Teaching University-Level Technology Students via the Learning Preferences and Problem-Solving Approach.

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Abstract

This article focuses on how technology educators can challenge students to "think" about technical problems. A key aspect of success in quality problem solving is understanding learning preferences and problem-solving approaches. The Learning Style Inventory (LSI) can be used to assess an individual's ideal way to learn, in essence, a person's learning preference (Kolb, 1984). It also can be beneficial to understand how students approach problems. The Kirton Adaption-Innovation Inventory (KAI) can be used to measure an individual's problem-solving approach (Kirton, 1999). The purpose of this study was to determine the most effective way to teach university-level technology students to solve problems, according to their learning preferences and problem-solving approaches. The results of the study indicated that a majority of the technology students had a combination of learning preferences. The next highest percent and frequency of the students' learning preferences was accommodating. In addition, the students in this study were both adaptive and innovative in their problem-solving approaches. One way to effectively teach problem solving to university-level technology students is to form teams of students whose members have differing learning preferences and approaches. Moreover, educators can provide learning activities that address the phases of the learning cycle and the ways in which students like to approach problems.

Introduction

The ever-changing technical work environment requires students to think fast and solve complex global problems. It is estimated that the root of problems in many organizations is a result of ineffective thinking (Wiele, 1998). Employers depend on technology educators to develop quality thinkers. Technology educators aim to give students a "high tech" education. This "high tech" education often means skills in computer-aided drafting, robotics, telecommunications, and quality assurance tools. However, are educators challenging students to "think" about technical problems? Starkweather (1997) argued that educators teach students to use equipment, but they often fail to teach technical problem solving, which is a higher order thinking skill. Williams (2001) agreed, acknowledging that teachers should focus on how to think rather than what to think. Each individual has a preference to his or her thinking. The Learning Style Inventory (LSI) can be used to assess an individual's ideal way to learn, in essence, his or her learning preference (Kolb, 1984). Another measure of thinking is the way in which students approach problems. The Kirton Adaption-Innovation Inventory (KAI) can be used to assess a person's approach to solving problems (Kirton, 2000). Understanding learning preferences and problem- solving approaches can help students to become quality thinkers and problem solvers. Currently, there is little research on learning preferences and problem-solving approaches among university-level technology students.

Purpose of the Study

The purpose of this study was to determine the most effective way to teach university-level technology students problem solving according to their learning preferences and problem-solving approaches. In order for students to make the most of their education, understanding their learning preference and approach to problem solving is essential. The research questions for this study are as follows:

1. What is the learning preference of technology students enrolled in an Industrial Engineering Department at a Midwestern university?

2. What is the problem-solving approach of technology students enrolled in an Industrial Engineering Department at a Midwestern university?

3. What is the most effective way to teach university-level technology students problem solving based on their preferences and approaches?

The data gathered in this study can help students and educators understand problem solving and the way in which they prefer to learn and approach problems. The results of this study may influence the way in which educators teach university-level technology students to solve problems both inside and outside of the classroom.

Review of Literature

Learning style or preference is defined as the manner in which an individual prefers to learn. There has been a variety of learning style models, such as field independent/dependent (Messick, 1976), holist-analytical and verbal-imaginer (Riding & Cheema, 1991), Three-layer Onion Model (Curry, 1983), the LSI by Kolb (1984), the Productivity Environmental Preference Survey (PEPS), Price (1996) and Fleming and Mills' (1992) Visual, Aural, Read/write, and Kinesthetic (VARK). Learning style is considered separate from ability and has been widely researched in the educational setting. Price (2004) explained that learning styles are self-reported accounts of an individuals' preferences for and perceptions of how they process information. In other words, learning styles predict the way in which learners want to learn and solve problems. One of the most used instruments in an educational setting is the LSI, which was used in this research.

