Technological and Personal Problem Solving Styles: Is there a Difference?

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Introduction

Problem solving, and technological problem solving in particular, is clearly a critical survival skill in our technologically advanced world. Government, business, vocational and technology education leaders have increasingly called for more emphasis on higher-order thinking skills and problem solving in both general and technological areas. The American technology education profession has identified problem solving as *the* technological method (Savage & Sterry, 1990). Authors outside technology education have also suggested that both general and technology teachers would be well advised to focus on enhancing problem solving skills. Given this, the authors sought to examine several key aspects of problem solving in more depth. Of these, the first was problem solving style. Problem-solving style is defined as a tendency to respond in a certain way while addressing problems and *not* as the steps employed in actually solving the problem. It has been operationally defined by Heppner (1988) in terms of three distinct dimensions which can be measured by the Problem Solving Inventory (PSI). Collectively, these dimensions (problem-solving confidence, approach/avoidance, and personal control) comprise problem-solving style.

Although many educators claim to address problem solving, if the increasing frequency of mention in the literature is to be believed, the portion of citizens who have developed adequate problem solving capabilities is insufficient. It is no coincidence that this inadequacy is occurring at the same time when our society is experiencing a decrease in technological literacy. This problem is all the more critical given that the pace of technological growth is escalating (Dyrenfurth, 1991; Johnson, 1989).

For over twenty years, psychologists have focused on real-life, applied problem solving (e.g., Folkman & Lazarus, 1980; Heppner, Hibel, Neal, Weinstein, & Rabinowitz, 1982). Investigators have attached various labels to the applied problem solving process including: interpersonal cognitive problem solving (Spivack, Platt, & Shure, 1976); personal problem solving (Heppner & Petersen, 1982); social problem solving (D’Zurilla & Nezu, 1982), and coping

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(Coyne, Aldwin, & Lazarus, 1981). However, because of the ambiguity of these terms, one challenge is to distinguish between the various types of problems. Problem solving is a critical process skill that involves virtually all aspects of existence. It is clear that problems of various types exist and that not all problems are technological. Furthermore, problem solving has been identified and promoted by many disciplines including mathematics, psychology, the physical sciences, the arts, and more. In different contexts, and in unique ways, all employ the problem solving process.

The linguistic and conceptual challenge is apparent. The term, *problem solving* has evolved into a generic construction that covers a wide range of different types of activity. For example, the *problems* of an alcoholic besieged with numerous financial, marital, and personal difficulties share little common ground with the *problems* that a design engineer encounters when designing ways to safely dispose of hazardous waste. It is clear that the well-structured problem presented to the chess master is something quite different from the problems facing a diplomat, a psychological counselor, or a local police department. Problem solving is frequently used in an imprecise and undisciplined manner to encompass numerous activities that are substantially different in type, focus, and intent.

Given this, and given our profession's focus on technology, the following question can be posed, How can technological problems be distinguished from other types of problems? Custer (in press) has developed a conceptual framework for making this distinction as well as for structuring technological problem solving into its various types (e.g., design, trouble-shooting, development, technical procedures, etc.). However, by and large the literature revealed relatively little that focused on the contrast of technological and personal problem solving. Given this lack of precision and the focus of technology education on problem solving, this study attempted to clarify some of these distinctions along one potentially key dimension, "problem solving style." A methodology and findings will be described indicating that differences exist between personal and technological problem when these were examined from the perspective of problem solving style.

Purpose of the Study

The purpose of this study was to better understand the problem solving style dimension of problem solving. Our goal was to explore whether technological problem solving is similar to, or different from, personal forms of problem solving.

We compared the problem solving styles (personal and technological) of a group of university students with a high inclination to and involvement with technology to those with minimal inclination to and involvement with technology. The intent was to ascertain whether there were significant differences among the groups with respect to their problem solving styles. Differences among these groups would provide insight into the nature of problem solving and provide empirical evidence that technological problem solving is distinct from other forms of problem solving or at least possesses some distinct features.

Research Questions

The study’s research questions were:

1. Do distinctly different types of university students exhibit significant differences in their styles of personal and technological problem solving?
2. Do students from different academic majors and with different demographic characteristics exhibit significant differences in personal and technological problem solving styles?
3. Can differences in technological and personal problem solving be inferred on the basis of problem solving style?

Method

While problem solving has many dimensions, and therefore could be approached in different ways (e.g., the steps or procedures used, the situation’s characteristics, the solver's traits, etc.), this study focused on problem solving styles. Building on Heppner's (1988) work, this study was designed to explore the relationships among selected factors that could be expected to affect problem solving (personal and technological) styles in different ways.

