AN EXAMINATION OF A HIGH SCHOOL HORTICULTURE CURRICULUM PROCESS DESIGNED FOR DIVERSE STUDENT LEARNING STYLES

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ABSTRACT

Educators have been confronted with the problem of presenting subject matter to students with varied learning styles, abilities, interests and goals. A study of related literature revealed a widespread indication of student diversity. Upon closer examination, it was determined that student diversity also existed in Utah secondary horticulture classes. A research project was conducted that explored the answer to the question of whether these students would benefit by expanding the curriculum to accommodate those differences. As part of the research project, a plant science curriculum that addresses student diversity was developed and implemented. The objective was to test whether the students had an increased motivation to learn as they accessed the curriculum according to their preferred learning modalities and individual interests. Qualitative analysis was accomplished through the use of pre-testing, surveys of both student participants and professional educators, and case studies. Student choice in course content teaching methodologies used was found to be a positive motivational factor in learning

INTRODUCTION

In typically diverse classrooms, teachers face the challenge of presenting their subject matter to an assortment of pupils. Students are unique individuals with differing learning styles, abilities, interests, vocational goals and post-secondary educational plans. Some might be mainstreamed special education students, while others may be gifted and talented. Students have preferred modes of learning, such as auditory, visual, tactile, or kinesthetic. Some students have already chosen their future vocation, while others have not yet identified personal strengths, which would lead them to a vocational choice.

Teachers are often unaware of the diversity in their classrooms and therefore do not address students' learning needs. According to Green (1999), if teachers do not address this individuality, the students will be stressed, low-motivated, and perform poorly. As a result, some will struggle in school and not reach their potential (Martin & Potter, 1998).

Students with diverse abilities and interests enroll in high school horticulture courses, which encompass a blend of vocational and science course objectives. How can teachers accommodate such student variety and engage them in learning course content? Teachers can incorporate differentiating instruction methods, assignments, and forms of assessment to meet the learning needs and interests of diverse student populations. The objective is to motivate students to learn as they access the curriculum through their preferred learning modalities and their individual interests.

REVIEW OF LITERATURE

As teachers learn about the variety of abilities and interests represented in their classrooms, then the need for diversifying curriculum will become more apparent (Johnson, 1997). The following review of literature discusses varied learning styles, individual abilities, vocational and educational interests and goals, and an investigation of the theory of choice as a motivational factor in the learning process.

Varied Learning Styles

Traditional agricultural science teaching methods such as lecture and textbook reading assignments fail to address the learning needs of many students (Bol & Strange, 1996). This type of instruction involves low-level rote practice, merely a measure of the ability to memorize and recall science facts rather than to understand and apply concepts to life (Kruse, 1998). Rote learning can eventually lead to long-term memory storage, although students usually hold the information only long enough to pass a test, and then dump it out of memory (Sousa, 1998). Students skilled in receiving and processing visual and auditory information experience greater success in traditional classes than those who need tactile, kinesthetic, or other sensory stimulation to aid learning.

The various ways in which people learn best are referred to as *learning styles*. Information is received and processed by the brain of each individual uniquely (Dunn, 1995; Martin & Potter, 1998). Dunn defined learning styles as the manners in which information is received, processed, absorbed, remembered, and applied. These assimilation tactics have been described by several educational researchers. The Dunn and Dunn Learning Style Model (Dunn, Griggs, Olson, Gorman & Beasley, 1995) described learning styles as "a biological and developmental set of personal characteristics that makes identical instructional environments, methods, and resources effective for some learners and ineffective for others" (p. 353).

Dunn (1995) studied one of the more common classification schemes separating learning styles into four basic categories: visual, auditory, tactile, and kinesthetic. Visual learners perceive information best through the sense of sight, whereas auditory learners need to hear the information for successful perception. Tactile learners require the sense of touch through hands-on activities; kinesthetic learners prefer to move their bodies when processing information, as they learn by doing. Dunn found that most children are tactile and kinesthetic learners.

