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How Cognitive Style and Problem Complexity Affect Preservice Agricultural Education Teachers' Abilities to Solve Problems in Agricultural Mechanics

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Abstract

The purpose of this experimental study was to determine the effects of cognitive style and problem complexity on Oklahoma State University preservice agriculture teachers' (N = 56) ability to solve problems in small gasoline engines. Time to solution was operationalized as problem solving ability. Kirton's Adaption-*Innovation Inventory was administered to determine cognitive style as* more adaptive *or* more innovative. *Preservice teachers were assigned randomly, by cognitive style, to solve either a simple or complex problem in a small gasoline engine. The simple problem was related to the electrical system of the engine – specifically, a closed spark plug gap. The complex problem was related to the fuel/air delivery system; specifically, debris was placed into the main jet of the carburetor. To determine content knowledge, students were administered a 30-item, researcher developed criterion-referenced test. The findings of this study indicated that no statistically significant differences existed in content knowledge based on cognitive style. All students were able to solve their problem successfully; however, regarding time to solution, a statistically significant interaction effect existed between cognitive style and problem complexity. A simple main effects test revealed a statistically significant difference between the more innovative students based on problem complexity.*

Keywords: problem solving; cognitive style; problem complexity; agricultural mechanics; preservice agricultural education teachers

Employees are faced continually with the need to solve real-world problems that arise at the workplace (Collis, Waring, & Nicholson, 2004; Coplin, 2003). However, employers have deemed employees inefficient at solving problems (Candy & Crebert, 1991; Evers, Rush, & Bedrow, 1998; Robinson, Garton, & Terry, Jr., 2007). The reasons employees struggle to solve problems efficiently and effectively while at work could be because they were never required to do so in their college coursework (Sproull, 2001).

Chi and Glaser (1985) defined problem solving as "a situation in which you are trying to reach some goal, and must find a means for getting there" (p. 229). Problems that people encounter range from simple to complex and also vary in structure (Chi & Glaser, 1985; Jonassen, 2000). Complexity is a function of the number of issues or variables involved with a problem, not necessarily how difficult the problem is to solve (Jonassen, 2000). Well-structured problems are found often in school settings where the problem solvers are provided a well-defined initial state, and the goal and operational constraints are known. Ill-structured problems,

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however, are encountered in everyday life and may require individuals to utilize knowledge of several content domains to identify the initial state, and they may have more than one potential solution (Jonassen, 1997; 2000).

One area of problem solving that has been researched heavily centers around various forms of knowledge individuals possess. Specifically, Nickerson (1994) discussed how unrealistic it is to expect individuals to think critically or solve problems without knowledge of the problem domain. The knowledge problem solvers bring to the situation is crucial for the development of problem space (Newell & Simon, 1972). Problem space, or mental model, is comprised of the problem context and the resources, solutions, and processes employed to solve the problem (Newell & Simon, 1972). "Problem solving is generally regarded as the most important cognitive activity in everyday and professional contexts" (Jonassen, 2000, p. 63). Not only is it a key skill necessary for employability (Robinson & Garton, 2008), it is also "the most important learning outcome for life" (Jonassen, 2000, p. 63). Kirton (2003) stated that problem solving is essential to the survival and existence of the entire human race and that each person has an instinctive ability to solve problems in various contexts. However, this instinctive ability needs to be fostered.

Fortunately, problem-solving skills can be taught and learned (Sproull, 2001), so long as educators are willing to consider new pedagogies. Fuhrmann and Grasha (1983) noted that it is important for educators to adjust their pedagogies to meet the needs of their students and society. Jonassen (2000) stated that, generally, educators do not teach problem solving approaches in the learning environment, in part because they lack a thorough understanding for how to do so effectively. Problem solving strategies require the use of higher-order levels of cognitive thinking (Ulmer & Torres, 2007), which is, at times, uncomfortable for both students and faculty (Snyder & Snyder, 2008). To ease the level of discomfort and encourage higher-order thinking among students, teachers must be cognizant of the various cognitive styles that students use to solve problems (Lamm et al., 2011).

