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Determining the Effects of the Smartphone as a Learning Tool on the Motivation of School-Based Agricultural Education Students in Louisiana

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Abstract

The smartphone is perhaps the most influential device in modern society. Research has indicated students perceived that using smartphones in the classroom aided learning. However, most American high schools ban students from using phones in the classroom. Previous research supports the idea that advanced smartphone applications in student- centered learning environments can improve achievement and motivation. Currently, there is little in the agricultural education literature pertaining to smartphone enhanced learning among secondary agriculture students. This study compared motivational differences between non-equivalent comparison groups. Secondary agricultural students from 13 schools across Louisiana completed the Course Interest Survey to measure motivation during a forestry unit. Data were analyzed using Hierarchical Linear Modeling. The analysis rendered no statistically significant differences between the groups in motivation. It was concluded that smartphones do not reduce motivation and should be considered in agricultural education classrooms where policy permits.

Keywords: smartphone; mobile learning; technology; forestry education

Introduction and Literature Review

In the most recent decade, information and communication technology experienced rapid developments lead by the Internet- capable cellular devices (Christin, Tamin, Santosa, & Miharja, 2014). Specifically, the smartphone has changed our daily lives more than any other technology in the past decade (Romero, 2011). Growth in wireless Internet has greatly expanded the boundaries of what could be accomplished with a cellular phone. Between 1981 and the present, wireless network speed increased exponentially from first- generation analog (i.e., 1G) to fourth- generation long term evolution (i.e., 4G LTE) (Sharma, 2013). Increase in wireless Internet speeds is but one reason that demand for smartphones has increased so dramatically. Smartphone technology has also continued a pattern of offering more power and becoming less expensive over a relatively short period of time (Shuler, 2009). In fact, there were almost a billion more cellular subscriptions than landline telephone connections in 2005 (Comer & Wikle, 2008) and smartphones began to replace personal computers almost as soon as the devices were able to access the internet. Smartphone sales surpassed laptops in

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2007 leading to more people who browsed the internet via cellular phone than traditional computers (Romero, 2011). In one tool, the smartphone incorporated all the capabilities of (a) music players, (b) cameras, (c) televisions, (d) Global Positioning Systems, (e) remote controls, (f) gaming consoles, (g) personal computers, and (h) even replaced routers by becoming wi-fi hotspots (Romero, 2011). These powerful devices may have an untold number of applications that could influence modern education in the United States and across the globe.

Millennials have grown up with a touchscreen mobile device in their hands and often rely heavily on technology to study and learn (Prensky, 2001). These students, defined as *digital natives* have been perceived as an academically driven group who require an updated classroom led by a skilled teacher armed with the most recent educational technology available (Williams, Warner, Flowers, & Croom, 2014). Millennial students are motivated by cutting edge technologies and smartphones have allowed them to utilize technology to foster their creativity (Su & Cheng, 2015).

Further, students have reported they perceived the utilization of smartphones for learning would increase their academic achievement (Gikas & Grant, 2013). However, smartphones are often viewed as a distraction by teachers and school administrators (Laskin & Avena, 2015). In fact, Commonsense Media (2010) reported 69% of school districts in the United States banned mobile phones in the classroom. Similarly, Smith, Stair, Blackburn, and Easley (2018) reported that less than one-third of agriculture teachers in Louisiana were employed in school districts where smartphones were allowed in the classroom. However, bans did not effectively stop students from bringing their devices to schools. Students reported even though they attend a school with a ban on cell phones, most carry them anyway (Lenhart, Ling, Campbell & Purcell, 2010).

The literature is mixed as to the effectiveness of the smartphone as a learning tool (Liu, Scordino, Renata, Navarrete, Yujung, & Lim, 2015; Liu & Huang, 2015; Su & Cheng, 2015). Often only basic functions such as the calendar, clock, and internet access are utilized by educators when smartphones are employed for learning (Thomas & Muñoz, 2016). Smith, Blackburn, Stair, and Burnett (2018) reported no statistically significant differences in the achievement of school-based agricultural education students who learned through the use of a smartphone versus those taught through traditional, printed materials in a forestry unit. However, empirical evidence has also suggested student achievement is increased when more advanced applications, such as (a) creating content, (b) posting information online, and (c) recordings are utilized (Liu et al., 2015; Su & Cheng, 2015).