Design and Variables

The study employed a quasi pre-test and post-test approach (Campbell & Stanley, 1969) (see Figure 1). Three different treatment groups were used. Each received the treatment (i.e., the curricula and teaching methods employed by each program) characteristic of their own discipline. Freshman and senior samples were drawn at the same point in time in a cross-sectional approach that assumed equivalent groups.

The dependent variables were personal and technological problem solving styles as measured by the Personal Problem Solving Inventory (PSI-PSYCH) (Heppner, 1988). This instrument was specifically adapted to measure technological problem solving style (PSI-TECH). The Problem Solving Inventory (PSI-PSYCH) reflects an individual's awareness and evaluation of his/her personal problem solving style and thus provides a global self-appraisal of that individual's ability to cope with personal problems. The technological version (PSI-TECH) examines perceived efficacy with technological problems. The PSI contains three subscales (Heppner, 1988): Problem solving Confidence ["…self-assurance while engaging in problem-solving activities" (p. 1)]; Approach/Avoidance ["…a general tendency of individuals to approach or avoid problem-solving activities" (p. 2)]; and Personal Control ["…the extent to which individuals believe that they are in control of their emotions and behavior while solving problems" (p. 2)].

Because previous conceptual and empirical studies of personal problem solving (Heppner & Petersen, 1982) have validated these three dimensions of style, they were selected as the dependent variables in the study. On close examination, Heppner's three-dimensional construct appears to apply well to technological problem solving. For example, the concept of self confidence would appear to affect one's ability to successfully solve a design problem just as much as self confidence affects the ability to solve a personal difficulty. The same can be said of the approach/avoidance and personal control dimensions. The technological versions of the instrument provided a means of examining the same subscales in relation to technological problem solving.

Type of Students	Type of Selection	Pre-test of Students (Freshman)	Treatment Program and Discipline	Type of Selection	Post-test of Students (Seniors)
Technology	P	O1	X1	P	O2
Engineering	P	O1	X2	P	O2
Humanities	P	O1	X3	P	O2

Figure 1. Design of the Study

P = Purposive class sampling
O1 = PSI-PSYCH, PSI-TECH, and demographics for pre-test assessment of freshmen
O2 = PSI-PSYCH, PSI-TECH, and demographics for post-test assessment of seniors
X1, X2, X3 = Three disciplinary/program areas

The independent variables were undergraduate students' academic area (technology, engineering and humanities) and demographic characteristics; such as grade levels, amount and type of prior work experiences (general or technological), grade point average, and gender.

Academic Area. This study involved undergraduate university students in the technology, engineering, and humanities disciplines. Based on their significantly different goals it was assumed that these three disciplines differ substantially in the nature of their academic training as well as in the career expectations they develop. It was also assumed that students enrolling in each discipline largely reflect the predominant characteristics of that discipline. The interrelationships among these three different disciplines can be conceptualized as a function of technological and theoretical dimensions (see Figure 2).

Technology-related programs exist to develop an understanding of, and capability to use, key aspects of industry and technology. They also aid in the discovery, development and application of student problem solving skills in a technological environment that draws from both engineering and technology theory. Thus, the orientation is practical, hands-on and applied.

Engineering programs, while also technological in emphasis, are generally much more theoretical and less *hands on*. Curricula emphasizing physical science, mathematics, and engineering sciences are geared toward theoretical solutions and highly quantified modeling of technological problems. By contrast, humanities students receive significant portions of their training in general courses as well as a concentration in a given liberal arts discipline. Their careers generally do not involve technological or engineering concepts but rather focus on abstract liberal arts content.

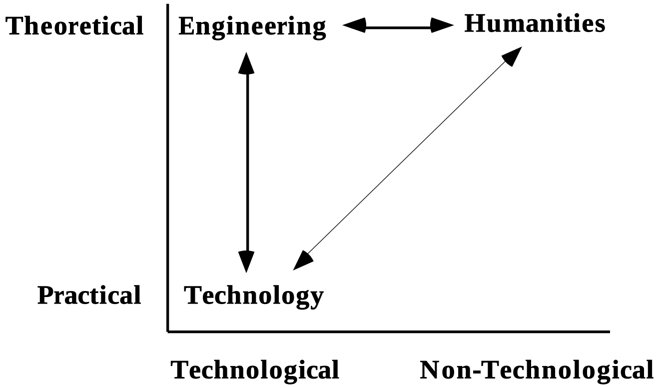

Figure 2. Envisioned Relationship Among Three Different Academic Areas

Central to the design of this study was the thesis that while these three different types of students could be anticipated to have similar PSI-PSYCH scores, based on their different educational experiences, the engineering and technology students would have more positive PSI-TECH scores than humanities students. It was also anticipated that educational experiences in engineering and technology programs would result in enhanced perceptions of technological problem solving effectiveness as compared to humanities students.