A learning theory that incorporates the whole body was developed by Gardner (1993), who divided learning styles into seven intelligences or skills; logical-mathematical, linguistic, spatial, musical, bodily-kinesthetic, interpersonal, and intrapersonal. Learning is a body-mind activity (Kovalik & Olsen, 1998) that is enhanced through sensory engagement (Kruse, 1998; Sousa, 1998). When teachers use sensory activities, then tactile and kinesthetic learners have greater access to learning opportunities (Bell, 1998; Sousa, 1998). Green (1999) reported that the human brain responds better to enriched learning environments than to single-modal environments. Studies by Druyan (1997) found that kinesthetic experience cultivates cognitive development and helps learners reconstruct misconceptions. As the five senses are employed in hands-on activities, learning is engaged for students with a wide variety of learning styles (Druyan, 1997; Green, 1999).

The human brain learns most efficiently when all of its main functions are part of the learning experience. Clark (1988) asserted that intelligence requires integration of the rational cognitive, spatial cognitive, emotional, physical or sensing function, and intuitive thinking brain functions. The affiliation of these brain functions creates higher levels of intelligence and optimal development of student potential.

Several brain functions can be effectively integrated into the learning process through school activities, including laboratory experiences. Laboratory experiences provide students with hands-on practice to explore academic concepts. Instead of simply demonstrating lessons, teachers who offer students the opportunity to work with manipulatives facilitate comprehension for tactile and kinesthetic learners (Colburn & Echevarria, 1999). Laboratory activities also give students the chance to practice professional skills in the context of agricultural science (Ellis, 1999). Students develop clearer understanding of agricultural science through experimentation with tangible objects, rather than simply reading about concepts or listening to a lecture.

Students with many different learning styles and abilities may be included in a single heterogeneous class (Nunley, 1996; Tomlinson, 1995). How can all of these different student learning needs be adequately addressed through only one or two teaching strategies? Campbell and Burton (1994) recommended that educators need to address student differences in order to provide equal opportunity to access learning experiences. The challenge for teachers is to differentiate teaching strategies to meet the needs of a diverse class.

Varied Abilities

Most classes contain learners of mixed abilities, including students who are enrolled in Advanced Placement courses or with a high grade point average, students with disabilities, students whose primary language is not English, and students who are unmotivated, often all sharing the same classroom and teacher. Student learners in each of these various categories will learn best in different ways.

Alexakos (2001) developed five teaching strategies to address the varied abilities of students in inclusive school environments.

1. Integrate a multi-sensory approach to enhance understanding.

2. Encourage student collaboration to master course concepts.
3. Provide authentic assessment and high expectations for each individual.
4. Incorporate a method of teaching concepts by breaking them down into small pieces, then relating each piece of information to the larger picture of past knowledge.
5. Create a nurturing and supportive learning environment.

Dunn stated that gifted students are often tactile and kinesthetic learners who also have the ability to learn through visual and auditory means, if needed (Dunn, 1995). However, low-achieving tactile and kinesthetic learners can only master difficult information by using their preferred modalities (Shaughnessy, 1998). When students are taught through their preferred perceptual preferences, they remember significantly more than through other strategies. Dunn emphasized that it does not matter how someone learns, but that learning occurs.

A common challenge for teachers is to differentiate instruction for diverse student needs in a mixed-ability classroom. There is no single learning template for a typical heterogeneous class. The one-size-fits-all model of instruction does not meet all students' needs (Tomlinson, 1995). Schools must change traditional teaching strategies in order to prepare students of all ability levels to be adequately productive and adaptive in the new millennium (Marshall, 1998).

Varied Vocational and Educational Interests and Goals

Professional educators are also faced with the challenge of teaching students with a variety of vocational and educational interests and goals (Hollenbeck, 1991). Teachers can focus on students' individual interests and varied goals through the development of a training program for each student and integration of real world applications. Unique talents and interests can be employed through the use of real-world applications of science concepts.

One example of this is a case in which seven Nevada science teachers guided hundreds of students through research projects on water-use issues of students' choice in the Desert Southwest (Ebert and Strudler, 1996). These students designed multimedia presentations using computers and Hyper Studio programs to display their own research findings. Interest in science increased, technological abilities and self-esteem increased, and students took charge of their own learning.