The literature abounds with research that seeks to shed light on how students learn best. Cognitive style, learning style, thinking style, problem solving style, and intellectual style are all terms used to describe how learners prefer to receive information (Kirton, 2003: Schunk, 2008; Sternberg & Grigorenko, 1997; Zhang & Sternberg, 2005). Although researchers have defined these terms differently, one characteristic of all cognitive styles is they are relatively stable characteristics developed early in life (Kirton, 2003; Rouse & Rouse, 1982). This stability is important because cognitive styles are thought to influence how people solve problems; however, cognitive styles are not an indicator of ability or intelligence (Kirton, 2003; Schunk, 2008; Sternberg & Grigorenko, 2005).

Although, historically the problem solving method has been a staple in agricultural education (Andreassen, 2004; Boone, 1990; Boone & Newcomb, 1990; Parr & Edwards, 2004), its success rests solely on the teachers who employ it. Parr and Edwards (2004) stated, "the pedagogical success of problem-solving rests upon agriculture teachers who are prepared to effectively use the method as they teach students and facilitate their learning" (p. 113). Therefore, because problem solving has the ability to transform and increase students' learning significantly (Boone, 1990), additional efforts should be made to prepare preservice and in-service teachers on how to instruct future and current students effectively while using the method (Boone, 1990; Parr & Edwards, 2004). Shoulders and Myers (2012) recommended that additional experimental research is needed that focuses on how teachers' use of problem solving strategies affects student performance and learning in classroom and laboratory settings. Teachers can help students solve problems by understanding how their students' cognitive style influences the problem solving process (Kirton, 2003). To do this effectively, teachers need to be aware of their own cognitive style and how it impacts interactions with students. Therefore, what effect does cognitive style have on preservice agricultural education teachers' ability to solve real-world problems in laboratory settings? This research question relates to Research Priority

Area 4: Meaningful, Engaged Learning in All Environments (Doerfert, 2011). Specifically, this research addresses key outcome number one, which states the need to "Deepen our understanding of effective teaching and learning processes in all agricultural education environments" (Doerfert, 2011, p. 9).

Theoretical Framework

"Increasing student awareness of their own problem solving style and how that style complements/challenges the problem solving styles of others can also be used as a tool in the classroom to enhance student awareness of their own cognitive tendencies" (Lamm et al., 2012, p. 28). One means for assessing problem solving on an individual basis is Kirton's (2003) Adaption-Innovation (A-I) Theory. Kirton's (2003) A-I Theory examines problem solving on the individual level claiming that problem solving ability is influenced by both learned levels of problem solving and a potential capacity to solve problems (Kirton, 1976). A-I Theory is strictly concerned with the influence of cognitive style on problem solving and how individuals prefer to solve problems (Kirton, 2003). Cognitive style variations result in creative problem solving differences when individuals are compared. Therefore, when solving problems, existing cognitive style variations will influence the management of problem solving situations, including the ability and agility to solve the problem easily and quickly (Kirton, 2003).

Based in A-I Theory, research has shown individual problem solving styles fall on a continuum ranging between adaption and innovation (Kirton, 2003). As such, the scale is continuous and emphasizes that an individual's problem solving style may be anywhere between the two. In this way, an individual is neither a complete adaptor nor a complete innovator (Kirton, 2003). According to A-I Theory, individuals on the adaptive end of the continuum prefer more structure when solving problems. They will suggest technically efficient solutions and seek to develop better ways of doing things within a system that exists already. Individuals with a more innovative style appreciate less structure when working through the problem solving process (Kirton, 2003). They are more novel in their approach and seek to develop new solutions that may exist within or outside the existing paradigm (Kirton, 2003). The *more innovative* will create multiple solutions (some effective and others implausible) and, therefore, are more likely to require realignment of objectives, plans, or strategies as they work to solve problems (Foxall, 1986; Kirton, 1999). In contrast, the *more adaptive* are efficient at completing simple problems quickly because they think within the existing system and aim for efficiency (Kirton, 1999; 2003). However, when the *more adaptive* are faced with a complex problem, they may take longer to solve it, as they are less likely to think of solutions outside of what they know to be true already (Kirton, 2003). The more innovative, on the other hand, will wrestle with simple problems as they strive to identify multiple solutions and may have difficulty choosing which route to take. However, the more innovative will be more agile when faced with complex, larger scale problems, as they are willing to work outside of the existing structure to identify a solution that may end up being more successful in the long run (Kirton, 2003).

