Journal of Agricultural Education, 66(1), Article 9
https://doi.org/10.5032/jae.v66i1.2784

Investigating the Effects of Cognitive Style on the Motivation of Students Enrolled in a Team-Based Learning Formatted Agricultural Mechanics Course at Louisiana State University

Whitney L Figland-Cook[1]
Richie Roberts[2]
J. Joey Blackburn[3]

Abstract

Educators have a plethora of teaching methods that allow them to tailor the learning environment to meet students' needs. One novel instructional approach that has grown in popularity in U.S. higher education has been the flipped classroom approach, which has become a popular way to embrace a student-centered learning environment. Of the various types of flipped classrooms, team-based learning allows students to learn content outside of classroom time and spend more time doing hands-on activities as a team in a laboratory environment. This study aimed to describe the effect of cognitive style on the motivation of undergraduate students enrolled in an introductory agricultural mechanics course at Louisiana State University. Descriptive statistics, including means, frequencies, and standard deviations, were utilized to test the hypothesis and gain a holistic understanding of the data. We also conducted a Mann-Whitney U test to determine if a statistically significant difference existed between motivation and cognitive style. No statistically significant differences were found between cognitive style and motivation. However, the more innovative students in this investigation had higher motivation scores than those identified as more adaptive.

Introduction and Review of Literature

It has become increasingly important for educators to adopt new instructional approaches to develop higher-order thinking skills for their students to meet the demands of the current workforce (Figland et al., 2019, 2020b; Fuhrmann & Grasha, 1983; Jonassen, 2000; Ulmer & Torres, 2007). Because of the complexity of problems that individuals face in the workplace, skills associated with problem solving, or critical thinking, have become highly desired (Eisner, 2010; Gokhale, 1995; Garcia-Perez et al., 2021) due to employers wanting individuals who can find, identify, and solve complex problems in an effective and efficient manner (Johnson, 1991; Rodriguez-Sabiote et al., 2022; Van der Zanden et al., 2018). However, it has been noted that students have not historically solved meaningful problems as a part of their education (Jonassen, 2000).

A common type of problem solving that can be encountered in our everyday lives revolves around the ability to troubleshoot problems. Troubleshooting, as defined by Herren (2015), is determining what causes a malfunction in a machine or process. Further, Custer (1995) and Jonassen (2000) added that

[1] Whitney L. Figland-Cook is an Assistant Professor of Agricultural Education at East Texas A&M University, P.O. Box 3011, Commerce, TX, 75429, whitney.figland@tamuc.edu; https://orcid.org/0009-0003-8669-2692
[2] Richie Roberts is a Professor and Department Head for the Department of Agricultural and Extension Education at New Mexico State University, MSC 3501, P.O. Box 30003, Las Cruces, New Mexico, 88003-8003; roberts3@nmsu.edu; https://orcid.org/0000-0002-2993-4945
[3] J. Joey Blackburn is the Academic Program Coordinator for Agriculture in the Department of Agriculture at St. Charles Community College, Culinary and Agriculture Center, 1 Academy Place, Dardenne Prairie, MO 63368; jblackburn@stchas.edu

troubleshooting also includes a subset of problems where the problem is situated in a real-world context. These problems are often integrated into our daily lives and are ill-structured in nature, which means they are defined by a single domain, and often their solutions are undefined. As such, they often require the learner to integrate multiple domains to achieve the solution (Jonassen, 2000). These ill-structured problems require the troubleshooter to possess knowledge, skill, and multiple experiences to interact effectively with the complex system they are troubleshooting (Johnson & Fleshner, 1993; Jonassen, 2003). According to Halpern (1984), the most important component of effective problem solving is an individual's ability to recognize and select the most appropriate solution. However, it has also been found that the path to deriving a solution between novice and expert troubleshooters is often quite different (Pate et al., 2004).

Previous research has been conducted to understand the differences between novice and expert troubleshooters. For instance, Dixon and Johnson (2011) found that expert troubleshooters employed key metacognitive processes, or the ability to reflect on their learning and adapt when solving a problem. Whereas novices had more difficulty troubleshooting because of a lack of metacognitive abilities (Dixon & Johnson, 2011; Gitomer, 1988). Such findings have also been linked to individuals' lack of experience and knowledge, which hinders novices from successfully troubleshooting (Dixon & Johnson, 2011; Johnson, 1989). On this point, Johnson (1989) argued that the main difference in troubleshooting ability between expert and novice troubleshooters was attributed to the information received and experience acquired in a specific domain.