Demographic Variables. These consisted of student grade level, work experience, GPA, and gender. It could be expected that seniors would have higher self-confidence, personal control, and approach than freshmen (Heppner, 1988). These differences would also be expected to translate into differences in technological problem solving because technological problem solving is a significant component of industrial technology and engineering programs.

The sampled students' work experiences were classified by type and amount of general and/or technological experience. Differences in work experience might not logically be expected to influence PSI-PSYCH scores. However, if there is indeed a difference between personal and technological problem solving, differences in technological work experience could well affect PSI-TECH scores.

Students' Grade Point Averages (self reported) were also examined. It could be anticipated that students with low and high GPA scores might show significant differences in their PSI-PSYCH scores. For example, students who are successful in school subjects could be expected to demonstrate similar levels of success in personal problem solving. The reverse could well prove to be true with the PSI-TECH scores.

Gender was another factor that might affect PSI-PSYCH and PSI-TECH scores differentially. In this study, male and female responses were compared to examine the pattern of problem solving style characteristics for both personal and technological problem solving.

Population & Samples

The study's population was considered to be mid-west public university students. From this population, the respondents were purposively selected, by class, from industrial technology students at Murray State University (Kentucky), Pittsburg State University (Kansas), and Central Missouri State University; engineering students at the University of Missouri-Columbia and the University of Missouri-Rolla; and humanities students at the University of Missouri-Columbia, Central Missouri State University, and Murray State University (see Figure 3).

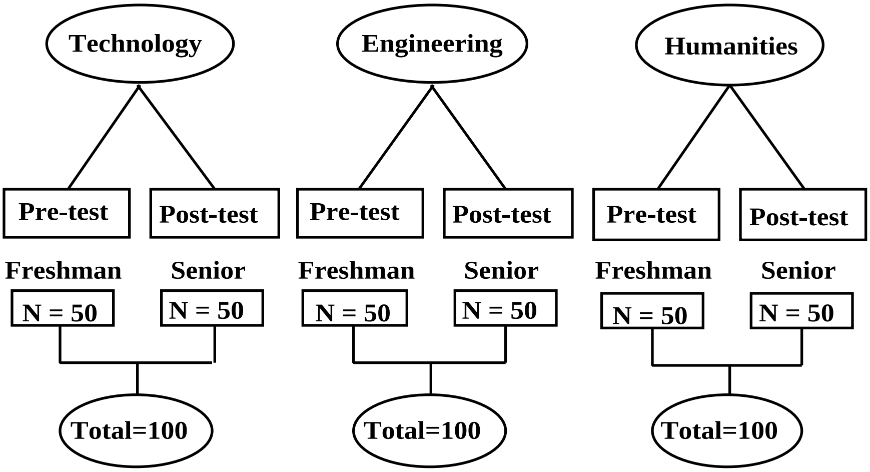

Figure 3. Research Samples

This approach of assembling a sample from several universities was used because of the difficulty of finding accessible midwest universities with sufficient enrollment in each of the three target programs. Furthermore, the focus of analysis was on discipline rather than individual universities. The minimal specified N was 300, consisting of 100 technology students, 100 engineering students and 100 humanities students. This targeted sample size was based on an anticipated medium effect size and a desired power of 0.70 (Stevens, 1992). However, because of the *sample by class* strategy used to ensure the targeted numbers of freshmen and seniors, an oversampling approach was used. This was to compensate for anticipated high numbers of sophomores and juniors in the selected classes. The final sample was derived from the five collaborating universities and it was assumed that since approximately half the sample came from a Research-I university and half from regional universities, that the sample was representative of the population (see Table 1).

Table 1
Student Sample By Major, Level and Institution

	Student Major						
	Technology		Engineering		Humanities		
University	Freshman	Senior	Freshman	Senior	Freshman	Senior	Total
UMC	0	0	41	27	44	35	147
UMR	0	0	9	23	0	0	32
MSU	22	21	0	0	2	7	52
PSU	22	20	0	0	0	0	42
CMSU	6	9	0	0	4	8	27
TOTAL	50	50	50	50	50	50	300

Instrumentation

Two test instruments were used to collect data on the dependent variables. The Personal Problem Solving Inventory, Form B, developed by Heppner (1988) was termed PSI-PSYCH. The Technological Problem Solving Inventory (PSI-TECH) was a modified version of the Personal Problem Solving Inventory created by altering *only* the directions to focus respondents on technological problem solving rather than personal problem solving. Specifically, the PSI-PSYCH version asked the respondents to think of personal relationship types of problems and then illustrated with depression, choosing a vocation, and inability to get along with friends. In contrast, the PSI-TECH version asked them to shift their mindsets to technological problems and then used examples such as lights that do not light, doors that stick, and a car that does not start. The PSI is scored such that high scores indicate low levels of a given quality. For example, the relatively high score for the humanities students on the PSI-TECH form of the instrument should be interpreted as low levels of problem solving self-confidence, high avoidance, and low personal control. Permission for the inclusion, modification and reproduction of both inventories was granted by the instrument's publisher.