In addition to achievement, learner motivation has been a variable of interest regarding smartphones in the classroom. Motivation has a direct influence on the amount of time a student will dedicate to learning [National Research Council (NRC), 2000]. Therefore, a lack of achievement in the classroom is often linked to a lack of motivation to perform (Dowdall & Colangelo, 1982; Reis & McCoach, 2000; Whitmore, 1982). However, motivation is complex. Students can be motivated through both intrinsic and extrinsic sources and motivation can change over time (Keller, 2010). Motivation encompasses more than classroom engagement, it also includes elements that cross the affective, cognitive, and psychomotor domains and people can be motivated by many factors including but not limited to: (a) emotions; (b) psychomotor characteristics; (c) physiological factors; and (d) cognitive components. (Keller, 2010).

In terms of technology, research has indicated the implementation of the smartphone into the learning process can have a positive impact on student motivation. Specifically, Yamamota and Wakahara (2013) reported an increase in motivation when students were allowed to utilize their smartphones to participate in class activities and access a virtual learning platform. Similarly, Su and Cheng (2015) concluded allowing students to use their smartphones in a gamified mobile learning system increased motivation to learn the content. Jung (2014) discussed the ubiquitous nature of the smartphone increased learner satisfaction and motivation. Overall, these factors have indicated technology generally has a positive impact on motivation, despite concerns of a smartphone being a distraction to the educational environment. Despite this, there is little discussion on how these modern technologies can be used more effectively within agricultural education.

Conceptual Framework

This study was conceptually underpinned by the Attention, Relevance, Confidence, and Satisfaction (ARCS) model for measuring learner motivation on a situational basis (Keller, 2010). Keller's (1987) ARCS model has been regarded as one of the most respected instructional design models in the United States (Bohlin, 1987). Keller (1987) postulated that students work harder toward activities they perceive are valuable and where success is reachable. Further, empirical evidence has shown that motivation can account for 16%–38% variance in student achievement scores (Means, Jonassen, & Dwyer, 1997). The first construct of the model, Attention, has been related to interest (Keller, 1987). Capturing and maintaining student interest in a learning environment is essential to instructional success and student achievement. "Attention is a combination of some key concepts including arousal, boredom, and curiosity" (Keller, 2010, p. 76). Being below ones optimal level of arousal due to boredom can be attributed to (a) unpleasantness, (b) constraint, (c) monotony, and (d) repetitiveness (Geiwitz, 1966).

Relevance is a construct best explained in pragmatic terms. Students often question how a lesson or topic of study will be useful in everyday life. Motivation research has suggested more effective teachers demonstrated relevance to their students better with animated stories that were derived from a deep understanding of the material (Keller, 2010). Communication research supports relevance as the central factor in determining whether or not people respond to a novel stimulus (Sperber & Wilson, 1986). It has been reported people only pay attention to the extent that a connection is found between the stimuli and significance to the subject's personal lives (Sperber & Wilson, 1986). When a person reaches the highest state of perceived relevance they have a heightened interest in a task, they are fully concentrated and unconcerned about success/failure and they experience pleasure while working (Keller, 2010). Environmental or psychological forces could not distract those who experienced this heightened state for an extended period of time (Csikszentmihalyi, 1990).

Confidence is generally aligned with how highly people expected to succeed or fail and how much control over a situation people perceived they have (Keller, 2010). Individual perceptions of control and predictability strongly relate to the psychological aspects of confidence (Keller, 2010). Rotter (1954) developed the notion of people's perception of control as either internal or external. Individuals with an internal locus of control tend to be more successful academically (DuCette & Wolk, 1973; Dollinger, 2000; Phares, 1976). Keller (2010) recommended teachers build confidence in students by ensuring they understood what was expected and could identify how to maximize their likelihood for success.

Satisfaction has often been reported to be influenced by one's subjective reflection of a personal outcome compared to societal outcomes (Keller, 2010). People are often not satisfied if they are not achieving the same goals or receiving the same rewards as their peers (Keller, 2010). Festinger (1957) introduced the idea of cognitive dissonance where dissonance was an uncomfortable state that people will attempt to reduce by achieving equally with their peers. To increase satisfaction, it has been recommended that teachers (a) use praise for correct responses liberally, (b) avoid boring tasks and drills, (c) give students personal attention, and (d) avoid the use of threats to get results (Keller, 2010).