Other research on problem solving has focused on the influence of cognitive styles on decision-making (Witkin et al., 1977). For example, in the context of agricultural mechanics, Blackburn et al. (2014) sought to assess the effects of cognitive style and problem complexity on the problem-solving ability of undergraduate students. This study's results indicated no statistically significant differences in the problem-solving ability of the more innovative individuals when solving a simple or complex problem. Similarly, Blackburn et al. (2016) assessed the troubleshooting ability of undergraduate students based on cognitive style, problem complexity, and hypothesis generation ability and reported no statistically significant differences. However, a more recent study by Figland (2021) found that cognitive style grouping did have a statistically significant and positive effect on undergraduate students' problem-solving ability regarding their time to solution and hypothesis generation ability. Further, Figland (2021) reported that regardless of problem complexity, students who generated the correct hypothesis were more efficient problem solvers.

In agricultural education, problem solving, and critical thinking skills have been commonly taught through the problem solving approach to teaching and learning (Phipps & Osborne, 1988). For many years, the problem solving approach has been considered the best method of instruction in agriculture (Phipps & Osborne, 1988) because school-based agricultural education (SBAE) programs have become an optimal place to assist students in developing and refining problem solving and higher-order thinking skills (Pate & Miller, 2011a). Despite this, educators have generally not taught an ample number of problem-solving skills in their curriculum (Pate & Miller, 2011b), which has been compounded by teachers' lack of knowledge on how to effectively implement new teaching approaches that can foster problem solving skill development (Granberry et al., 2022, 2023; Jonassen, 2000; Ulmer & Torres, 2007).

To combat the lack of skills, educators have begun incorporating innovative teaching methods such as the flipped classroom approach (Figland et al., 2019). The first flipped classrooms emerged in the early 2000s (Frederickson et al., 2005; Strayer, 2007; U.S. Department of Education, 2001). This teaching and learning approach can allow students to take command of their own learning outside the classroom while allowing educators to facilitate meaningful interactive learning experiences during class (Lage et al., 2013). Team-based learning (TBL) is a modified version of the flipped classroom concept that primarily uses student-centered learning and shifts instruction from a traditional lecture format (Artz et al., 2016; Nieder et al., 2005). Essentially, TBL allows students to take on the responsibility of learning conceptual knowledge outside of class and focus on procedural knowledge during traditional classroom time (Michealsen & Sweet, 2008). In this format, students can develop problem-solving and critical thinking skills by having the time and space to solve real-world problems as a component of their coursework (Figland et al., 2019).

Although TBL emerged in the 1970's, research supporting its use and effectiveness has been few and far between, especially in agricultural education. However, recent research on the use of TBL has been conducted. McCubbins et al. (2016) examined students' perceptions of TBL in a capstone course. The findings suggested that students had a positive view of TBL and were satisfied with the learning environment (McCubbins et al., 2016). The results from this study also indicated that working in groups positively impacted students' motivation to work and learn in a collaborative environment (McCubbins et al., 2016). Similarly, McCubbins et al. (2018) assessed student engagement in a TBL formatted course and found that TBL supported students' critical thinking, motivation to learn, and ability to effectively apply course concepts. Further, Figland et al. (2019) reported that students were highly satisfied with a TBL-formatted agricultural mechanic course. These students perceived that TBL supported the development of critical thinking skills, created a positive collaboration between group members, and increased their self-efficacy in agricultural mechanics (Figland et al., 2019).

It has also become apparent that awareness of a student's cognitive style is a crucial factor in the overall success of their ability to solve problems (Jonassen, 2000). Broadly, cognitive style can be defined as an individual's preferred way of organizing and retaining information to solve problems (Keefe, 1979; Kirton, 2003). However, it should be noted that individuals vary in their preferred cognitive style, which can influence their pattern of thinking and reasoning (Kirton, 2003; Jonassen, 2000). For quite some time, research has focused on cognitive styles' influence on teaching and learning, specifically their influence on the decision-making process (Witkin et al., 1977). Educational research has overwhelmingly conveyed the importance of the cognitive style of individuals as an important function of their everyday life and has also been heavily linked to students' motivation (Myers & Dyer, 2006; Parr & Edwards, 2004; Roberts et al., 2016; Roberts & Robinson, 2018; Thomas, 1992; Torres & Cano, 1995; Witkin et al., 1977). As such, the following question has persisted: Does cognitive style affect the motivation of students enrolled in a TBL-formatted course in agricultural mechanics?

Purpose and Hypothesis

The purpose of this study was to determine the effect of cognitive style on the motivation of students enrolled in an introductory agricultural mechanics course at Louisiana State University. The following null hypotheses guided this study:

> $H_0$1: No statistically significant differences existed in motivation based on cognitive style for students enrolled in an introductory agricultural mechanic's course.