The Personal Problem Solving Inventory (PSI-PSYCH). This inventory is a standardized self-report measure designed to assess perceptions of personal coping problem solving styles and ability (Heppner, 1988). Factor analysis revealed three factors: (a) problem solving confidence, (b) approach/avoidance, and (c) personal control (Heppner & Petersen, 1982). In essence, people who perceive themselves as effective problem solvers (having high confidence, high personal control, and a positive attitude on approaching problems) differ significantly from those who perceive themselves as ineffective (lacking confidence and personal control, and avoiding problems). In addition, the PSI has been found to be significantly correlated with behavioral observations of actual problem solving competence (Heppner, Hibel, Weinstein, & Rabinowitz, 1982). Reliability estimates revealed that the three factors were internally consistent (coefficient alpha a = 0.72 to 0.90) and stable over a two week period (0.83 to 0.89).

The Technological Problem Solving Inventory (PSI-TECH). The PSI-TECH inventory was a modified version of Heppner's (1988) PSI-PSYCH. This approach to investigation was used because it appeared reasonable that careful modification of an existing tool, with established psychometric properties, was preferable to developing a new inventory. The only change made to create the PSI-TECH inventory was in its directions to deliberately shift the respondent's focus from personal to technological problem solving. The thirty five questions that form the actual inventory remained unchanged.

Demographic Information. A form was developed and included with the instruments to collect necessary demographic information; gender, age, academic level, work experience, and college grade point average.

Pilot Study

During April 1993, a pilot study was conducted to explore the instrument's usability with three groups of university students (technology, engineering and humanities). The results indicated that clearer directions were needed to adequately focus the respondents on the distinction between technological and personal problem solving. Consequently, additional examples of the two types of problem solving perspectives were developed and added to the directions. Additionally an explicit set of verbal instructions was developed to focus the subjects' attention on the key differences between the two instruments. These changes (both written and verbal) were reviewed by a sample of pilot test participants to confirm that the distinction between the instruments had been achieved. To further emphasize the distinction, the two forms of the instrument were color-coded.

Data Collection and Analysis

The data were collected from students in the three different disciplines. A trained test administrator asked students to respond to the two different forms of the instrument. The order of administration was reversed for half of the sample to control for administration order bias.

A 3 x 2 x 2 multivariate analysis of variance procedure was used to compare the various mean scores [three levels of discipline programs (technology, engineering and humanities), two levels of student's academic levels (senior and freshman) and two levels of different work experience (general and technological)]. The six dependent variables used in the study consisted of the subscales of the two forms of the instrument (problem solving confidence, approach/avoidance style, and personal control for both the PSI-PSYCH and the PSI-TECH). Subsequent to MANOVA analysis, a split plot univariate analysis of variance was conducted to explore the effects of the various levels of the factors (three disciplines) on the multiple dependent variables. This approach was necessary in order to provide a method of testing the differences between the two composite scores and among the six subscales. A probability level of 0.05 was used throughout to judge the findings.

The PSI-PSYCH and PSI-TECH means and standard deviations for all subjects were calculated. For normative purposes, PSI norm means and standard deviations from the PSI-PSYCH college student samples of Heppner (1988) were also consulted.

Several preliminary approaches were employed to analyze the data. A regression analysis detected no significant relationship between GPA, age, and students' personal or technological problem solving styles. Thus, it was concluded that the effects of these variables need not be included in the overall data analysis model. No attempt was made to compare male and female scores because of low percentages of females responding in engineering and technology programs and the analytical method's requirement for equal cell sizes. Further justification for this decision is based on Heppner's previous research with American college students, which has consistently indicated a lack of statistically significant differences on PSI-PSYCH scores between the genders (e.g., Heppner, et al., 1982; Heppner, Reeder, and Larson, 1983; Larson & Heppner, 1985; Neal & Heppner, 1986; Mcallister-Salehi, 1990). Given that Heppner's findings with respect to gender differences about problem solving style are different than the PATT research (de Klerk Wolters, 1989) about attitudes towards technology, this suggests that these two characteristics (style and attitude) are different.