Purpose and Objectives

The purpose of this study was to assess the effects of cognitive style and problem complexity on the problem solving ability of preservice agricultural education teachers enrolled in a small gasoline engines course at Oklahoma State University. The following research questions guided the study:

1. What are the personal characteristics of preservice teachers enrolled in the small gasoline engines course at Oklahoma State University?
2. What differences exist in content knowledge based on cognitive style and assignment to problem complexity group?
3. What effect does cognitive style have on the amount of time required to solve problems correctly?
4. What effect does problem complexity have on the amount of time required to solve problems correctly?
5. What interactions exits between cognitive style and problem complexity on the amount of time required to solve problems correctly?

The following null hypotheses guided the statistical analyses of the study:

$H_0$1: There is no statistically significant difference in content knowledge due to cognitive style.
$H_0$2: There is no statistically significant difference in the time required to solve problems correctly based on cognitive style.
$H_0$3: There is no statistically significant difference in the time required to solve problems correctly based on problem complexity.
$H_0$4: There is no statistically significant difference in the time required to solve problems due to the interaction of cognitive styles and problem complexity.

Methods and Procedures

This study employed a Completely Randomized Factorial 2x2 (CRF-22) design (Kirk, 1995). CRF designs allow researchers to test the effects of multiple independent variables on a dependent variable (Ary, Jacobs, & Razavieh, 2002). Specifically, the independent variables of interest for this study were preservice teachers' cognitive style and the complexity of the problem assigned, randomly, to each participant. The dependent variable of interest was the amount of time required for preservice teachers to solve their assigned problem.

The population of this study was all preservice agricultural education majors (N = 56) enrolled in the one credit-hour small gasoline engines course at Oklahoma State University during the 2012–2013 academic year. Thirty-three of the preservice teachers completed the course during the fall semester of 2012, and 23 completed the course during the spring semester of 2013. Once IRB approval was granted, participants were administered Kirton's (2003) Adaption-Innovation Inventory (KAI) on the first day of the four-week course. On the last day of the course, they were administered a 30-item researcher developed criterion-referenced test and assigned randomly, by cognitive style, either a simple or complex engine problem to solve (see Figure 1). Funke (1991) defined problem complexity as the "number of variables, issues, and type of functional relationship" (p. 186). Using this definition, the simple small gasoline engine problem was a closed spark plug gap, and the complex problem was debris placed in the main jet of the carburetor. A representative of Magneto Power, a distributor of Briggs & Stratton® engines, confirmed that the carburetor problem was more complex than the spark plug problem (C. Francis, personal communication, September 24, 2012).

Due to IRB restrictions, and the fact that the engines provided by Briggs & Stratton® were missing gasoline tanks, the participants were not allowed to attempt starting procedures.

Instead, each participant was provided a written scenario that described the symptoms their assigned engine would exhibit if they had attempted to employ starting procedures. The researcher was present during the problem solving activity to designate a common start time. When the participants identified the problem with the engine, they were instructed to write the clock time in the designated space on the written scenario page.

		Problem Complexity	
		Simple (One)	Complex (Two)
Cognitive Style Group	More Adaptive	Treatment Group A *n* = 15	Treatment Group B *n* = 12
	More Innovative	Treatment Group C *n* = 12	Treatment Group D *n* = 17

Figure 1. Random Assignment into a CRF 2x2 design.

The KAI was administered to determine cognitive style as either *more adaptive* or *more innovative*. The KAI is comprised of 32-items designed to measure individuals' preferred style for solving problems. Scores on the KAI range from 32 to 160, with a theoretical mean of 96. Individuals who score below the mean are considered *more adaptive* and those who score 96 or higher are considered *more innovative* (Kirton, 2003). The KAI was created for use with working adults, but it has been employed in numerous additional contexts, including education (Kirton, 2003). Multiple studies have been completed that established the reliability of the KAI. Kirton (2003) reported reliability coefficients ranging from 0.74 to 0.86 for populations of teenagers and 0.84 to 0.91 for adults. Post-hoc reliability analysis yielded a reliability coefficient of 0.79, indicating the instrument was reliable for the population of this study.

The researchers created a 30-item criterion-referenced test to determine the level of content knowledge of the students involved in this study. Test items were based on the curriculum in the small engines course at Oklahoma State University as well as information available from the Briggs & Stratton® PowerPortal website. Because the engines used were Briggs & Stratton® brand, it was important to retrieve information from their website to include on the test. The test was evaluated for face and content validity by a panel of experts that consisted of three faculty members in agricultural education and one faculty member in agricultural engineering. The agricultural engineering faculty member was in his 18th year as instructor of record for the small engines course. The panel of experts reviewed the instrument for ease of reading, content, semantics, and general construction. Recommended changes were made to the instrument to enhance clarity and readability prior to administration.