Theoretical Framework

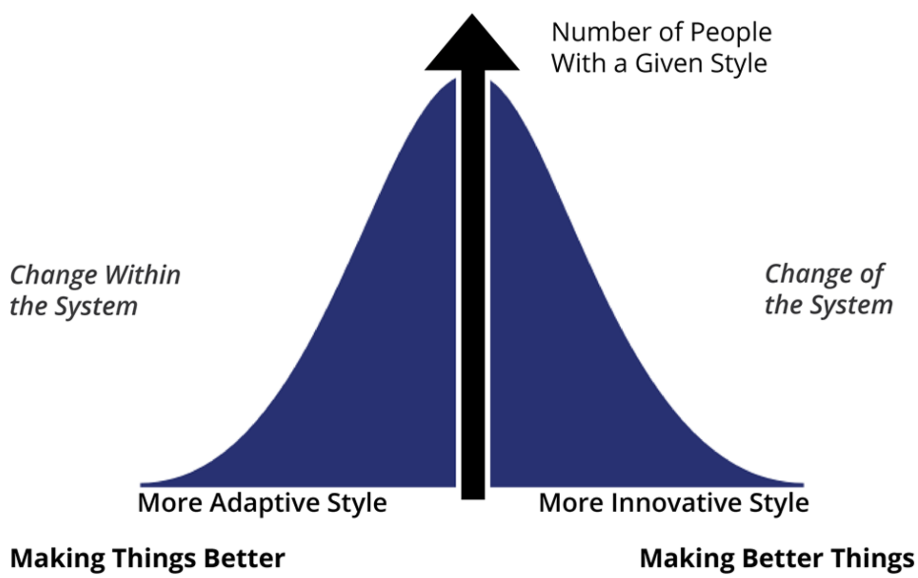
The theoretical framework used for this study was Kirton's (2003) adaptation-innovation theory (A-I theory). According to Kirton (2003) cognitive style is "the preferred way to which people responds to and seek to bring about change" (p. 43). Therefore, the result describes differences regarding the problem solving and cognitive styles between individuals. The A-I theory is founded on the belief that every individual is creative and can solve problems, whether simple or complex (Kirton, 2003).

Further, A-I theory presumes individual cognitive style is predetermined from the initial stages of life and remains stable, regardless of previous factors. However, A-I theory is a measure of cognitive style that examines problem solving individually (Kirton, 2003). Therefore, this theory is concerned with the influence of individual cognitive style and preferred mode of learning. It is also important to note that the term *preferred* relates to the difference between an individual's style and behavior and the term *style* indicates a distinction between individual style and the level of cognitive capacity (Kirton, 2003).

In this investigation, we used A-I theory as a lens to examine where individuals' cognitive style falls between adaptation and innovation on a continuum (Kirton, 2003; see Figure 1). Therefore, this type of scale does not allow any individual to be purely an adaptor or purely an innovator. Specifically, individuals with scores ranging from 32 to 95 are considered more adaptive and prefer a more structured environment when solving problems. These individuals prefer well-established problems and favor working within the current problem structure (Kirton et al., 1991). More adaptive individuals collaborate well with group members and generate ideas that favor consensus (Kirton, 2003). On the contrary, individuals whose scores range from 96-160 are considered more innovative in nature and prefer less structure to solve the problem, and often challenge boundaries (Kirton, 2003; Lamm et al., 2012). More innovative individuals tend to break the boundaries and generate ideas outside the current group structure (Kirton, 2003). Often, individuals falling more on the innovative side of the continuum tend to be novel and find diverse ways to solve problems. Whereas adaptors tend to be safer, more predictable, conforming, and less ambiguous when solving problems (Kirton, 1999, 2003). Therefore, the KAI was utilized in this study to understand students' cognitive styles and better understand how individuals in those groups tend to solve problems and interact with other cognitive styles when paired together.

Figure 1

Kirton's (2003) Adaptation-Innovation Theory (A-I Theory)



Methods

The data associated with this study were collected as part of a larger research project that investigated the effect students' cognitive style had on small engines problem-solving ability (Figland et al., 2019). A one-group pretest-posttest preexperimental design was used to collect data associated with this research project (Campbell & Stanley, 1963; Salkind, 2010). This method has been used in educational research when all individuals were assigned to an experimental group and observed at two time periods (Campbell & Stanley, 1963; Salkind, 2010). However, because there is no comparison group in this investigation, it was impossible to determine if the change occurred from the intervention or other extraneous variables.

Population/Sample

The population of this study was students enrolled in an introductory agricultural mechanics course at Louisiana State University during two spring academic terms, Term A (n = 17) and Term B (n = 15). However, one student from Term B did not complete enough course work and was excluded from the study. Therefore, our population was N = 31. Demographically, the majority of our participants were female (n = 17, 54.8%), classified as sophomores (n = 13, 41.9%), and majored in Agricultural and Extension Education (n = 13, 41.9%) at Louisiana State] University.