No research exists in agricultural education that has investigated the motivational characteristics of the smartphone as a learning tool. Many school districts have banned the use of smartphones in the classroom (Commonsense Media, 2010; Smith et al., 2018), therefore few accessible populations of teachers may exist. Further, Coley, Warner, Stair, Flowers, and Croom (2015) reported few agriculture teachers in Tennessee even had access to mobile devices to use for learning. Therefore, the principal question that arose from the review of literature was: what effect does utilizing the smartphone for learning have on the motivation of Louisiana school-based agricultural education students? This research aligns with the American Association for Agricultural Education's National Research Agenda Research Priority 4: Meaningful, Engaged Learning in All Environments. Specifically, this study helps to provide answers to Research Priority Question One: "How do digital technologies impact learning in face-to-face and online learning environments?" (Edgar, Retallick, & Jones, 2016, p. 39).

Purpose of the Study

The purpose of this study was to compare the motivation (i.e., Attention, Relevance, Confidence, Satisfaction, and overall motivation) of students in a forestry curriculum based on learning through smartphone technology or traditional, printed materials. The following research questions guided the study:

1. Describe the motivation (eg., Attention, Relevance, Confidence, Satisfaction and overall motivation) of Louisiana school-based agricultural education students learning tree identification.
2. What differences existed in overall motivation between students learning through smartphone technology and students learning through printed materials?

Null Hypothesis

H_o1: There were no statistically significant differences in Attention, Relevance, Confidence, Satisfaction, and overall motivation between students learning through smartphones and students learning through printed materials.

Methods and Procedures

Data collected for this study were a part of a larger study that also sought to compare the achievement differences of students taught utilizing smartphones versus those taught through traditional, printed materials. Therefore, the design of this study mirrors Smith et al. (2018). This pre-experimental study design employed nonequivalent comparison groups. (Campbell & Stanley, 1963; Shadish, Cook & Campbell, 2002). Seven agriculture teachers were assigned to the treatment group and fully completed all parts of the study and six were in the comparison group. The treatment group was comprised of $n = 128$ and $n = 135$ students were in the comparison group who were either enrolled in Agriscience I or Agriscience II. These courses are where an introduction to forestry unit is most commonly taught in Louisiana. Table 1 depicts the personal characteristics of the students as reported in Smith et al. (2018). The majority (73.4%) of the students were male and Caucasian (71.5%). Over 60% of the students were either 15 or 16 years of age.

Table 1

Personal Characteristics of Louisiana Students Enrolled in Secondary Agriculture Classes Offering a Forestry Curriculum in the Fall of 2016 (n = 263)

Variable		*F*	*%*
Gender			
	Male	193	73.4
	Female	70	26.6
Age			
	13	10	3.8
	14	37	14.1
	15	77	29.3
	16	82	31.2
	17	44	16.7
	18	12	4.6
	19	1	0.4
Ethnicity			
	Caucasian	188	71.5
	African-American	51	19.5
	Asian	3	1.1
	American Indian	3	1.1
	Hispanic	9	3.4
	Other	9	3.4

Neither random sampling nor random assignment was utilized in this study due to the small number of school districts with policies that allowed the use of smartphones in the class. Approximately 30% of school districts in Louisiana allow the use of smartphones for learning Smith et al. (2018). Since randomization was not employed, pretreatment equivalence was not assumed. Smith et al. (2018) reported no differences in content knowledge as measured on a 30-item pretest.

Recruitment of Participants and Training

Agriculture teachers in Louisiana were invited to participate in this study as a member of the treatment group if they met the following criteria: (a) volunteered to participate; (b) taught high school courses; (c) taught 50 minute periods; and (d) were employed in a district with a policy that allowed the use of smartphones in the classroom. Comparison group teachers only had to meet the first three criteria. A total of 16 teachers were identified for the treatment group and 14 were identified for the comparison group. The 30 teachers were invited to attend a workshop during the 2016 Louisiana Agriscience Teachers' Association summer conference and 22 attended.

The beginning of the workshop focused on basic leaf identification (i.e., leaf parts, leaf arrangements, leaf margins, and leaf types). During the second phase of the workshop, teachers were separated by treatment (n = 10) and comparison (n = 12) groups. The teachers in the treatment group were taught how to employ two smartphone applications, LeafSnap® and V-tree, to identify 30 species of trees native to Louisiana. The treatment group was also taught how to employ Quizlet to formatively assess students. The comparison group teachers were taught how to utilize traditionally, printed materials (e.g., field guides) to identify the same 30 tree species. This group was provided paper flashcards to engage students in formative assessment. The groups were then brought back together and taught how to utilize Test Generator (TG) Web© to assess students' leaf identification knowledge.