Learning Style Inventory

Kolb (2007) observed that individuals learn in different ways and understanding one's own preference of learning can be beneficial in problem solving. Kolb (1984) created the LSI to assess an individual's preference to learning. One of the purposes of the LSI is to serve as an educational tool to increase individuals' understanding of the process of learning and his/her unique individual preference to learning. Another purpose of the LSI is to provide a research tool for investigating experiential learning and the characteristics of individual learning preferences. The scores on the LSI determine one of the four learning modes:

- Concrete/Experience (CE): likes to learn from specific experiences, relating to people, and is sensitive to feeling and people.
- Reflective/Observation (RO): likes to learn by reflecting; carefully observes before making judgments, views issues from different perspectives, and looks for the meaning of things.
- Abstract/Conceptualization (AC): likes to learn by thinking; analyzes ideas logically, plans systematically, and acts on the intellectual understanding of a situation.
- Active/Experimentation (AE): likes to learn by doing; shows the ability to get things done, takes risks, and influences people through action (Kolb, 2007, p. 5).

Each of these learning modes creates the four phases of the learning cycle. When technology students cycle through the four phases, effective learning takes place. The four phases formulate an individual's learning preference. The four learning preferences follow:

- Diverging – combining experiencing and reflecting (CE & RO) learning preferences.
- Assimilating – combining reflecting and thinking (RO & AC) learning preferences.
- Converging – combining thinking and doing (AC & CE) learning preferences.
- Accommodating -- combining doing and experiencing (AE & CE) learning preferences-Figure 1 provides characteristics of each of the learning preferences (Kolb, 2007, p. 10).

Research shows that individuals who choose careers in science, technology, engineering, and math (STEM) tend to have converging and assimilating learning preferences (Kolb, 2007). Threeton and Walter (2009) found that post-secondary automotive technology students tended to have accommodating and converging learning preferences, indicating that students in

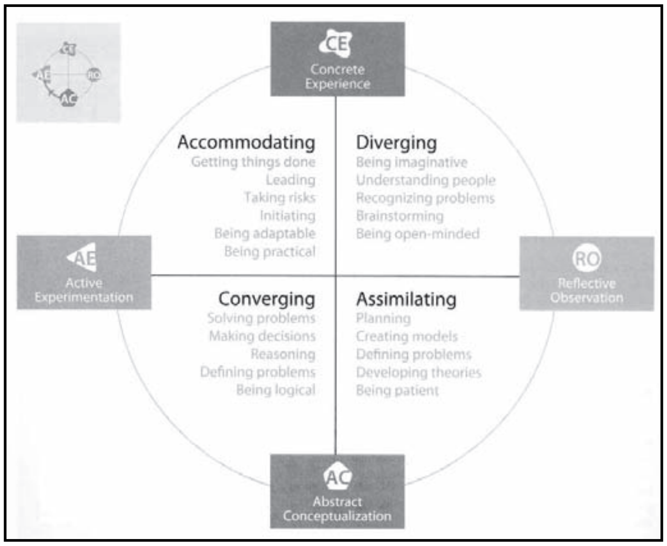

Figure 1. Learning preferences.

the study preferred hands-on activity and the practical use of ideas and theories. All of the learning preferences were represented in their study. In addition, a study using the PEPS found that teaching students according to their learning style does influence their learning. Similarly, all of these learning styles were represented in a recent study of the effectiveness of instructional methods based on learning style preferences of agricultural students conducted by Fazarro, Pannkuk, Pavelock & Hubbard (2009). Each learning preference has strengths in the problem- solving process. This research seeks to determine the learning preferences of university-level technology students.

Problem-Solving Approach

Technological problem solving involves higher order thinking and is a critical survival skill in today's progressive work environment. Government, business, vocational, and technology education leaders have increasingly called for more emphasis in the classroom on higher order thinking. Ernst (2009) agreed that higher order thinking and problem solving are essential for the technology professional and described technology students as perceiving themselves to be highly capable in their problem-solving ability. Furthermore, problem solving has been identified and promoted by many disciplines, including STEM. Technology students in particular need to be proficient in technical problem solving. Students have different abilities and approaches when solving problems. Students with the same ability can approach problems in different ways. Problem solving approaches are consistent, however, there are individual differences in the ways people prefer to move toward new ideas, manage change, and respond effectively to complex, open-ended opportunities and challenges. Olowa (2009) acknowledged that teaching students how to seek their own strategies and answers to problems rather than teaching students to memorize facts about the problem was an effective technique in enhancing problem solving. According to Adaption-Innovation (A-I) theory, individuals manage problems differently depending on their approach (Kirton, 2000). A-I is not considered a level of behavior. Behavior has several outside factors and approach is just one aspect considered at play. This research will focus on the approach that university-level students take when dealing with problems, not on problem-solving ability.