Homogeneity was tested using independent sample t-tests to determine if there were statistically significant differences between the students enrolled in Term A and Term B based on age (p = 0.596) and cognitive style (p = 0.109). A Chi-Square test was then utilized to determine if gender differences existed between the two academic terms (p = .576). This analysis revealed that our population was homologous; therefore, the data were merged for further analysis.

Instrumentation

To determine individual cognitive style, the Kirton's Adaptation-Innovation Inventory (KAI) was utilized. The KAI was given to all students in a paper format at the beginning of the term. The instrument consisted of 32 items directed at understanding an individual's preferred learning mode. Scores fall between 32 and 160 on a continuum, with a midrange of 96 (Kirton, 2003). Meaning that individual scores ranging from 32 – 95 are considered more adaptive, while scores from 96 – 160 are identified as more innovative.

Due to the wide use of this instrument, the internal reliability of this instrument has been measured through multiple studies. Kirton (2003) reported that internal reliability coefficients ranged from .84 − .89 after data analysis from six different studies. Further, a multitude of other studies that utilized the KAI showed reliabilities between .83 and .91 (Kirton, 2003).

To assess student motivation, we utilized the Course Interest Survey (CIS) developed by Keller (2010). The primary goal of this instrument was to determine how motivated students were before and after a particular lesson or course. For this study, all students in this course completed the CIS instrument via paper format at the beginning and end of the small gasoline unit. The CIS instrument was attached to the back of the pretest packet and posttest packet, which were handed out on the first day of the small engine module and the last day. This instrument had 34 items, which were composed of the four subscales of the ARCS model (Attention, Relevance, Confidence, and Satisfaction). Participants responded on a five-point Likert-type scale from *1 = not true, 2 = slightly true, 3 = moderately true, 4 = mostly true*, and *5 = very true*.

The CIS instrument has been utilized in various educational settings to determine its validity and reliability. The validity of this instrument was tested by correlating students' CIS scores with their course grades and overall GPA (Keller, 2010). It was determined that all of the correlations between the CIS and course grades were above the .05 alpha level, and there were no correlations between the CIS and GPA at the .05 alpha level. This finding supports the validity of the CIS as a situational measure of motivation and not a construct measure of student learning (Keller, 2010). Also, internal reliability estimates were determined by utilizing Cronbach's alpha. The reliability estimates were determined by pretesting, revising, and retesting of 45 undergraduate students at the University of Georgia (Keller, 2010) and are displayed in Table 1. Internal consistency estimates were overall high for each subscale; therefore, the instrument was deemed reliable.

Table 1

CIS Internal Consistency Estimates by Keller (2010)

Scale	Reliability Estimate Cronbach's ά
Attention	.84
Relevance	.84
Confidence	.81
Satisfaction	.88
Total Scale (CIS)	.95

Course Structure
To determine cognitive style, the KAI was administered on the first class of the term. Based on the student cognitive style score, the students were purposefully grouped into five teams. These teams were grouped as either homogenous, adaptive, homogeneous, innovative, or heterogenous for the remainder of the semester. Further, all course content, exams, and learning activities were designed around the team-based learning method outlined by Michealsen and Sweet (2008).

The students were administered a 30-item pretest and the Course Interest Survey (CIS) on the first day of the small gasoline engines unit. The small gasoline engine unit consisted of five individual modules. Those modules included (a) small engine tool and part ID, (b) 4-cycle theory and fuel, (c) ignition and governor systems, (d) cooling/lubrication system, and (f) troubleshooting. At the completion of the small gasoline engines unit, the students completed the 30-item criterion referenced posttest and CIS.

Data Analysis
To achieve the objective of this study, descriptive statistics including means, frequencies, and standard deviations were used to gain a deeper understanding of the population and phenomenon being observed. Further, Mann-Whitney U tests were employed to determine if a statistically significant difference exists between motivation and cognitive style. Mann-Whitney U tests were utilized in this study because the data were not normally distributed.

Results

At the beginning of the course, students were administered the Course Interest Survey (CIS) (Keller, 2010). The students completed the CIS at the beginning of the small gasoline engines unit and then were reassessed at the end of the unit. Overall, average individual pre- motivation was 150.45, with scores ranging from 129-167. When looking at individual cognitive style categories, more adaptive individuals had a mean score of 149.57, with a range of 129-167 on the pre-motivation survey, while more innovative individuals had a mean score of 153 and a range of 135-165. Regarding the four CIS construct areas, the more adaptive individuals had a mean score of 4.01 in the pre-attention construct, which is interpreted as *mostly true*. The more innovative students also had a mean pre-attention score of 4.19, which was *mostly true*. In the relevancy area, the more adaptive individuals had a mean score of 4.61, and the more innovative individuals had a pre-relevancy score of 4.68, which was interpreted as *very true*. Within the satisfaction area, the more adaptive individuals had a mean score of 4.49, interpreted as *mostly true.* The more innovative students had a mean score of 4.60 pre-satisfaction scores, interpreted as *very true*. Finally, in confidence, the more adaptive students had a mean score of 4.45, which was *mostly true*. Finally, the more innovative individuals had a pre-confidence mean score of 4.50, interpreted as *very true* (see Table 2).