During the Winter and Summer semesters of 1993, pre-test data were collected from 180 freshman students and post-test data from 204 senior students. Data were gathered from purposive samples representing the study's three academic majors. In all, instruments were distributed to 750 university students. A total of 546 or 72.8% of the distributed instruments were returned. After eliminating those instruments which were incomplete or which had been completed by students who were inappropriate for this study (e.g., by sophomores and juniors), 384 or 70.3% of returned instruments were usable. The actual 50 students used in each cell were selected on a random basis from the returned and usable instruments.

Findings

The demographic characteristics of the sample include gender, age, academic major, academic level, amount and type of work experience, and grade point average. The data showed that the highest percentage of students involved in this study was male (67.7%) with ages ranging from 17 - 51 years old. The average age was 22.6 years. Their average GPA was 3.02 with the majority reporting in the 3.0 - 4.0 range. The average general work experience (e.g., sales, fast food worker, grocery store shelf stocker, etc.) was 2.37 years, whereas the average technological work experience (e.g., farm work, factory work, etc.) was only 1.73 years. In addition to the two types of work experience, the actual amount of experience was stratified into two levels; one with no work experience and one with more than three years work experience. Higher percentages of general work experience were reported (111 - 37%) than for technological work experience (68 - 22.7%) (see Table 2).

Table 2
The Number and Percentages of Students Selected for the Study by Gender, Age, Program, Level, Work Experiences, and Grade Point Average

Variable	Category	Number	Percentage
Gender	Female	97	32.3%
	Male	203	67.7%
Age	17 - 20 years	109	36.3%
	21 - 25 years	137	45.7%
	26 - 30 years	33	9.0%
	31 - 35 years	14	4.7%
	36 - 40 years	5	1.6%
	More Than 41 years	2	0.7%
Academic Major	Technology	100	33.3%
	Engineering	100	33.3%
	Humanities	100	33.3%
Academic Level	Senior	150	50.0%
	Freshman	150	50.0%
Work Experience			
General	No Experience	102	34.0%
	Some but less than 3 years	87	29.0%
	More than 3 years	111	37.0%
Technological	No Experience	181	60.3%
	Some but less than 3 years	51	17.0%
	More than 3 years	68	22.7%
GPA	Less Than 1.99	4	1.3%
	2.00 - 2.99	110	36.7%
	3.00 - 4.00	186	62.0%

Cronbach's coefficient alpha estimates of internal consistency reliability were computed for each of the three subscales on both forms of the instrument (PSI-PSYCH and PSI-TECH). For the three subscales (problem solving confidence, approach/avoidance, and personal control) of the Personal Problem Solving inventory (PSI-PSYCH) these estimates were 0.85, 0.80. and 0.71 respectively. On the Technological Problem Solving Inventory (PSI-TECH) the same three subscales yielded alpha coefficients of 0.88, 0.81, and 0.76 respectively. The estimates obtained in this study were very similar to those obtained by Heppner (1988) and were judged to be sufficiently high to warrant the use of the PSI-TECH on the basis of reliability.

Question One - Overall and Subscale Score Analyses

This research question focused on the effect of participation in the three academic majors on personal and technological problem solving style scores. Problem solving styles of groups of university students with a high inclination to and involvement with technology were compared to those with a minimal inclination and involvement. The intent was to ascertain if any significant differences existed among the groups with respect to their problem solving styles. If such differences did exist, this would suggest the existence of a difference between technological and personal problem solving.

No significant differences were detected *among* the three majors on the overall personal problem solving scale (PSI-PSYCH). However, the findings *did* reveal, pursuant to acceptance of the sampling assumptions, statistically significant differences *among* the overall PSI-TECH scores comparing engineering, humanities, and technology students. On the PSI-TECH, the humanities students had the highest score (least positive) while the engineering students had the second highest score and the technology students had the lowest score (most positive). (As documented in this article's instrumentation section, it is important to note that *Low* scores on the PSI indicate high levels of problem solving self confidence, high approach behavior and high levels of personal control.)

The difference between personal problem solving and technological problem solving scores *within* the individual disciplines was found to be significant for humanities students and technology students, but not for engineering students. Humanities students had the highest scores (least positive) in technological problem solving and the lowest scores in personal problem solving. Technology students had the lowest scores (most positive) in technological problem solving and medium scores in personal problem solving (see Figure 4).

The data were also analyzed at the sub-scale level. Significant differences were found when comparing the two problem solving style subscales (problem solving confidence, and approach/avoidance) for both PSI-PSYCH and PSI-TECH scores across the three disciplines. Further comparisons of scores on each of the technological problem solving confidence, technological approach/avoidance, and personal control subscales among the three purposeful samples of students revealed that humanities students had the highest scores (i.e., were least positive) on all of the three technological subscales, while engineering students had medium scores and technology students had the lowest scores (i.e., were most positive) on each of the three subscales.

