers are placed in modular classrooms they need to be trained and

Table 1. Relationship of Modular Technology to the Standards

NATURE OF TECHNOLOGY	
Standard 1 — The characteristics and scope of technology	3.90
Standard 2 — The core concepts of technology	3.30
Standard 3 — The relationship among technology and the connections between technology and other fields	4.45
Standard 3 was high because the software in each module deals with math, science, etc., as well as technology.	
TECHNOLOGY AND SOCIETY	
Standard 4 — The cultural, social, economic, and political effects of technology	3.10
Standard 5 — The effects of technology on the environment	3.80
Some laboratories had environmental module topics.	
Standard 6 — The role of society in the development and use of technology	3.70
Standard 7 — The influence of technology on history	4.15
In most cases, each module started with historical information about the specific topic being addressed.	
DESIGN	
Standard 8 — The attributes of design	4.45
Standard 9 — Engineering design	4.15
Standard 10 — The role of troubleshooting, research and development, invention, innovation, and experimentation in problem solving	4.30
Concerning Standards 8, 9, and 10, since many of the modules allow the students to design and test a product, these three standards were rated very high.	
ABILITIES FOR A TECHNOLOGICAL WORLD	
Standard 11 — Apply the design process	4.20
Standard 12 — Use and maintain technological products and systems	4.10
Standard 13 — Assess the impact of products and systems	3.40
Standard 13 was rated a bit lower than other design standards because often the module didn't go far enough in assessment of the product that was designed.	
THE DESIGNED WORLD	
Standard 14 — Medical technology	1.80
Standard 15 — Agricultural and related biotechnologies	2.80
Standard 16 — Energy and power technologies	4.50
Standard 17 — Information and communications technologies	4.60
Standard 18 — Transportation technologies	4.25
Standard 19 — Manufacturing technologies	4.80
Standard 20 — Construction technologies	4.00
Ratings within the designed world in most cases were higher because there were complete modules that were related to Standards 16 to 20.	

prepared correctly to be successful.
- Many additional lifelong learning skills can be developed in most modular classrooms.
- Modular classrooms help to meet many of the Standards for Technological Literacy (ITEA, 2000).
- Modular equipment seems to be the biggest concern for many teachers in terms of keeping the equipment in good working order and up-to-date.

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