Table 2

Pre-Course Interest Survey Scores for Students Enrolled in Introduction to Agricultural Mechanics by Cognitive Style (N = 31)

Item	*f*	*M*	*SD*	Minimum	Maximum
Overall Pre-Motivation	31	150.45	10.430	129	167
Overall Pre-Motivation by Cognitive Style					
More Adaptive	23	149.57	10.166	129	167
More Innovative	8	153	11.464	135	165
Individual Construct Pre-Motivation by Cognitive Style					
Attention					
More Adaptive	23	4.01	.521	2.250	4.750
More Innovative	8	4.19	.496	3.125	4.625
Relevance					
More Adaptive	23	4.61	.293	3.890	5.00
More Innovative	8	4.68	.509	3.625	5.00
Satisfaction					
More Adaptive	23	4.49	.452	3.56	5.00
More Innovative	8	4.60	.385	4.00	5.00
Confidence					
More Adaptive	23	4.45	.384	3.75	5.00
More Innovative	8	4.50	.509	3.625	5.00

On the post-motivation survey, the average motivation scores were 151.10, with scores ranging from 109-167. Also, the 23 more adaptive individuals had an average score of 152.09, with a range of 109-167 on the post- motivation survey. Whereas the eight more innovative students had an average score of 156 and ranged from 141-167 on the post- motivation survey. In regard to the four CIS construct areas, in the attention area, the more adaptive individuals had a mean score of 4.09, which was interpreted as *mostly true*. The more innovative students had a mean post-attention score of 4.33, which was considered *mostly true*. In the relevancy area, the more adaptive and innovative individuals had a mean score of 4.64, interpreted as *very true*. In the satisfaction area, the more adaptive individuals had a mean score of 4.56, and the more innovative students had a mean score of 4.67, which was recorded as *very true*. Finally, in the area of confidence, the more adaptive students had a score of 4.58, and the more innovative individuals had a post-confidence mean score of 4.70, which was interpreted as *very true* (see Table 3).

Table 3

Post-Course Interest Survey Score for Students Enrolled in Introduction to Agricultural Mechanics by Cognitive Style (n = 31)

Item	*f*	*M*	*SD*	Minimum	Maximum
Overall Post- Motivation	31	153.10	11.80	109	167
Overall Post- Motivation by Cognitive Style					
More Adaptive	23	152.09	12.79	109	167
More Innovative	8	156	8.37	141	167
Individual Construct Pre-Motivation by Cognitive Style					
Attention					
More Adaptive	23	4.09	.565	2.875	5.00
More Innovative	8	4.33	.347	3.875	4.875
Relevance					
More Adaptive	23	4.64	.418	3.110	5.00
More Innovative	8	4.64	.341	4.110	5.00
Satisfaction					
More Adaptive	23	4.56	.455	3.110	5.00
More Innovative	8	4.67	.316	4.110	5.00
Confidence					
More Adaptive	23	4.58	.341	3.75	5.00
More Innovative	8	4.70	.258	4.25	5.00

A Mann-Whitney U test was used to determine the difference between students' motivation and cognitive style. The Mann-Whitney U test determined that there were no statistically significant differences in motivation by cognitive style ($p = .619$) (see Table 4).

Table 4

Mann-Whitney U Test for Differences in Motivation by Cognitive Style for Students Enrolled in Introduction to Agricultural Mechanics

U	*Z*	*p*
81	-.498	.619

Conclusions and Implications

Overall, the statistical analysis revealed there were no statistically significant differences between an individual's cognitive style and motivation. Therefore, the researchers failed to reject the null hypothesis. However, it should be noted that the more innovative students had higher motivations on the pre and post-test than the more adaptive students. Further, when diving deeper into each individual ARCS construct, all students had the highest motivation in the area of relevance and satisfaction. Therefore, the students in this course felt that the course content was relevant to their overall learning and indicated that they were highly satisfied with the course. This conclusion was consistent with research completed by Figland et al. (2019), which indicated students have an overwhelmingly positive perception of a team-based learning formatted agricultural mechanics course and were highly satisfied with the course. However, these findings were not consistent with previous research by McCubbins et al. (2016) and McCubbins et al. (2018), which indicated that working in teams increased student motivation to learn and work collaboratively.