Another example of real-world application of agricultural science concepts is teacher use of the Global Learning and Observations to Benefit the Environment (GLOBE) program (Singletary & Jordan, 1996) as an expansion of classroom education. The GLOBE program extends school learning to the world. Diverse students learn about science concepts through topics of individual interest. They choose their own research project, collect data from the field and submit it on the Internet. Scientists then analyze it and publish the collected data from school children internationally on the World Wide Web. GLOBE experiences integrate classroom instruction with technology, data collection and analysis, bringing real-world relevancy to science concepts in areas that engage student interests.

There are other ways that teachers can focus on students' individual interests and goals. Ellibee (1990) promoted agricultural education programs that conform to the needs of the student, rather than the student conforming to the program. An agricultural education program in Colorado developed a computer program that enabled teachers to construct a training program for each student, depending on occupational objective (Hollenbeck, 1991).

The key to successful programs is awareness of individual needs and integration of vocational skill education as students gain occupational preparation through relevant learning experiences. Successful agricultural education programs can offer such learning experiences by providing a curriculum that is interesting and meets a broad range of students' personal and career interests (Sutphin, 1990). Multifaceted programs furnish preparation for college and careers, develop life skills, and offer placement opportunities for high school graduates. The Genesee Area Skill Center in Michigan enrolls horticulture students with diverse backgrounds and abilities (Koontz, 1990). Classroom and hands-on training is received at the school and at businesses in the community through co-op, work experience and apprenticeships. Skilled entry-level employees are produced from the program and approximately 40% of their graduates go on to college.

Educators at Chino Valley High School in Arizona have also demonstrated the value of diversification in agricultural education (Morgan & Henry, 1991). The curriculum has built competence by successful exposure to various areas of agriculture. Small-scale facilities on campus allow students to operate agribusiness enterprises with greenhouses, mechanics facility, nursery, vegetable garden, and an aquaculture facility. Active participation instills capitalistic principles that prepare young people to build a strong economy in the future.

Choice–A Motivating Factor

To differentiate classroom instruction for diverse student interests, Tomlinson (1995) suggested offering students a variety of assignment options and activities. Variety in a student-centered classroom may provide learning opportunities for many individuals. The following are examples of several different teaching strategies that can be employed.

Several science teachers in Utah have been observed by this researchers to address student diversity by offering choices in learning opportunities. Hinton, at Riverton High School, and Eyring, at Juan Diego Catholic High School, guided students using discovery and inquiry learning with student-designed lab experiments in cooperative learning groups. Carrascillo-Gomez, at Riverton High School, taught students about cell organelles by having them design their own three dimensional model of a cell created from their choice of materials. Wolfe, at Mt. Ogden Middle School, implemented several teaching strategies, such as collaborative learning activities, hands-on labs, copying lecture notes, question and answer periods, and science show and tell sessions. Johnson, at South Ogden Middle School, used assignment options as learning tools and presented the same concept in several different ways. Students chose how they wanted to learn the concepts independently and were in control of their own grades. The 1998-1999 Utah State Science Core test scores for these students averaged 73%, while the district average was 62%, illustrating the success of this teaching style.

Nunley and Johnson, at Grainger High School, offered assignment options in a layered curriculum, to differentiate instruction for diverse students. A layered curriculum is one in which the students choose their unit grade according to how many assignments they complete. When questioned, 93% of students in differentiated classes of Nunley and Johnson responded that they preferred those types of classes over traditional 'lecture and textbook' classes and felt that having a choice was a major motivational factor. They indicated assignment choices were harder, but they learned more because they chose how they wanted to learn. Students enjoyed the autonomy to choose how they wanted to learn concepts and the opportunity to control their own grades by seeing the rubric criteria in advance. The seven percent of students who preferred traditional instruction were visual and auditory learners, and were more comfortable with a 'lecture and textbook' type of class because it fit their learning style.

Bohince (1996) and her students found that learning was more engaging when the teacher became the assistant and the students assumed the main role of responsibility in class activities and projects. She stated that student-directed projects are the key to keeping students involved. Students planned their projects based on learning objectives and grading rubrics, then conducted the project themselves, guided by the teacher when needed. Bohince found that this method stimulated learning by implementing motivational oriented content.