A second workshop was initially scheduled for late summer of 2016, however, this workshop was cancelled due to The Great Flood of 2016 that affected a large portion of Louisiana. Small group and individual training sessions were utilized to replace the second workshop. This training focused on how to (a) follow the study protocol, (b) employ the smartphone applications (treatment group) or printed materials (comparison group), and (c) employ guided inquiry to teach the lessons. All teachers received between two and three hours of training to teach the lessons. Fidelity of the treatment was ensured by having teachers complete daily logs, which were returned at the end of the study. All data were collected between September 19, 2016, and September 27, 2016, for a total of seven instructional days. Table 2 provides a summary of the procedures utilized by both groups of teachers Smith et al. (2018).

Table 2

Instructional Procedures Utilized by the Treatment and Comparison Groups

Instructional Day	Specific Tasks Completed
1	Pre-test of tree leaf identification; download applications
2	Lesson on the Importance of Forestry and Leaf Identification Terminology
3	Identification of tree leaf samples; formative assessment
4	Identification of tree leaf samples; formative assessment
5	Identification of tree leaf samples; formative assessment
6	Identification of tree leaf samples; formative assessment
7	[a]Course Interest Survey Administered; [b]Post-Test of tree leaf identification

Note. [a] Data utilized in the current study. [b] Data reported in Smith et al. (2018);

Instrumentation

Student motivation was assessed with the Course Interest Survey (CIS) created by Keller (2010). The overall goal for the CIS is to assess how motivated students are with respect to a specific lesson or class being taught. Keller (2010) discussed that the CIS is not a general measure of motivation, but a situation- specific instrument. The instrument contained 34 items, which measured the four subscales of the ARCS model. The Likert-type items recorded student levels of agreement using a five-point scale (1 = Not True; 2 = Slightly True; 3 = Moderately True; 4 = Mostly True; 5 = Very True). All students in the study completed the instrument online immediately before they completed the post-test. Keller (2010) reported all reliability coefficients for the subscales of the CIS were between α = 0.81 and α = 0.95, therefore a pilot study was not conducted. Post-hoc reliability analysis for this study yielded α = 0.78 for Attention, α = 0.84 for Relevance, α = 0.71 for Confidence, and α = 0.81 for Satisfaction.

Data Analysis

Data associated with the first research objective were analyzed through measures of central tendency, specifically the mean and standard deviation. Keller (2006) outlined scoring procedures for the CIS, and included utilizing the mean for the subscales and overall motivation. It should be noted that some negatively worded items required reverse coding so that a higher mean indicted increased motivation.

The second research objective sought to determine if differences existed in student motivation between students who learned through smartphone technology and students who learned through printed materials. To accomplish this goal, hierarchical linear modeling (HLM) was employed. The independent variable was grouped (i.e., treatment or control). The dependent variables were the four constructs measured by the CIS (i.e., Attention, Relevance, Confidence, and Satisfaction) as well as overall motivation. An intraclass correlation coefficient (ICC) was calculated (ICC = 9.4%) to ensure HLM was appropriate for the nested data. ICC values ranging from 5% to 20% warrant social sciences research to employ HLM (Muthén, 1994; Raudenbush & Bryk, 2002; Peugh, 2010). After calculating the ICC from the unconditional model, the HLM technique had three steps. The first step produced the level one model which measured student differences in each DV at the school level. The second step produced the full model which measured group- level outcomes on the DV nested in schools. The third step utilized likelihood ratio testing to determine if adding a school-level variable improved the level one model. This model building process was necessary to determine if adding school level effects improved the model. Most importantly, step two (full model) specifically addressed research question number two. The final analysis conducted on all variables in the model consisted of a treatment group (n = 128) and a comparison group (n = 135) that completed the CIS instrument after the learning process was completed.

Findings

Research question one sought to describe the motivation of Louisiana school-based agricultural education students who learned leaf identification through smartphone technology and those taught through traditional, printed materials (see Table 4). For both the treatment group (M = 3.24; SD = 0.79) and comparison group (M= 3.42; SD = 0.79) means for Attention were in the real limits of Moderately True. Treatment group means for Relevance (M=3.52; SD=0.85), Confidence (M = 3.86; SD = 0.69), and Satisfaction (M = 3.55; SD = 0.82) fell in the real limits of Mostly True. Similarly, comparison group means for Relevance (M = 3.60; SD = 0.80), Confidence (M = 3.93; SD = 0.68), and Satisfaction (M = 3.61; SD = 0.81) fell in the real limits of Mostly True. The overall motivation for the treatment group (M = 3.54; SD = 0.71) and comparison group (M = 3.64; SD = 0.69) were in the real limits of Mostly True.