It should be noted that the more innovative individuals had higher motivation on the pre-and post-test than the more adaptive students. As such, an implication from this investigation was that the more innovative students have higher motivation because of the TBL course structure, which allowed them to take control of their learning (Michealsen & Sweet, 2004; Sibley & Ostafichuk, 2015). This conclusion would also be consistent with Kirton (2003), who reported that more innovative individuals prefer a less structured environment that allows for more idea generation ability. However, it should be highlighted that more innovative individuals are the least successful troubleshooters. This finding could be due to the nature of the problem being solved. In this course, all students were given the same troubleshooting problem and a hypothesis generation sheet. The problem that was given was open-ended but only had one solution. On this point, Kirton (2003) found that more innovative individuals tend to get lost in the details and often have difficulty wading through all their ideas. Perhaps the more innovative individuals in this investigation generated too many ideas and had a tough time deciding where to begin, which extended their time to solution and negatively affected their motivation.

Recommendations

Additional research is recommended to investigate the role of cognitive diversity on student motivation. The results from this study indicated no statistically significant relationship existed between cognitive diversity and motivation. However, the more innovative students reported being more motivated on the pre- and post-test than any other group. Investigating factors associated with student motivation may bring insight into the role motivation has on problem-solving ability.

Further research is also warranted to examine the effect an individual's metacognition has problem solving ability and cognitive style. Metacognition is the ability of an individual to regulate their cognitive activity. Research should be done to collect an individual's metacognitive ability to understand what factors can affect overall problem-solving ability. Understanding that association could allow researchers to uncover miscues in the problem-solving process and help the individual become a better problem solver by understanding how the individual regulates their cognitive processes.
Also, replication of this study is needed to increase the population size and statistical power. Increasing the population size to 50 students or more would allow the researchers to analyze the data utilizing parametric statistics without committing Type-II errors. Further, when replicating this study, it is recommended that full random assignment of treatment and control groups be utilized. This will allow the researchers to generalize the findings beyond the population being studied.

Recommendations for Practice

From a practitioner standpoint, it is recommended that individuals be grouped by their cognitive styles in a manner conducive to the learners and environment. Results from a previous study indicated that purposeful cognitive style grouping has an effect on overall problem-solving ability when working in groups. Post-secondary practitioners should be able to recognize different cognitive styles and understand how to format learning activities/materials to meet diverse learning needs and promote problem solving ability.

It is also recommended that institutions utilize TBL or a form of flipped classroom, especially in a laboratory-based setting like agricultural mechanics. Perhaps greater knowledge of such instructional approaches to use in laboratory-based contexts could be addressed through greater professional development opportunities (Granberry et al., 2022, 2023; Roberts et al., 2020a, 2020b). Although results from this study found no differences, the students still had positive perceptions and motivations from the course (Figland et al., 2020a), which indicated students have an overwhelming positive perception of a team-based learning formatted agricultural mechanics course and were highly satisfied with the course.

Limitations

The limitations of this study were the inability of the researchers to control all extraneous variables. Specifically, due to the nature of a pre-experimental study, full randomization of treatments and control groups was not utilized because all students elected to be enrolled in the introductory agricultural mechanics course. To make these findings generalizable, full randomization of treatments and control groups would be necessary. Also, due to the low sample size, the power of the statistical procedures was low. Due to this factor, there was a higher chance of committing a Type-II error. Therefore, non-parametric statistics were utilized to describe and analyze the data to lower the potential for committing a Type-II error. Such limitations warrant future examination of this phenomenon using a larger sample size to distill whether the findings of this study could be corroborated.

References

Artz, G. M., Jacobs, K. L., & Boessen, C. R. (2016). The whole is greater than the sum: An empirical analysis of the effect of team-based learning on student achievement. *NACTA Journal, 60*(4), 405−411. http://www.nactateachers.org/index

Blackburn, J. J., Robinson, J. S., & Lamm, A. J. (2014). How cognitive style and problem complexity affect preservice agricultural education teachers' abilities to solve problems in agricultural mechanics. *Journal of Agricultural Education*, *55*(4), 133–147. https://doi.org/10.5032/jae.2014.04133

Blackburn, J. J., & Robinson, J. S. (2016). Determining the effects of cognitive style, problem complexity, and hypothesis generation on the problem solving ability of school-based agricultural education students. *Journal of Agricultural Education*, *57*(2), 46–59. https://doi.org/10.5032/jae.2016.02046

Campbell, D. T., & Stanley, J. C. (1963). Experimental and quasi-experimental designs for research. In D. T. Campbell & J. C. Stanley (Eds.)., *Handbook of research on teaching*. Routledge.