PURPOSE AND OBJECTIVES

The literature revealed teaching strategies to address the diversity of student populations. This study of student diversity grew into the development of this research project. Assuming that diversity of interests, abilities and learning styles exists in student populations, as the literature suggests, the following research question was explored. Would the students benefit by expanding the curriculum to accommodate that diversity? The search for the answer to this question became the basis of this research project. The purposes of the project were fourfold:

a. To determine whether student choice in the manner in which course content is learned would be a positive motivational factor in learning, when compared to no choice in the manner in which course content is learned.
b. To develop a diversified curriculum that accommodates for varied student vocational interests, learning styles and abilities.
c. To receive, by survey response, student assessment of the benefits and problems of diversifying the curriculum.
d. To receive, by survey response from Utah's horticulture educators, professional assessment regarding the possible benefits and problems of the diversified curriculum.

METHODS/PROCEDURES

This project was conducted with the morning and the afternoon Horticulture classes at an applied technology center in an urban area of the Intermountain West, beginning on September 17, 2001 and ending on October 30, 2001.

Each of the two classes met daily for approximately 2 ½ hours. Students completed a questionnaire to choose a course learning track (basic, advanced, or vocational), as well as to identify vocational interests, purpose for enrolling in the course, horticulture background, and previous science courses. All three curriculum tracks accommodated diverse student learning styles; namely visual, auditory, tactile, and kinesthetic. Of the 14 students in this study, 6 chose the basic track, 4 chose the advanced track and 4 chose the vocational track.

Curriculum Implementation

The plant science unit was taught during the first five weeks of this project according to the varied learning tracks chosen by the students. This was followed by a two-week non-choice section of the unit, in which all of the students were taught the same material utilizing the same instructional methodologies, with no diversification.

To implement the teaching of the diverse learning tracks portion of the project, the 1994 Utah State Office of Education plant science curriculum was expanded to offer a scientific as well as vocational study of plants from the atomic level through taxonomy, physiology and ecology. Students were taught basic plant science lessons collectively in the classroom, and then divided into cooperative learning groups depending on track choice with varying assignments, experiments and assessments. These were conducted in the classroom, in the greenhouse and outdoors.

Grading for the course was organized on a point system with all students responsible for equal numbers of points for the different daily assignments. In this manner, all students were held equally responsible for course content, even though the students had different abilities, learning styles, and chosen learning tracks. As described below, this curriculum style was designed to avoid penalizing basic students for not keeping up with advanced students, restricting advanced students from learning more or boring vocational students with uninteresting material.

Students who chose the basic horticulture track were first taught fundamental plant science lessons in the classroom with the rest of the students. They then applied that knowledge through hands-on labs, experiments, worksheets, and other simplified learning activities.

Those students who chose the advanced horticulture track entered the course having already acquired a basic understanding of horticulture knowledge and desired a deeper conceptual understanding. They expanded their study of each topic by studying the text, *Botany* (Moore, Clark, and Vodopich, 1998), answering chapter questions in written or oral form, conducting lab experiments, and exploring concepts through advanced activities.

Students who chose the vocational track were taught basic plant science lessons along with the rest of the class, but also experienced additional course individualization. Lesson assignments led these students to study applications of plant science in light of their particular vocational interests. Outcomes are discussed in the results section of this document.

Evaluation

Evaluation of the effectiveness of this enhanced curriculum was accomplished through pre-testing instruments and qualitative post-testing. Before the study began, all students were administered a series of tests by a third party assessment coordinator. The pre-evaluations included:

1. National Association of Secondary School Principals (NASSP) Learning Styles Profile
2. SRA Reading Index 12
3. California Occupational Preference System (COPS) Interest Inventory
4. Student interest questionnaire.

These evaluations served to determine whether diversity existed among study participants and what array of abilities, learning styles, preferences, vocational goals, post-high school educational goals and other related interests were present. The presence of student diversity established a need for varying the curriculum.

During the study students were tested on course content understanding through a variety of assessment tools to access diverse learning modalities. Types of assessments included, but were not limited to, paper and pencil tests, performance assessments, games, oral and written reports, lab reports, oral questioning, and visual identification.