PSYCH problem solving confidence and TECH problem solving confidence. The differences between the self-confidence levels of humanities and technology students and between engineering and technology were significant for TECH problem solving confidence. There were no significant differences in PSYCH problem solving confidence subscores among technology, engineering, and humanities students. There was, however, a significant difference between the PSYCH problem solving confidence and TECH problem solving confidence subscores for humanities students but not for engineering or technology students.

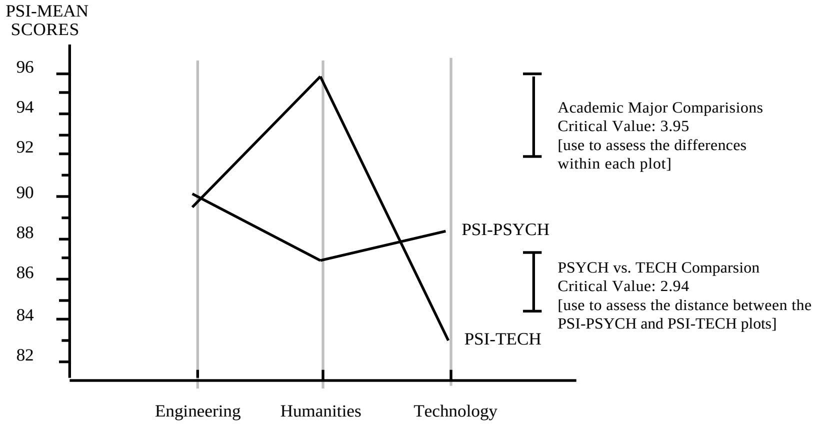

Figure 4. Comparison Between Personal Problem solving (PSI-PSYCH) and Technological Problem solving (PSI-TECH) Scores of Three Academic Majors

PSYCH approach/avoidance and TECH approach/avoidance. The differences among academic majors were significant on the TECH problem solving approach/avoidance scale. Differences between the PSYCH approach/avoidance and TECH approach/avoidance subscores of humanities students and between PSYCH approach/avoidance and TECH approach/avoidance subscores of technology students were also significant, but this was not the case for engineering students.

PSYCH personal control and TECH personal control. None of the differences in this subscale were significant, across either the personal or technological dimensions among the three academic majors. Also, no difference was detected between PSYCH and TECH problem solving for each discipline.

Research Questions Two and Three

No significant differences were found between freshmen and seniors on either the overall personal or technological problem solving scores or on the subscales. There were also no statistically significant differences in either form (personal or technological) of problem solving style related to amount and type of work experience. No significant interactions were found among academic majors, levels, problem solving types and subscores.

Conclusions

The following conclusions were drawn pertaining to the differences between personal and technological problem solving styles. The consistent lack of significant differences across the three academic majors along the personal problem solving style dimensions indicate that students in distinctly different academic majors are similar in personal problem solving style. However, significant differences on the technological problem solving dimension across all three academic majors suggest that students in different academic majors differ in technological problem solving style. This pattern of differences was also consistent across the subscore profiles for PSI-PSYCH and PSI-TECH forms of the instrument. Specifically, for a given discipline, when a technological confidence score is low, the approach/avoidance and personal control scores also tends to be consistently low.

Given the significant differences between PSI-PSYCH and PSI-TECH scores for humanities and technology students (2 of the 3 academic majors), it may be concluded that there is a high likelihood that personal and technological problem solving styles for these two groups of students are different. However, no significant difference existed between these two problem solving styles (personal and technological) for engineering students. This may be explained by noting that engineering has grown to be highly abstract, theoretical and removed from practical hands-on applications (i.e., closer to the Humanities in Figure 2). Given that the PSI-TECH instrument instructions defined and illustrated technological problem solving in a highly applications-oriented manner, it is not surprising that the response patterns of engineering and technology majors were different, even though both deal with technology. The difference between the results of engineering and technology students suggests that there may be multiple forms of technological problem solving (i.e., a distinction may exist between applied and theoretical technological problem solving style) (For a more in-depth discussion of this point, see Custer, in press).

Given the persistent lack of significant differences between freshmen and seniors, it can be concluded that four year degree programs do not substantially change either an individual's personal or technological problem solving style. Similarly, work experience also does not appear to affect either personal problem solving or technological problem solving styles.

Discussion

One purpose of this study was to explore whether style differences existed when students were confronted with different types of problems. Given that these two types of problem situations are typically quite different in nature, intuitively it makes sense that the problem solving styles used to solve them would also differ. For example, a psychology major might be expected to be more self confident in resolving a conflict with a friend than in repairing an automobile. The results of this study provide evidence supporting that such differences between technological and personal problem solving style may, in fact, exist. This suggests that problem solving style is one of the important individual differences university students bring to their study of, and interaction with, technology.