The KAI was created to measure the problem-solving approach of individuals (Kirton, 1999). The KAI places individuals on a continuum with extreme innovators at one end and extreme adaptors at the other end. The KAI score is not a dichotomy; there are no pure adaptors or innovators. There is no preferred score. Individuals can be classified as more adaptive or less adaptive and more innovative or less innovative, so scores need to be viewed in relation to the population mean or other individuals. The population mean is 95. Individuals with KAI scores that ranged from 32-95 were considered relatively adaptive, and individuals with scores that ranged from 96-160 were considered relatively innovative (see Table 1).

Kirton (2000) observed that differences in problem-solving approaches produced distinctive patterns of behaviors (see Table 2).

Table 1. Population Distribution of KAI Scores.

Innovators		Adaptors
96-110	Mild	95-80
111-124	Medium	79-65
125-139	High	64-50
140 or more	Very high	49 or less

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Occupations that tend to possess more adaptive individuals include plant and production managers, technical engineers, and programmers. This study aims to determine the learning preferences and problem-solving approaches of university-level technology students.

Methodology

This study included 95 students enrolled in the Industrial and Engineering Department at Southeast Missouri State University in the fall of 2008. The researchers selected five classes for the study. Class 1 (n = 15); class 2 (n = 9); class 3 (n = 24); class 4 (n = 36); and class 5 (n = 11). The majors of the participating students included construction management, interior design, technical graphics, industrial education, manufacturing technology, engineering technology, and telecommunications. Four students with undecided majors were included in the data. The study was approved by the University Research Involving Humans Subjects Committee.

Table 2. Characteristics of Adaptors and Innovators.

The Adaptor	The Innovator
Characterized by precision, reliability, efficiency, methodicalness, prudence, discipline, conformity.	Seen as undisciplined, thinking, tangentially approaching task from unsuspected angles.
Concerned with resolving residual problems thrown up by the current paradigm.	Could be said to search for problems and alternative avenues of solution, cutting across current paradigms.
Seeks solutions to problem in tried and understood ways.	Queries problems' concomitant assumptions: manipulates problems.
Reduces problem by improvement and greater efficiency, with maximum of continuity and stability.	Is a catalyst to settled groups, irreverent of their consensual views; seen as abrasive, creating dissonance.
Seen as sound, conforming, safe, dependable.	Seen as unsound, impractical; often shocks his opposite.
Liable to make goals of means.	In pursuit of goals, treats accepted means with little regard.

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Instruments

All participants were asked to complete the LSI and the KAI. The researchers administered and scored the instruments in two class sessions in the third and fourth week of the fall semester of 2008.

The Learning Style Inventory. The Learning Style Inventory (LSI) is a statistically reliable and valid 12-item assessment tool, developed by Kolb (1984). Subjects rank their preferences on each question from 1 to 4, with 1 being the least way they like to learn and 4 being the best way they like to learn. From the rankings, a total score was calculated.

Kirton Adaption-Innovation Inventory. The KAI is described as a self-reporting 33-item questionnaire with scores ranging from 32-160 (Kirton, 1999). The KAI asks the student the degree of difficulty (very hard to very easy) it would be for him or her to maintain the statement consistently over a long time.

Results

The purpose of this study was to determine the most effective way to teach university- level technology students problem solving according to their learning preferences and problem approaches.

> ***Results of research question 1:*** *What is the learning preference of technology students enrolled in an Industrial Engineering Department at a Midwestern university?*

Of the 95 students who participated in the study, 70 students successfully completed the LSI for a 74% response rate. Forty-nine males and 21 females, ranging in age from 18-50, participated in the study. Table 3 displays the participants LSI mode scores.

A majority of the participants in this study had combination learning preferences. The next highest percent and frequency of the students learning preferences was accommodating.

Table 3. LSI Mean and Standard Deviation Mode Scores of Technology Students.

	Mean	SD
Abstract/Conceptualization (AC)	29.18	6.50
Concrete/Experience (CE)	29.86	8.86
Active/Experimentation (AE)	31.30	8.99
Reflective/Observation (RO)	30.46	6.84

Table 4. Learning Preference Frequency and Percentages of Technology Students.