Dixon, R. A., & Johnson, S. D. (2011). Experts vs. novices: Differences in how mental Representations Are Used in Engineering Design. *Journal of Technology Education*, *23*(1), 47–65. https://scholar.lib.vt.edu/ejournals/JTE/v23n1/pdf/dixon.pdf

Eisner, S. (2010). Grave new world? Workplace skills for today's college graduates. *American Journal of Business Education (AJBE)*, *3*(9), 27–50. https://doi.org/10.19030/ajbe.v3i9.478

Frederickson, N., Reed, P., & Clifford, V. (2005). Evaluating web-supported learning versus lecture-based teaching: Quantitative and qualitative perspectives. *The International Journal of Higher Education and Educational Planning*, *50*(4), 645−664. https://www.learntechlib.org/p/64947/

Figland, W. L., Blackburn, J. J., & Roberts, R. (2020a). Undergraduate students' perceptions of team-based learning during an introductory agricultural mechanics course: A mixed methods study. *Journal of Agricultural Education*, *61*(1), 262–276. https://doi.org/10.5032/jae.2020.01262

Figland, W. L., & Roberts, R., & Blackburn, J. J. (2020b). Reconceptualizing problem solving: Applications for the delivery of agricultural education's comprehensive, three-circle model in the 21st Century. *Journal of Southern Agricultural Education Research*, *70*(1), 1–20. http://jsaer.org/wp-content/uploads/2020/09/70-Figland-Roberts-Blackburn.pdf

Figland, W. L., Blackburn, J. J., Stair, K. S., & Burnet, M. F. (2021). Investigating the effects of cognitive style diversity on the hypothesis generation and troubleshooting ability of undergraduate students enrolled in an introductory agricultural Mechanics Course at Louisiana State University. *Journal of Agricultural Education*, *62*(1), 156–169. https://doi.org/10.5032/jae.2021.01156

Fuhrmann, B. S., & Grasha, A. F. (1983). *The past, present, and future in college teaching: Where does you teaching fit in*? Little, Brown, and Company.

García-Pérez, L., García-Garnica, M., & Olmedo-Moreno, E. M. (2021). Skills for a working future: How to bring about professional success from the educational setting. *Education Sciences*, *11*(1), 27–42. https://doi.org/10.3390/educsci11010027

Gitomer, D. H. (1988). Individual differences in technical troubleshooting. *Human Performance, 1*(2), 111–131. https://doi.org/10.1207/s15327043hup0102_3

Gokhale, A. A. (1995). Collaborative learning enhances critical thinking. *Journal of Technology Education, 7*(1), 22−30. https://scholar.lib.vt.edu/ejournals/JTE/v7n1/pdf/gokhale.pdf

Granberry, T., Blackburn, J.J., & Roberts, R. (2023). The state of agricultural mechanics in the preparation of school-based agricultural education teachers. *Journal of Agricultural Education, 64*(4). https://doi.org/10.5032/jae.v64i4.160

Granberry, T., Roberts, R., & Blackburn, J. J. (2022). "A challenge that I'm willing to take on:" The self-efficacy of female undergraduate students in agricultural mechanics. *Journal of Agricultural Education*, *63*(3), 44–58. https://doi.org/10.5032.jae.2022.03044

Johnson, S. D. (1989). A description of expert and novice performance differences on technical troubleshooting tasks. *Journal of Industrial Teacher Education, 26*(3), 19–37. https://doi.org/10.1111/j.1937-8327.1988.tb00021.x

Johnson, S. D. (1991). Productivity, the workforce, and technology education. *Journal of Technology Education, 2*(2), 1−18. https://scholar.lib.vt.edu/ejournals/JTE/v2n2/pdf/johnson.pdf

Jonassen, D. H. (2000). Toward a design theory of problem solving. *Educational Technology: Research and Development, 48*(4), 63−85. http://link.springer.come/article/10.007%2FBF02300500LI=true#page-1

Keller, J. M. (2010). *Motivational design for learning and performance: The ARCS model approach.* Springer.

Kirton, M. J. (1999). *Kirton adaption-innovation inventory feedback booklet*. Occupational Research Center.

Kirton, M. J. (2003). *Adaption-innovation: In the context of diversity and change*. Routlage.

Kirton, M., Bailey, A., & Glendinning, W. (1991). Adaptors and innovators: Preference for educational procedures. *The Journal of Psychology*, *125*(4), 445–455. https://psycnet.apa.org/doi/10.1080/00223980.1991.10543307

Lage, M. J., Platt, G. J., & Treglia, M. (2000). Inverting the classroom: A gateway to creating an inclusive learning environment. *The Journal of Economic Education*, *31*(1), 30–43. https://www.tandfonline.com/doi/abs/10.1080/00220480009596759

Lamm, A. J., Shoulders, C., Roberts, T. G., Irani, T. A., Unruh, L. J., & Brendemuhl, J. (2012). The influence of cognitive diversity on group problem solving strategy. *Journal of Agricultural Education, 53*(1), 18–30. https://doi.org/10.5032/jae.2012.01018