Reliability of criterion-referenced tests is achieved by following the eight factors recommended by Wiersma and Jurs (1990). These eight factors, as well as the researchers' attempt to address each one, are listed in Table 1.

Table 1

Examples of how the Eight Factors, Identified by Wiersma and Jurs (1990), Necessary for Establishing Reliability of Criterion-referenced Tests, were Addressed

Factor	How Factors were Addressed
1. Homogeneous items	Test items were of the same font size and style to ensure consistency.
2. Discriminating items	Items of varying difficulty were included.
3. Quantity of items	The test included 30 multiple-choice items.
4. High quality test	Attention was paid to the formatting of the test, as verified by the panel of experts.
5. Clear directions	Directions were printed at the top of the tests provided to students and read aloud prior to the beginning of the problem solving activities.
6. Controlled environment	Test administration occurred in the participants' normal classroom setting.
7. Participant motivation	The course instructor informed students that he was opting to use the test as a part of the course grade.
8. Scorer directions	An answer key was developed to ensure the questions were assessed accurately.

Debate in the literature exists as to whether reliability coefficients are appropriate for criterion-referenced tests. Some researchers insist that since criterion-referenced tests compare individuals to specified criteria, reliability estimates, such as internal consistency, are inappropriate (Popham & Husek, 1969). However, Kane (1986) argued that internal reliability coefficients above 0.50 would reflect aggregated mean scores accurately. Due to this debate in the literature, the researchers elected to employ the Kuder-Richardson (*KR-20*) formula to calculate a reliability coefficient. A reliability coefficient of 0.69 was recognized; therefore, the test was deemed reliable.

A two-way independent analysis of variance (ANOVA) was employed to determine the main and interaction effects of the independent variables (Field, 2009). To determine statistical significance, an *a priori* alpha level was set at 0.05. Effect size, using partial eta squared (η_p^2), was calculated to determine practical significance, which is a statistic used to inform the researcher whether or not the treatment effect is "large enough to be useful in the real-world" (Kirk, 1995, p. 64). η_p^2 was interpreted via the guidelines of Cohen (1988): (a) 0.0099 is a *small* effect size, (b) 0.0826 is a *medium* effect size, and (c) 0.20 is a *large* effect size. Simple main effects tests were employed to understand the interaction effect of the independent variables better (Kirk, 1995). Cohen's *d* statistic was calculated to establish the practical significance of the simple main effects test. Cohen's *d* was interpreted through the following guidelines: (a) 0.20 is a *small* effect size, (b) 0.50 is a *medium* effect size, and (c) 0.80 is a *large* effect size (Kirk, 1995).

Findings

Research question one asked about the personal characteristics, such as sex, age, academic classification, and cognitive style of students enrolled in the small gasoline engines course at Oklahoma State University (see Table 2). Regarding the sex of the students, 30 (53.6%) were male, and 26 (46.4%) were female (see Table 2). Six (10.7%) students were 19 years of age, 17 (30.4%) indicated they were 20 years old, 17 (30.4%) were 21 years of age, eight (14.3%)

were 22 years old, and five (7.2%) indicated they were 23 years of age or older. In all, one (1.8%) student was a freshman, eight (14.3%) were sophomores, 28 (50.0%) were juniors, 14 (25.0) were seniors, and two (3.6%) students indicated they were graduate students. Forty-six (82.1%) of the students indicated they were Caucasian, and six (10.7%) self-reported Native American as their ethnicity. In all, 49 (87.5%) of the students indicated they participated in school-based agricultural education when they were in high school. Additionally, 21 (37.1%) students indicated that they had completed one course focused in agricultural mechanics while in high school. Six (10.7%) students completed two agricultural mechanics courses, seven (12.5%) students completed three courses focused in agricultural mechanics, one (1.8%) student completed four agricultural mechanics courses, and six (10.7%) students indicated they completed more than four courses in agricultural mechanics.