	Frequency	Percentage
Diverging	8	11
Assimilating	8	11
Converging	5	7
Accommodating	12	17
Combination	37	54
Total	70	100

The results indicated that the technology students in this study majoring in technology fields did not correspond with converging and assimilating learning preferences typical in STEM fields.

Results of research question 2: *What is the problem-solving approach of technology students enrolled in an Industrial Engineering Department at a Midwestern university?*

Of the initial 95 students asked to participate in the study, 81 successfully completed the KAI for an 85% response rate. Twenty females and 61 males, ranging from the age of 18-50, participated. The KAI scores ranged from 66-133 (see Table 5).

The mean score of the technology students was 96, which is close to the population mean of 95. In addition, this study is consistent with the scores for engineering and technology careers, which typically range between 95 and 97.

Results of Research Question 3: *What is the most effective way to teach university-level technology students problem solving based on their preferences and approaches?*

Table 5. KAI Scores.

	N	Range	Mean Score	Stand. Dev.
Adaptive	41	66-95	86	8.22
Innovative	40	96-133	106	7.98
Total	81	66-133	96	12.8

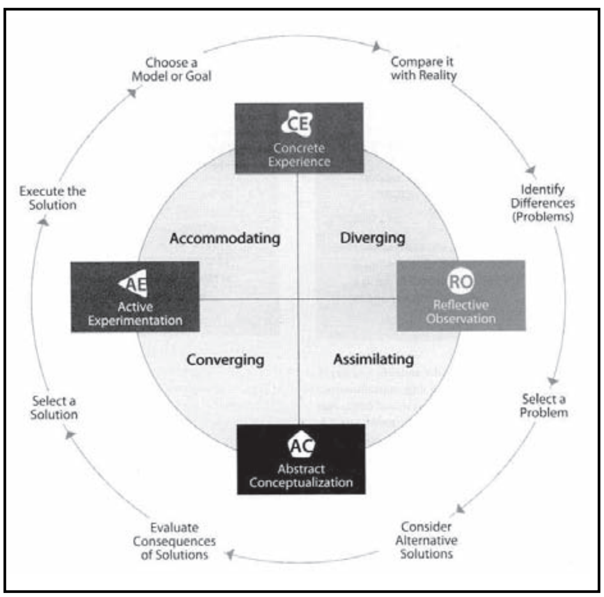

Figure 2. Learning preferences and the problem solving process.

Problem solving and learning preferences.

The strengths of a student's learning preferences influence his or her problem solving skills (see Figure 2). Figure 2 shows a modified problem-solving model and links the steps of the problem-solving model to learning preferences. For example, diverging preferences may prefer and excel at problem identification; assimilating preferences at problem selection and seeking alternatives; converging preferences at problem evaluation and selections; and accommodating preferences at problem evaluation and execution. The most effective way to teach problem solving may be to make sure that the students' cycle through the learning preference phases and are put in teams with students who vary in their learning preferences.

The technology students in this study were more accommodating, indicating that they would be most successful in evaluating and implementing the problem. A majority of the technology students in this study has combination learning preferences, signifying that they may excel at problem solving because they cycle through the learning phases.

In terms of education in general, diverging learning preferences prefer to look at situations from different perspectives and like to develop alternative possibilities; assimilating preferences tend to look at a large framework of ideas and integrate information into theories or models; converging preferences enjoy gathering information to solve problems and like to bring ideas together; and accommodating preferences tend to put ideas into action and adapt to changing circumstances. The majority of technology student in this study had a combining or balancing learning preference, indicating that they may be comfortable with a variety of learning modes.

Problem solving and problem-solving approach.

The problem-solving approach also influences students' problem-solving skills. Adaptors prefer their problems to be associated with more structure, often using the rules to stay within the current paradigm. Innovators, in contrast, prefer solving problems with less structure and tend to abandon the current paradigm. Table 6 shows the characteristics of adaptor and innovators in problem solving.

The technology students in this study were both adaptive and innovative, indicating that if partnered with someone with the opposite

Table 6. Characteristics of Adaptors and Innovators in Problem Solving.