No significant differences were found in personal problem solving style among the three different academic majors. In this case, personal problems refer to problems such as depression, interpersonal conflicts, agonizing over important life decisions, etc. It could have been anticipated that humanities students would have different personal problem solving styles than their more technically-oriented engineering and technology counterparts. The results of this study did *not* bear this out. Instead, it appears that college students are, by and large, fairly homogeneous when it comes to personal problem solving style.

However, a very different pattern emerged when the focus shifted to technological problem solving styles where significant style differences *did* exist among different academic majors. In terms of technological problem solving style, different discipline areas seem to be populated by different types of people, as demonstrated by their differing PSI-TECH scores. As noted above, this makes intuitive sense because college students are not homogeneous in terms of technological interests, background, or ability.

At this juncture, a comment should be made regarding an essential distinction that must be maintained between style and capability. The focus of this study was deliberately and exclusively on problem solving *style* rather than *ability*. While it might be anticipated that some correspondence could exist between the two, an examination of such a relationship was clearly beyond the scope of this research. It is also important to note that style, defined as a tendency to respond in a certain way, is something different than strategies actually used to solve problems (e.g., spiral, four-step, rational, etc.).

Educational levels did not appear to affect problem solving styles. This study found that the differences in the overall personal and technological problem solving scores, and their subscale scores, between freshmen and seniors were not significant. Congruent with this finding, Neal (1983) found that there were no significant differences between freshmen and seniors in personal problem solving. One possible explanation is that the time span between the freshman and senior years (three years in this study) is not long enough to effect major change in personal problem solving style. Again, it is very important that style not be confused with knowledge and/or capability. Certainly college programs are predicated on the assumption that they augment knowledge and capability but this was not measured by this study.

This study found no significant relationship between work experience and problem solving style. These results were somewhat different from the research findings of other studies (Gabel & Sherwood, 1984; Johnson, 1988; Malone, 1987; Pumipuntu, 1992; Reeder, 1986). The Gabel and Sherwood (1984) study indicated that prior knowledge or experience was a factor in determining student success in problem solving. Johnson (1988) found that the problem solver's knowledge, past experience, and expertise affected problem solving behavior. One reason for this study not being supportive of Gabel and Sherwood's (1984) and Johnson's (1988) results may be that their studies focused on *ability* rather than *style*.

Implications

Problem solving has become an important survival skill in our technologically advanced society. In technology education areas, teacher and curriculum design studies are increasingly calling for more emphasis on "higher-order thinking skills" and technological problem solving. The prominence afforded to problem solving by the technology education profession (Savage, et al., 1990) coincides with the critical thinking/higher order skills thrust which is occurring throughout education. Therefore, both general and technology teacher educators and researchers would be well advised to explore methods of enhancing the problem solving skills of their students.

The results of this study suggest that personal and technological problem solving styles may well be separate and distinct. The tendency in education has been to employ the term “problem solving” generically to include such diverse activities as coping with marital problems and trouble-shooting electronic circuits. The results of this study suggest that such generalization may be inappropriate. Instead, problem solving should be viewed as nature specific. In other words, different types of problem situations (e.g., personal or technological) require different kinds and levels of knowledge and capability. This is substantiated by this study's findings that individuals manifest different style characteristics when addressing problems of different natures.

It was also noted that problem solving style did not change from the freshman to the senior year. Despite this stability over a three year period, however, it is conceivable to posit that were a longer treatment period employed, (e.g., the twelve years from grades one to twelve), it would be more likely that significant change could be effected. The reason such earlier involvement (particularly elementary school level) might have a substantial effect on problem solving style is that the impact would be felt before critical style and attitudinal characteristics solidify in students (around ages 10-14) as documented by de Klerk Wolters (1989). Thus, this suggests that problem solving, and particularly technological problem solving, education should begin in the elementary grades to encourage children to actively explore and interact with both personal and technological problems when they are inherently curious about and actively engaged with their world and while their problem solving styles are still in the developmental process.

This study suggests implications for technology education teachers as well. Much remains to be learned, not only about problem solving style but also about how students solve problems and how to teach students how to do so more effectively. Furthermore, given the likelihood that technological and personal problem solving are different it is necessary for teachers to be able to assist students in learning how to solve both types of problems. Therefore, it may also be important that teachers' knowledge and training be extended to include an awareness and appreciation of the myriad of factors, psychological and technical, and including problem solving style, which affect problem solving.