McCubbins, O. P., Paulsen, T. H., & Anderson, R. (2018). Student engagement in a team-based capstone course: A comparison of what students do and what instructors value. *Journal of Research in Technical Careers*, *2*(1), 8−21. https://doi.org/10.9741/2578-2118.1029

McCubbins, O. P., Paulsen, T. H., & Anderson, R. G. (2016). Student perceptions concerning their experience in a flipped undergraduate capstone course. *Journal of Agricultural Education*, *57*(3), 70–86. https://doi.org/10.5032/jae.2016.03070

Michaelsen, L. K., & Sweet, M. (2008). The essential elements of team-based learning. *New Directions for Teaching and Learning*, *2008*(116), 7−27. 1 https://doi.org/10.1002/tl.330

Michaelsen, L. K., Knight, A. B., & Fink, L. D. (2004). *Team-based learning: A transformative use of small groups*. Stylus Publishing, LLC.

Nieder, G. L., Parmelee, D. X., Stolfi, A., & Hudes, P. D. (2005). Team-based learning in a medical gross anatomy and embryology course. *Clinical Anatomy*, *18*(1), 56–63. https://doi.org/10.1002/ca.20040

Pate, M. L., & Miller, G. (2011a). Effects of regulatory self-questioning on secondary students' problem-solving performance. *Journal of Agricultural Education, 52*(1), 72–84. https://doi.org10.5032/jae.2011.01072

Pate, M. L., & Miller, G. (2011b). Effects of think-a-loud pair problem solving on secondary-level students' performance in career and technical education courses. *Journal of Agricultural Education*, *52*(1), 120−131. https://doi.org/10.5032/jae.2011.01120

Phipps L. J., & Osborne, E. W. (1988). *Handbook on agricultural education in public schools.* The Interstate Printers & Publishers, Inc.

Roberts, R., & Robinson, J. S. (2018). The motivational changes preservice agricultural education teachers endure while facilitating quality supervised agricultural experiences: A six-week project-based learning experience. *Journal of Agricultural Education, 59*(1), 255–270. https://doi.org/10.5032/jae.2018.01255

Roberts, R., Terry, R., Jr., Brown, N. R., & Ramsey, J. W. (2016). Students' motivations, value, and decision to participate in service-learning at the National FFA Days of Service. *Journal of Agricultural Education*, *57*(2), 199–214. https://doi.org/10.5032/jae.2016.02199

Roberts, R., & Stair, K. S., Granberry, T. (2020a). Images from the trenches: A visual narrative of the concerns of preservice agricultural education teachers. *Journal of Agricultural Education*, *61*(2), 324–338. https://doi.org/10.5032/jae.2020.02324

Roberts, R., Witte, B. M., Stair, K. S., Blackburn, J. J., & Smith, H. E. (2020b). The dimensions of professional development needs for secondary agricultural education teachers across career stages: A multiple case study comparison. *Journal of Agricultural Education*, *61*(3), 128–143. https://doi.org/10.5032/jae.2020.03128

Rodríguez-Sabiote, C., Olmedo-Moreno, E. M., & Expósito-López, J. (2022). The effects of teamwork on critical thinking: A serial mediation analysis of the influence of work skills and educational motivation in secondary school students. *Thinking Skills and Creativity*, *45*, 101–163. https://doi.org/10.1016/j.tsc.2022.101063

Salkind, N. (2010). *Encyclopedia of research desig*n. Sage.

Sibley, J., & Ostafichuk, P. (2015). *Getting started with team-based learning*. Stylus Publishing, LLC.

Strayer, J. (2007). *The effects of the classroom flip on the learning environment: A comparison of learning activity in a traditional classroom and a flip classroom that used an intelligent tutoring system* (Doctoral dissertation). The Ohio State University, Columbus.

U.S. Department of Education. (2001). *The condition of education 2001*. https://nces.ed.gov/pubs2001/2001072.pdf

Ulmer, J. D., & Torres, R. M. (2007). A comparison of the cognitive behaviors exhibited by secondary agriculture and science teachers. *Journal of Agricultural Education, 48*(4), 106–116. https://doi.org/0.5032/jae.2007.04106

Van Der Zanden, P.; Denessen, E., Cillessen, A., Meijer, P.C. (2018). Domains and predictors of first-year student success: A systematic review. *Educational Research Review, 23,* 57-77. https://doi.org/10.1016/j.edurev.2018.01.001

Witkin, H. A., Moore, C. A., Goodenough, D. R., & Cox, P. W. (1977). Field-dependent and field-independent cognitive styles and their educational implications. *Review of Educational Research, 47*(1), 1−64. https://journals.sagepub.com/doi/pdf/10.3102/00346543047001001