Qualitative post-evaluations of the effect of diversifying horticulture curriculum were in the form of a student survey, a teacher survey and case studies. The student survey asked study participants for responses regarding the personal interest-oriented course choices, opinions of curriculum, and how it did or did not assist them in learning the course material. The teacher survey was sent on-line to all horticulture instructors in Utah to evaluate the new curriculum, based on their professional teaching experience. Two case study subjects were selected from the student population. Results from these case studies were evaluated and summarized. The following section contains a report of the data from these evaluations.

RESULTS

The preliminary teacher survey, pre-test instruments, student survey, post-project teacher survey and case studies are described below. The purposes of these instruments were to establish whether or not student diversity existed among the study participants and to obtain qualitative evaluation of the effectiveness of the project.

Preliminary Teacher Survey

In an effort to narrow the field in the investigation of how to address student diversity, a closer study ensued to determine whether individuals with varied abilities, learning styles and interests enroll in Utah secondary horticulture courses.

In June, 2001, 10 Utah horticulture instructors were surveyed to identify student variability for the 2000-2001 school year. When asked what types of varied abilities their students had, teachers responded that 17% of their students were also enrolled in a special education program, 22% were gifted, and the balance were spread between the two. When asked about learning styles, nine out of ten teachers responded that more than 50% of their students were tactile and kinesthetic learners. One responded that most students were tactile and visual learners. When asked why students enrolled in their horticulture courses, the primary reasons were that the students enjoyed working with plants and fresh flowers and desired an enjoyable class, they needed the vocational or science credit offered by these classes to graduate from high school, or they wanted to learn more in-depth botany information in preparation for college. Teachers reported that 20% or less of their students had chosen a specific career path in the field of horticulture, such as florist, landscape designer or nursery manager and needed guidance to prepare them for pursuing their chosen vocations. Influence from parents and peers were an additional enrollment factor. The teachers surveyed also clearly indicated that the reported figures were typical of each yearly student population.

Pre-test Instruments

To determine whether student diversity existed among the 14 study subjects, they were administered several pre-test evaluations. The students completed a questionnaire, on which they indicated their vocations of interest. Diverse vocational interests were indicated, as 4 students expressed primary interest in greenhouse management, 6 students were interested in floral design, 4 students indicated interest in landscape design, and a few students marked other categories as secondary interests, such as botany, landscape installation and nursery management. The students were also asked about their science background and all but 2 of the students responded that they had previously taken biology and other science classes.

A third party assessment coordinator determined learning styles, reading ability, and occupational interests tested all study participants. All four basic learning styles and combinations of such were identified in the student population, namely visual, auditory, tactile, and kinesthetic. Students showed a range of reading abilities and one even began receiving remedial reading assistance at the school. The COPS Interest Interview identified 11 out of 12 possible areas of vocational interest by these students. These tests were administered before the start of the plant science unit instruction to establish a base of diversity among the students.

Student Survey

At the conclusion of the research study, the participant students were asked to respond to a survey containing 19 questions regarding their experiences with both the learning tracks section and the non-choice section of the plant science unit. Research topics of interest included learning styles, academic abilities, vocational interests, and motivation.

In the first part of the survey students were asked to state their preferred learning style, which was identified from the results of the NASSP Learning Styles Profile. The reported learning styles included visual, auditory, tactile, kinesthetic, and combinations of these styles. Students were asked whether their academic abilities were accommodated and all but one responded positively. When asked whether this part of the unit addressed their particular vocational interest, 93% responded that it did. Students were also asked to describe how motivated they were to learn the course material; 86% responded that they were somewhat to very motivated to learn, while 14% responded that they were not as motivated to learn. When asked if there was anything they disliked about the learning tracks section of the unit, 71% stated there was not. The others complained about long lessons or the other groups' activities.

The second part of the student survey addressed the non-choice section of the unit. When asked whether their academic abilities were accommodated in this section, 79% responded positively and 21% responded negatively. When asked if this part of the unit addressed their particular vocational interests; 71% stated that it did and 29% stated that it did not. Students were asked to describe how motivated they were to learn the course material; 71% responded that they were somewhat to very motivated to learn and 29% responded that they were not as motivated to learn. When asked if they preferred to work with the whole class on the same assignments and labs, 29% replied that they did and 71% replied that they preferred small learning groups instead of working with the whole class.