Table 3

Attention, Relevance, Confidence, Satisfaction and Overall Motivation of the Treatment (n=128) and Comparison Group (n = 135)

Construct	*M*	*SD*
Attention		
Treatment Group	3.24	0.79
Comparison Group	3.42	0.79
Relevance		
Treatment Group	3.52	0.85
Comparison Group	3.60	0.80
Confidence		
Treatment Group	3.86	0.69
Comparison Group	3.93	0.68
Satisfaction		
Treatment Group	3.55	0.82
Comparison Group	3.61	0.81
Overall Motivation		
Treatment Group	3.54	0.71
Comparison Group	3.64	0.69

Note. Real Limits 1.00–1.49 = Not True; 1.50–2.49 = Slightly True; 2.50–3.49 = Moderately True; 3.50–4.49 = Mostly True; 4.50–5.00 = Very True

The second research question sought to determine if differences existed in overall motivation between students who learned with smartphones and those who learned with printed materials. The level one predictor for overall motivation was the grouping variable (treatment or comparison). The intercept in this model was based on the fixed effects and was the treatment group mean (120.5). There was no statistically significant difference ($p > .05$) in overall motivation (see Table 4) between the treatment ($n = 128$) and comparison group ($n = 135$) at level one ($\gamma_{00} = 3.18$, SE = 2.95, $t = 1.10$, df = 263, $F = 1.17$ and $p = .281$).

Table 4

Level One Model for Overall Motivation between Treatment and Comparison group before accounting for individual differences

Fixed effects	*Coefficient (SE)*	*t (df)*	*F (p)*
Level one model			
Intercept ($_{1j}$ mean)	120.5 (2.11)	57.0 (263)	6853.4 (.000)
Group ($_{0j}$) variance nested in school (γ_{00})	3.18 (2.95)	1.10 (263)	1.17 (.281)

Note: Deviance (maximum likelihood) $X^2 = 2415.8$; three estimated parameters.

The full model analyzed overall motivation between groups as a function of school (see Table 5). The new intercept estimate (120.2) was the mean for the treatment group adjusted for individual differences by school. There was no statistically significant difference ($p > .05$) in motivation between the nested treatment ($n = 128$) and comparison group ($n = 135$) at level two ($\beta_{0j} = 1.04$, SE = 5.94, $t = .176$, df = 11, $F = .031$ and $p = .864$). The critical value for X^2 (df = 1) was 6.63 ($p < .01$). The -2LL ratio test between the models yielded statistically significant differences when the variance due to group was confounded with the variance due to school ($X^2 = 15.1$, df = 1, $p < .01$).

Table 5

Full Model for Motivation between the Treatment and Comparison Group after Adjusting for Individual Student Differences as a Function of School

Fixed effects	*Coefficient (SE)*	*t (df)*	*F (p)*
Intercept (adjusted β_{1j} mean)[a]	120.2 (4.11)	29.2 (12)	1648.7 (.000)
Group (β_{0j}) variance nested in schools	1.04 (5.94)	.176 (11)	.031 (.864)

Note: Deviance (maximum likelihood) = 2400.7; four estimated parameters, fixed effect was group (IV) and random effect was school (subject)

Conclusions

After analyzing the results from the CIS, it can be concluded that these students were, overall, motivated to learn tree leaf identification regardless of whether they were taught through smartphone technology or printed materials. Regarding the CIS subscales, both groups of students believed the content was relevant. These students were also confident they could be successful. Further, both groups of students felt satisfied with the unit of instruction, regardless of how they were taught. However, both groups of students perceived attention as the lowest of the subscales. The mean of the attention subscale was not low enough to conclude the students were not interested. However, the attention subscale was not rated high enough to confidently conclude these students were highly interested in the topic of leaf identification.