The Adaptor	The Innovator
Tend to accept the problems as defined with any generally agreed constraints.	Tend to reject generally accepted perception of problems and redefine it.
Generally, early resolutions of problems, limiting disruption and immediate increased efficiency are important to them.	Tend to be less concerned with immediate efficiency, looking to possible long-term gains.
Prefer to generate a few relevant and acceptable solutions aimed at "doing things better."	Prefer to produce numerous ideas, some of which may not appear relevant or be acceptable to others.
Typically have easy solutions to implement.	Typically solutions result in "doing things differently."

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approach, they would be successful in problem solving. Again the most effective way to teach problem solving to technology students may be to team students with individuals who use different problem-solving approaches, so the strengths of the approaches can prevail. In terms of education in general, adaptors prefer well-established lesson plans and like to go in depth in the lesson. Innovators, on the other hand, prefer less structure. They like to learn a breadth of information.

Discussion & Implication

Employers rely on technology educators to develop and promote technical problem-solving skills in students. Problem solving is a vital component of most careers, especially those in technical fields. Wiele (1998), Williams (2001), Starkweather (1997), and many others have pointed out the importance of being able to successfully solve problems. Previous studies show that individuals in STEM fields tend to have converging and assimilating learning preferences. The results of this study did not yield similar outcomes as the previous studies. The technology students in this study had combination learning preferences followed by accommodating, indicating that students who had combination learning preferences tended to work through the learning phases and progress through the problem-solving cycle. Accommodating students like to get things done and tend to enjoy leading, taking risks, initiating, being adaptable, and being practical in solving problems. As educators, if we understand the learning preferences of students, we can better equip them with the skills to solve problems and to work with and learn from others who have different learning preferences. Threeton and Walter (2009) caution educators to not rely on one teaching technique to reach the diverse learning preferences of technology students. They recommended adopting various instructional techniques and activities to educate students. It is also critical that students understand their own learning preferences. Many students do not have a firm grasp on how they prefer to learn. Students who know and understand their learning preferences may be able to better focus on their strengths and address their weaknesses when solving problems. Students who have a combined learning preference may also be able to better relate to and understand other preferences and therefore excel in problem-solving teams. In addition to learning preferences, an understanding of approaches to problem solving can affect technology students.

The approach, as measured by the KAI, of the studied technology students was typical of the population mean. The technology students in this study were a combination of adaptive and innovative in their approach to problem solving. This variation might reflect the diversity of the students. Having a good balance between innovative and adaptive approaches often provides a well- balanced approach toward various technical problems. Research has shown that students pursuing degrees in STEM areas tend to be more adaptive. This study contradicted previous studies revealing that the technology students in this study tended to be a combination of adaptive and innovative. For educators, understanding KAI can aid in lesson planning, because adaptors are more apt to prefer a step-by-step procedure for doing an assignment and innovators would prefer to have a process. Understanding KAI may also help with interpersonal conflict associated with team assignments and projects. Educators would be able to better accommodate students and better formulate teams consisting of different approaches. In addition, if the students and educators were aware of their approach to problem solving, they could be more efficient by focusing on their strengths or developing areas they are not as comfortable with. Furthermore, educators can provide learning activities that address the phases of the learning cycle and ways in which students like to approach problems.

Conclusions

The purposes of this study were to determine university-level technology students' learning preferences, problem-solving approach, and the most effective way to educate technology students' to solve problems based on their preferences and approaches. Students enrolled in the Industrial and Engineering Department completed the LSI and the KAI to assess their learning preference and problem-solving approach. The 70 students who completed the LSI had very close mode (AC, CE, AE, and RO) scores. Most technology students in this study had a combination learning preference with the next highest percentage an accommodating preference. Eighty-one of the students completed the KAI with a mean score of 96. This score is consistent with the population mean. The technology students in this study were a combination of adaptive and innovative and not typical of individuals in STEM fields.

Technology educators and students alike will benefit from knowing and understanding their learning preferences and problem solving approaches. Knowing and exposing students to the various preferences and approaches could make them better problem solvers and more adaptable to diverse situations. Even with the emphasis that is placed on problem solving, researchers know relatively little about the process, how to measure it, and how to best prepare students to be efficient and effective technical problem solvers. More research is needed on teaching problem solving that focuses on and isolates components and preferences of the problem-solving process. Additionally, more research needs to be conducted on the development of technical problem-solving teams formed in accordance to learning preferences and approaches to problem solving.

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