Study participants were asked to compare the two sections with each other and state their preference and reasons; 71% preferred the learning tracks section and working in separate learning groups and 29% preferred working with the whole class. Those who preferred the learning tracks section generally felt that it met the needs and ability levels of all students. Those preferring to work together in the non-choice section generally felt that it was less intimidating whereas their lack of ability was not as readily identified as in the learning tracks section.

Teacher Survey

In addition to surveying the student study participants at the conclusion of the research study, 13 horticulture teachers throughout the State of Utah received six sample lesson plans to review and respond to by survey. Responses were received from 10 of those teachers, reflecting a response rate of 77% for tabulation in this study. The sample lesson plans were selected through the use of a scientific systematic sampling method, in which every fifth lesson plan in the population was selected for review. Teachers estimated the percentages of students in their horticulture classes that might also be enrolled in the special education program, classified as gifted, or those that favor differing learning styles. Additionally, they were asked whether their students had the same or different vocational interests or reasons for enrolling in the classes. The responses to these survey questions established whether or not a basis of diversity existed among their student populations.

Utah horticulture teachers were asked whether other types of student diversity existed in their classrooms also. When asked about other forms of diversity, 100% of the teachers reported that their students had differing vocational interests, 80% reported that they had differing reasons for taking the horticulture class, 10% reported that all students enrolled for an easy “A” grade, and 10% reported that students needed the class for graduation credit. All respondents felt that this type of curriculum would work in other academic disciplines.

Teachers commented on the benefits, student outcomes and possible problems that could be perceived from possible implementation of this curriculum. A full 100% of the responding teachers felt that this type of curriculum would be beneficial to their students and that it would accommodate many aspects of student diversity. Responses regarding possible benefits included: individual students’ interests would be more fulfilled, students’ varying abilities would be accommodated, and this curriculum would address the needs of tactile and kinesthetic learners, as well as the non-college bound students. Possible problems with implementing a diversified curriculum identified by the teachers included: the large amount of preparation time required, discipline problems while trying to keep all students on-task, lack of student ambition, the difficulty of supervising three different student group activities simultaneously, and managing large class sizes of 28 to 40 students. When asked whether the benefits would outweigh any management problems, 60% said yes and 40% said no.

Case Studies

Two students were chosen for case study analysis to examine the effects of diversifying curriculum based. These two students were both very interested in plants, both scored in the 97th percentile on the SRA Reading Index 12, received the same instruction in the same class, and were on the same advanced learning track. The difference was found in their interest and experience in science. One student (referred to here as Tina) was not as interested in the details of science principles and had limited science background before this class because science was a minor part of her home school curriculum. The other student (referred to here as Tom) was very interested in science and had taken many science classes previously.

The advanced students were assigned to read chapters in an advanced placement botany textbook and write answers to two thought questions from the chapter as homework in advance of corresponding lessons in the classroom. These two students following the daily lessons for the advanced track activity often conducted scientific labs from the associated lab manual.

On the third day of the learning tracks section of the plant science unit Tina said that she was not able to understand the textbook because she lacked the science background necessary for adequate comprehension. In addition, she was not very interested in the material, so she lacked the motivation necessary to apply the effort required to understand the book. She was close to changing from the advanced track to the basic track. Tina remained on the advanced track after accommodations were made by allowing her to browse through the textbook, conducting an oral discussion instead of written answers to the textbook thought questions, and a daily choice of participating with the advanced group or the basic group activities. Throughout the plant science unit, Tom read the botany textbook prior to each corresponding class lesson and participated in the advanced class activities.

DISCUSSION OF THE RESULTS

A review of the literature showed several teaching strategies to address the diversity among student populations nationally. Professional educators and researchers have shared their experiences and suggested strategies that address the variety of student learning styles, individual abilities, vocational interests, and educational goals. Further investigation in Utah schools showed evidence of student diversity in science and horticulture classrooms and teaching strategies to address the needs of those students. Given the evidence that student diversity commonly existed, as the literature and studies displayed, an answer was sought to the question of whether students would benefit by expanding a plant science curriculum to accommodate that diversity. Original research was developed to find an answer to that question. The ideas gleaned from a study of the literature and from surveys of local student populations guided the development of this research project.