HLM analysis of data concerning students using smartphones to improve learner motivation failed to provide a statistically significant difference when compared to students using printed materials as determined on a multilevel analysis of motivation. Consequently, we failed to reject the null hypothesis. It can be concluded that utilizing smartphone technology to teach tree identification does not influence a student's motivation, positively nor negatively. This conclusion contradicts previous research that indicated learner motivation was increased when smartphones were implemented for learning (Burns-Sardone, 2014; Jung, 2014; Hwang & Chang, 2011; Lin-Siegler, Dweck & Cohen, 2016; Liu & Huang 2015; Su & Cheng, 2015; Yamamota & Wakahara, 2013).

Discussion and Implications

While research in the educational literature regarding smartphone usage and effectiveness is mixed, anecdotal evidence supported the broad education literature that smartphones increase students' motivation to learn (Burns-Sardone, 2014; Jung, 2014; Hwang & Chang, 2011; Lin-Siegler, Dweck & Cohen, 2016; Liu & Huang 2015; Su & Cheng, 2015; Yamamota & Wakahara, 2013). However, this research study indicated there were no differences in motivation when smartphones were employed for tree identification.

One important note was that the CIS subscale of Attention was rated lower than the other components of the instrument. This begs the question *Why?* Keller (2000) discussed that one element of attention is variation. Perhaps the repetitive nature of learning tree leaves and being formatively assessed each day caused the students to lose interest and subsequently rate attention lower than the other constructs. It is possible that attention would have been rated higher if the leaf identification curriculum had been designed to include a wider variety of activities. Though not statistically significant, the comparison group reported slightly higher motivation scores on all four CIS subscales. It is unclear what, if any, aspects of the lessons may account for those possible changes.

Keller's ARCS model is highly focused on how Attention relates to interest (Keller, 1987). If gaining and maintain attention is key to instructional success and student achievement, then these students may have been too accustomed to using their phones in class. None of the treatment group schools were in their first year of smartphone use, therefore, the novelty effect of using smartphones for learning may have been less impactful then if smartphone use was being implemented for the first time in the classroom. Perhaps these digital natives (Prensky, 2001) were desensitized to the smartphone and its effectiveness as a motivator was negated. Feasibly, this research may be reinforcing the notion that *good teaching is good teaching* and the employment of smartphones, like other educational technologies, is not a magic solution, but rather one more pedagogical tool for teachers to utilize.

The nature of students using smartphones also makes it difficult to truly measure how they may have directly impacted learning. For any new technology, there are barriers to implementation. The time to download and gain familiarity with the smartphone applications was part of the research protocol that was not included for students in the comparison group. Teachers in the treatment group could have been faced with integration barriers such as student skill level, lack of time to plan, and technical support (Kotrlik, Redmann, & Douglas, 2003; Coley et al., 2015) that decreased their perceived value of using the specific apps used in this study. If so, a negative impact on student motivation may have developed during the course of the study.

Recommendations

Future research should utilize the CIS at multiple points during the data collection process, similar to the work of Bunch (2012). This would allow for a baseline measure of motivation across the ARCS subscales to determine if, or how, motivation changes throughout a unit of instruction. Additionally, future studies should incorporate the ARCS model of planning (Keller, 2000) in conjunction with utilizing smartphone technology in the classroom. The findings of this study provide a very robust statistical analysis that failed to find significant differences in motivation between students who used smartphones and those who did not use smartphones. Most importantly, the findings suggest that smartphones are a valid learning tool because they do not diminish motivation. Agricultural educators can, therefore, be more confident in incorporating smartphones into their teaching practice without reservations of its effectiveness.

Further research should more closely examine the process and reactions of student groups while using smartphones in class. There were many unanswered questions as a result of this study. Additional research, perhaps through qualitative inquiry can better examine student reactions and perceptions of smartphone usage in the classroom. It is also possible that because the lessons were so carefully constructed, that students were equally engaged. Additional analysis of student reaction could help gain insight of their attention and motivation throughout the learning process.

More research should be conducted to understand how the motivation of using smartphones changes over time. While previous studies have suggested that smartphones increase engagement, they are also dated in terms of smartphone advancements and technology. A greater understanding of how students considered to be digital natives perceive smartphone usage is critical to better understand their effectiveness in agricultural education and all areas of secondary education.

Limitations

The following limitations should be considered:

1. Full power of random assignment was not utilized to select participating schools; therefore generalizability cannot extend beyond the participants in the study.
2. Variability, such as competence/interest in forestry or time of day forestry was taught, may have existed between schools in the study. Teacher effect may also be a limitation as factors such as years of experience, enthusiasm, and knowledge about forestry may have impacted teacher performance.
3. Non-treatment related variability, such as student background, prior knowledge or some other construct may have existed between the treatment and comparison groups.