Table 2

Selected Personal and Educational Characteristics of Students Enrolled in a Small Gasoline Engines Course at Oklahoma State University (N = 56*)*

Variable		*f*	%
Sex			
	Male	30	53.57
	Female	26	46.43
Age			
	19	6	10.71
	20	17	30.35
	21	17	30.35
	22	8	14.28
	23 or Older	5	8.92
Academic Classification			
	Freshman	1	1.78
	Sophomore	8	14.28
	Junior	28	50.00
	Senior	14	25.00
	Graduate Student	2	3.57
Ethnicity			
	Caucasian	46	82.14
	Native American	6	10.71
Participated in School-Based Agricultural Education			
	Yes	49	87.50
	No	5	8.92
	No Response	2	3.57
Number of School-Based Agricultural Mechanics Courses Completed			
	1 Course	21	37.50
	2 Courses	6	10.71
	3 Courses	7	12.50
	4 Courses	1	1.78
	More than 4 Courses	6	10.71

Table 3 lists the cognitive styles of the students, as measured by the KAI. In all, 27 (48.2%) students were classified as *more adaptive,* and 29 (51.8%) students were classified as *more innovative* (see Table 3).

Table 3

Cognitive Styles of Students enrolled in a Small Gasoline Engines Course at Oklahoma State University (N = 56)

Item	*f*	%
More Adaptive	27	48.21
More Innovative	29	51.78

Note. KAI score range 32 to 95 = more adaptive; 96 to 160 = more innovative

Prior to the problem solving portion of the study, students were administered a 30-item criterion referenced test to determine their overall knowledge of small gasoline engines. Table 4 lists the content knowledge scores by cognitive style and problem complexity. The overall mean test score was 16.55 (55.17%) out of 30. Out of a possible score of 30, the overall mean test score for the *more adaptive* students was 16.19 (53.97%). The *more innovative* students had a mean test score of 16.90 (56.33%) (see Table 4).

Table 4

Mean Content Knowledge Test Scores by Cognitive Style and Problem Complexity (n = 56)

Cognitive Style	Problem Complexity	*M*	%	*SD*	*n*
More Adaptive	Simple	16.07	53.57	3.88	15
	Complex	16.33	54.43	6.05	12
	Total	16.19	53.97	4.86	27
More Innovative	Simple	17.67	58.90	3.34	12
	Complex	16.35	54.50	4.00	17
	Total	16.90	56.33	3.74	29
Total	Simple	16.78	55.93	3.67	27
	Complex	16.34	54.47	4.85	29
	Total	16.55	55.17	4.29	56

A two-way independent ANOVA was utilized to determine if statistically significant differences existed between the students based on cognitive style and assignment to problem complexity group. Prior to employing the ANOVA, Levene's test for equality of error variances was calculated to ensure error variances were equal (Field, 2009). Levene's test was determined not to be statistically significant ($p = .10$); therefore, equality of error variances was assumed.

The ANOVA yielded a $F(1, 52) = 0.45$, $p = 0.506$ for the interaction effect of cognitive style and problem complexity (see Table 5). Due to a lack of significance in the interaction effect, an analysis of the main effects was necessary (Kirk, 1995). Regarding the main effect of cognitive style, the ANOVA yielded a $F(1, 52) = 0.47$, $p = 0.50$. The main effect of problem complexity yielded a $F(1, 52) = 0.20$, $p = 0.659$ (see Table 5). As such, the researchers failed to reject the first null hypothesis.

Table 5

Analysis of Variance Summary Table for the Effect of Problem Complexity and Students' Cognitive Style on Content Knowledge

Source	*SS*	*df*	*MS*	*F*	*p*	η_p^2
Cognitive Style	8.98	1	8.98	0.47	0.50	0.01
Problem Complexity	3.75	1	3.75	0.20	0.66	0.00
Cognitive Style * Problem Complexity	8.55	1	8.55	0.45	0.51	0.01
Error	992.15	52	19.08			
Total	16357.00	56				

Regarding time to solution, the overall mean time to solution for students assigned to the simple problem was 21.44 (*SD* = 18.64) minutes (see Table 6). The mean time to solution for those students assigned to the complex problem was 39.34 (*SD* = 14.13) minutes. The *more adaptive* students assigned to the simple problem required an average of 27.13 (*SD* = 20.90) minutes. The *more adaptive* students assigned to the complex problem had a mean time to solution of 23.25 (*SD* = 15.27) minutes. The *more innovative* students assigned to the simple problem required an average of 14.33 (*SD* = 12.87) minutes. The *more innovative* students assigned to the complex problem had a mean time to solution of 33.65 (*SD* = 11.89) minutes (see Table 6).