A plant science curriculum was expanded to allow for student diversity by allowing students to choose between basic, advanced and vocational learning tracks with differing activities for each track. Students experienced learning course content with their choice of learning track and without their choice of learning track. Students expressed their assessment of the benefits and problems of curriculum diversification on a survey at the culmination of the study. Horticulture teachers throughout the state were also given a survey and asked to evaluate sample lesson plans from this curriculum and evaluate the possible benefits and problems of implementing this curriculum. Two students were observed for the purpose of a case study analysis to examine the effects of diversifying curriculum for individual needs.

The pre-test instruments indicated that the students had varying vocational interests, science background, horticulture experience, academic abilities, learning styles, and choice of learning track. This established a basis of diversity among the study participants. The results of the student survey showed that the expanded curriculum addressed most of the students' varied vocational interests, most students were motivated to learn, and it was enjoyed by most of the students. Most students preferred the learning tracks section because they had a choice of learning options instead of no choice of learning options.

Utah horticulture teachers surveyed expressed that student diversity existed in their classrooms also. Most of the teachers felt that this type of curriculum would be beneficial to their students and that it would accommodate many aspects of student diversity. Possible management problems were expressed, such as classroom discipline, difficulty supervising and implementing several activities simultaneously, and dealing with large class sizes. Many teachers felt that this type of curriculum might be possible with some modifications for their particular situations.

The case studies showed two students with many similarities, but personal differences in science background and interest affected the way they were able to access the curriculum. At the end of the study, Tina reported that she was more motivated to learn because she was not forced to learn in a certain way and that she appreciated the accommodations made for her. She liked the basic labs better than the advanced labs because the information was more understandable. The advanced track contained too much information for this student, and she was unprepared to assimilate it adequately. At the end of the study, Tom stated that he was more motivated to learn the material because a greater amount and depth of information and learning activities were available to him on the advanced track than with other tracks. This student loved science, was thirsty for learning, was able to fill his need for knowledge, and remained enthused and engaged.

Tina and Tom were both good readers, participated in the same class discussion, on the same advanced learning track, with the same amount of information at hand, but responded to the curriculum in different ways based on their science backgrounds and interest in the material. By allowing them choices and learning options, their educational needs were accommodated and they both learned the concepts successfully.

This study showed that addressing the diversity of student populations by providing learning options, accommodations and attention to individual needs was a positive motivational factor in learning and was preferred by most students.

Recommendations

After creating and implementing the expanded plant science curriculum, the researchers have several observations and recommendations for the future. Even with small classes, managing three different student activities simultaneously was very difficult, especially while also creating new curriculum. Managing a diverse curriculum with large class sizes would probably be even more difficult to manage. As experience was gained in the process of teaching the plant science unit, more effective management techniques were gradually developed and successfully implemented. Further curriculum refinement would be beneficial to offer a more manageable product for large class sizes.

Future applications of this type of curriculum may be more successful if the curriculum is developed prior to beginning the unit of study. Management difficulties would be reduced by offering variations of the same lab or activity, instead of three separate activities with differing supplies and instructions.

An important recommendation for teachers is to remain open-minded about how students choose to learn and how they learn best in differing ways. By allowing options and student creativity in testing, labs, assignments, and other educational formats, students learn in their own ways. The objective sought after is that all students learn.

After teaching this expanded unit of plant science, it is recommended that the order of lessons and the unit length be altered. In addition, it is recommended that the main textbook for the advanced track be changed from *Botany* (Moore, Clark & Vodopich, 1998) to *Introductory Plant Biology* (Stern, 1997). Plant science texts appropriate for the basic and vocational horticulture tracks would also be beneficial so that these students, too, would have the opportunity to preview the lesson content before it is taught.

The final recommendation is to extend this type of curriculum expansion to as many other disciplines as possible to allow greater motivation and learning accommodations for students throughout their varied courses of study.

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