Additional research should include longitudinal studies designed to investigate the evolution of problem solving styles and capabilities, both general and technological. Additionally, in-depth studies pursuing the relationship between problem solving style and actual problem solving capability/effectiveness are also needed.

References

Campbell D. T., & Stanley J. C. (1969). *Experimental and quasi-experimental designs for research.* Chicago: Rand McNally & Company.

Coyne, J. C., Aldwin, C., & Lazarus, R. S. (1981). Depression and coping in stressful episodes. *Journal of Abnormal Psychology, 90*(5), 439-447.

Custer, R. L. (in press). Examining the dimensions of technology. *International Journal of Technology and Design Education*.
D'Zurilla, T. J., & Nezu, A. M. (1982). Development and preliminary evaluation of the social problem solving inventory. *Psychological Assessment*, *2*(2), 156-163.
de Klerk Wolters, F. (1989). *The attitude of pupils towards technology*. Unpublished doctoral dissertation, Eindhoven University of Technology. Eindhoven, Netherlands.
Dyrenfurth, M. J. (1991). Technological literacy synthesized. In M. J. Dyrenfurth & M. R. Kozak (Eds.), *Technological Literacy*, 40th yearbook, Council on Technology Teacher Education. (pp. 138-183). Peoria, IL: Macmillan/McGraw-Hill.
Folkman, S., & Lazarus, R. S. (1980). An analysis of coping in a middle-aged community sample. *Journal of Health and Social Behavior, 21*(3), 219-239.
Gabel, D. L., & Sherwood, R. D. (1984). Analyzing difficulties with mole-concept tasks by using familiar analog tasks. *Journal of Research in Science Teaching*, *21*(8), 843-851.
Heppner, P. P. (1988). *Personal Problem Solving Inventory, Form B*. Palo Alto, CA: Consulting Psychologists Press, Inc., 3803 E. Bayshore Rd., Palo Alto, CA 94303.
Heppner, P. P. (1988). *The problem solving inventory (PSI)-Research manual*. Palo Alto, CA: Consulting Psychologists Press, Inc.
Heppner, P. P., & Petersen, C. H. (1982). The development and implications of a personal problem solving inventory. *Journal of Counseling Psychology*, *29*(1), 66-75.
Heppner, P. P., Hibel, J., Neal, G. W., Weinstein, C. L., & Rabinowitz, F. E. (1982). Personal problem solving: A descriptive study of individual differences. *Journal of Counseling Psychology*, *29*(6), 580-590.
Heppner, P. P., Reeder, B. L., & Larson, L. M. (1983). Cognitive variables associated with personal problem solving appraisal: Implications for counseling. *Journal of Counseling Psychology*, *30*(1), 537-545.
Johnson, J. R. (1989). *Technology: Report of the Project 2061 phase I technology panel*. Washington, D.C.: American Association for the Advancement of Science.
Johnson, S. D. (1988). Problem solving behavior research model for industrial education. *Journal of Industrial Teacher Education*, *25*(3), 29-40.
Larson, L., & Heppner, P. P. (1985). The relationship of problem solving appraisal to career decision and indecision. *Journal of Vocational Behavior*, *26*(1), 55-65.
Malone, J. S. (1987). *Psychological adjustment to multiple sclerosis*. Unpublished master's thesis, University of Illinois, Champaign.
Mcallister-Salehi, J. M. (1990). *Stress, roles, problem solving, support, and illness*. Unpublished doctoral dissertation, University of Missouri-Columbia, Missouri.
Neal, G. W. (1983). *Personal problem solving awareness and utilization of campus helping resources*. Unpublished doctoral dissertation, University of Missouri-Columbia, Missouri.

Neal, G. W., & Heppner, P. P. (1986). Problem solving self-appraisal, awareness, and utilization of campus helping resources. *Journal of Counseling Psychology*, *33*(1), 39-44.

Pumipuntu, S. (1992). *Learning styles and problem solving of industrial arts students in teachers colleges in northeast Thailand.* Unpublished doctoral dissertation, University of Missouri-Columbia, Columbia, Missouri.

Reeder, B. L. (1986). *Interpersonal problem solving activities of black undergraduates: A follow-up study.* Unpublished doctoral dissertation, University of Missouri-Columbia, Columbia, Missouri.

Savage, E. E., & Sterry, L. E. (1990). *A conceptual framework for technology education*. Reston, Va: International Technology Education Association.

Spivack, G., Platt, J. J., & Shure, M. B. (1976). *The problem solving approach to adjustment*. San Francisco: Jossey-Bass.

Stevens J. (1992). *Applied multivariate statistics for the social science* (2nd ed.). Hillsdale, New Jersey: Lawrence Erlbaum Associates.