Table 6

Mean Time to Solution for Treatment Conditions Cognitive Style and Problem Complexity (n = 56)

Cognitive Style	Problem Complexity	*M*	*SD*	*n*
More Adaptive	Simple	27.13	20.90	15
	Complex	23.25	15.27	12
	Total	25.41	18.37	27
More Innovative	Simple	14.33	12.87	12
	Complex	33.65	11.89	17
	Total	25.66	15.48	29
Total	Simple	21.44	18.64	27
	Complex	29.34	14.13	29
	Total	25.54	16.78	56

Prior to employing a two-way ANOVA, Levene's test of equality of error variances was employed. The Levene's test was determined not to be statistically significant (p = 0.24); therefore, equal error variances were assumed. The ANOVA yielded a $F(1, 52) = 7.50$, $p = 0.01$, and power = 0.77 for the interaction effect of cognitive style and problem complexity (see Table 7). As such, the researchers rejected the fourth null hypothesis. The partial η^2 for the interaction effect was 0.13, indicating a practical effect between medium and large.

Table 7

Analysis of Variance Summary Table for the Effect of Cognitive Style and Problem Complexity on Time to Solution

Source	*SS*	*df*	*MS*	*F*	*p*	η_p^2
Cognitive Style	19.76	1	19.76	0.08	0.78	0.00
Problem Complexity	814.96	1	814.96	3.32	0.07	0.06
Cognitive Style * Problem Complexity	1841.83	1	1841.83	7.50	0.01	0.13
Error	12762.53	52	245.43			
Total	52004.00	56				

A test of simple main effects was necessary due to the statistically significant interaction effect of cognitive style and problem complexity. Simple main effects tests are employed to understand statistically significant interaction effects better (Kirk, 1995). Table 8 depicts the results of the simple main effects test. A statistically significant difference (p = 0.00) in time to solution was found for the *more innovative* students. Cohen's *d* statistic was 1.56, indicating a rather large practical effect between the *more innovative* students assigned the simple problem and those who were assigned the complex problem (see Table 8).

Table 8

Simple Main Effects Test for Cognitive Style

Cognitive Style		*SS*	*df*	*MS*	*F*	*p*	*d*
More Adaptive	Contrast	100.54	1	100.54	0.41	0.525	0.21
	Error	12762.53	52	245.43			
More Innovative	Contrast	2624.00	1	2624.0	10.69	0.00	1.56
	Error	2983.04	54	55.24			

Conclusions

Statistically significant differences in content knowledge did not exist between the students based on cognitive style or assigned problem complexity group. Pate and Miller (2011) stated that content knowledge should not differ significantly if curriculum and instruction does not vary. This conclusion is also congruent with KAI theory and other literature that cognitive style is not an indicator of cognitive capacity (Kirton, 2003; Sternberg & Grigorenko, 2005). However, this is not consistent with Dyer and Osborne (1996) who reported differences in student achievement attributed to learning styles as measured by the Group Embedded Figures Test (GEFT). Alarmingly, no group of preservice teachers achieved an average score that would be considered passing in most school scenarios. The literature proclaims that knowledge is a prerequisite for problem solving, and that it is essential in the formation of problem space (Newell & Simon, 1972). Perhaps content knowledge is not a true prerequisite for troubleshooting small gasoline engines. It is possible that students gained knowledge associated with performing the troubleshooting task, but did not receive enough content understanding to answer questions about faulty engine systems.

All students were able to identify the fault of their assigned engine within the bounds of their two-hour small gasoline engines laboratory course. This finding supports KAI theory that all people can solve problems regardless of cognitive style (Kirton, 2003). The typical student required just over 25 minutes to identify their assigned problem, regardless of its complexity. The *more innovative* students assigned the simple problem were the most efficient problem solvers and the *more innovative* students assigned the complex problem were the least efficient problem solvers. A statistically significant interaction effect was detected between cognitive style and problem complexity; therefore, the researchers rejected the fourth null hypothesis. This conclusion conflicts with Kirton (2003) who stated that those who are *more innovative* in nature tend to struggle to solve simple problems because they generate several possible solutions resulting in issues determining the correct path to take to solve the problem.

A simple main effects test revealed a statistically significant difference in time to solution between the *more innovative* students based on problem complexity. Students who were *more innovative* in nature were able to solve simple small gasoline engines problems better than those confronted with more complex problems. The simple main effects test did not indicate a statistically significant difference in time to solution among the *more adaptive* students; however, the *more adaptive* students assigned the complex problem were able to solve the complex problem nearly four minutes quicker than those who were assigned the simple problem. This conclusion contradicts Kirton's (2003) assertion that one cognitive style is superior in terms of problem solving performance. It appears that when time was operationalized as a measure of successful problem solving performance (Jonassen, 2000), the *more adaptive* were more consistent than the *more innovative* who excelled at solving simple problems but struggled to solve complex problems.

Recommendations for Practice

The results of this study indicated a difference in the ability of the *more innovative* to solve a simple versus complex problem related to small gasoline engines. As such, those who are *more innovative* in nature should recognize this phenomenon and take extra measures to find success when solving more complex problems. This is especially important due to the fact that problem solving has been identified consistently as a desired skill for entry-level employment in the agricultural industry (Alston, Cromartie, Wakefield, & English, 2009; Graham, 2001; Robinson, 2009; Robinson & Garton, 2008; Robinson et al., 2007). Instructors of small gasoline engines should consider cognitive style as an important variable if they require students to troubleshoot engines as a part of the course. This study shows that the *more innovative* struggle to solve complex problems; therefore, instructors should spend time teaching students how to work through problem space to solve problems accurately and efficiently (Newell & Simon, 1972; Sproull, 2001). Perhaps instructors can pair up innovative students with adaptive students to increase their ability to solve problems by teaching them not only the technical skills but also the value of teamwork and interpersonal relationships in the workplace.

The preservice teachers who were the research subjects for this study should recognize that, as a whole, they performed poorly on the content knowledge examination. This finding indicates preservice teachers do not possess the knowledge they need and should seek additional experiences in small gasoline engines before they teach the content to secondary students. Agricultural education leaders in Oklahoma should be alerted to this and offer professional development workshops for agricultural education teachers in small gasoline engines. Although this research study focused on small gasoline engines content only, these preservice teachers should reflect deeply on their experiences and seek experiences to fill in any existing gaps in their knowledge.

Recommendations for Future Research

Research is needed to investigate further the effect of cognitive style when solving problems of varying complexity. Kirton (2003) stated that, generally, the *more adaptive* excel at solving simple problems and the *more innovative* tend to struggle when solving these types of problems. The results of this study indicate that the *more innovative* solve the simple problem most efficiently. As such, this study should be replicated with a larger sample at multiple higher education institutions that offer courses in small gasoline engines. Additional variables such as students' mechanical aptitude and their ability to generate hypotheses should be added to future studies to account for more variance in time to solution. Requiring troubleshooters to write their hypotheses would allow researchers to have insight as to how students navigate problem space to determine possible solutions (Newell & Simon, 1972).

Additional research should focus on determining if various teaching methods and strategies affect the problem solving ability of the *more adaptive* and *more innovative* differently. Much of the problem solving literature discusses the role of various forms of knowledge in the problem solving process. Statistically significant differences in content knowledge were not found between the groups; however, there was not a single treatment group of students with a mean score that would be considered passing in most educational settings, which is troubling considering the participants of this study will likely teach small gasoline engines curriculum to future secondary students in school-based programs. Further research should also focus on the procedural knowledge of preservice agriculture teachers to determine how it influences problem solving in small gasoline engines. Procedural knowledge has been defined as knowledge of how to perform tasks and has also been identified as a prerequisite for problem solving (Hegarty, 1991; McCormick, 1997).

Future research should require students to solve problems in additional agricultural contexts other than small gasoline engines to determine if the findings of this study are consistent in other domains. Additionally, much of the literature regarding cognitive style has centered on group problem solving. Research should investigate if pairing students, purposefully, by cognitive style has an effect on problem solving success and time to solution. Students should be paired with those of similar and opposite cognitive style and required to utilize the think-aloud paired problem solving (TAPPS) procedure (Lochhead, 1987). Lamm et al. (2012) reported that when attempting to solve an unstructured, abstract problem the *more adaptive* struggled to get through the beginning stages of the problem solving process. Research should determine if this phenomenon is similar when students are charged to solve more structured problems found in troubleshooting tasks.

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