References

Bohlin, R. M. (1987). Motivation in instructional design: Comparison of an American and a Soviet model. *Journal of Instructional Development, 10*(2), 11–14. doi: 10.1007/bf02905786

Bunch, J. C. (2012). *The effects of a serious digital game on the animal science competency, mathematical competency, knowledge transfer ability, and motivation of secondary agricultural education students* (Unpublished doctoral dissertation). Oklahoma State University, Stillwater, OK.

Burns-Sardone, N. (2014). Making a case for BYOD instruction in teacher education. *Issues in Informing Science and Technology, 11*(1), 192–200. Retrieved from http://iisit.org/Vol11/IISITv11p191- 201Sardone0505.pdf

Campbell, D. T., & Stanley, J. C. (1963). *Experimental and quasi-experimental design for research.* Chicago, IL: Rand McNally & Company.

Christin, G. N., Tamin, O. Z., Santosa, I., & Maharja, M. (2014). Adjustment of daily activities: The influence of smartphone adoption on the travel patter of mobile professionals in the greater Jakarta area. *Journal of Engineering and Technological Sciences, 46*(4), 394–409. doi: 10.5614/j.eng.technol.sci.2014.46.4

Coley, M. D., Warner, W. J., Stair, K. S., Flowers, J. L., & Croom, D.B. (2015) Technology usage of Tennessee agriculture teachers. *Journal of Agricultural Education 56*(3), 35–51. doi: 10.5032/jae.2015.03035

Comer, J. C., & Wikle, T. A. (2008). Worldwide diffusion of the cellular telephone, 1995-2005. *Professional Geographer, 60*(2), 252–269. doi: 10.1080/00330120701836303

CommonSense Media. (2010). *Hi-tech cheating: Mobile phones and cheating in schools: A national poll.* Retrieved from https://www.commonsensemedia.org/blog/cheating-goes-hi-tech

Csikszentmihalyi, M. (1990). *Flow: The psychology of optimal experience.* New York, NY: Harper and Row.

Dollinger, S. J. (2000). Locus of control and incidental learning: An application to college student success. *College Student Journal*, *34*(4), 537-540. Retrieved from https://www.questia.com/library/journal/1G1-69750050/locus-of-control-and-incidental-learning-an-application

Dowdall, C. B., & Colangelo, N. (1982). Underachieving gifted students: Re-view and implications. *Gifted Child Quarterly, 26,* 179-184.

DuCette, J., & Wolk, S. (1973). Cognitive and motivational correlates of generalized expectancies for control. *Journal of Personality and Social Psychology, 26*(3), 420–426. doi: 10.1037/h0034486

Edgar, D. W., Retallick, M. S., & Jones, D. (2016). Research priority 4: Meaningful, engaged learning in all environments. In T. Roberts, A. Harder, & M. Brashears (Eds.), *American Association for Agricultural Education National Research Agenda* (pp. 37–40). Retrieved from http://aaaeonline.org/resources/Documents/AAAE_National_Research_Agenda_2016-2020.pdf

Festinger, L. (1957). *A theory of cognitive dissonance*. Stanford, CA: Stanford University Press.

Geiwitz, J. P. (1966). Structure of boredom. *Journal of Personality and Social Psychology,* 3(5), 592–600. doi: 10.1037/h002302

Gikas, J., & Grant, M. M. (2013). Mobile computing devises in higher education: Student perspectives on learning with cellphones, smartphones & social media. *Internet and Higher Education, 19,* 18–26. doi: 10.1016/j.iheduc.2013.06.002

Hwang, G., & Chang, H. (2011). A formative assessment-based mobile learning approach to improving the learning attitudes and achievements of students. *Computers & Education*, *56*(4), 1023–1031. doi: 10.1016/j.compedu.2010.12

Jung, H. J. (2014). Ubiquitous learning: Determinants impacting learners' satisfaction and performance with smartphones. *Language Learning & Technology, 18*(3), 97–119. Retrieved from https://scholarspace.manoa.hawaii.edu/bitstream/10125/44386/1/18_03_jung.pdf

Keller, J. M. (1987). Development and use of the ARCS model of instructional design. *Journal of Instructional Development, 10*(3), 2–10. doi: 10.1007/BF02905780

Keller, J. (2006). *Development of two measures of learner motivation.* Unpublished Manuscript. Florida State University, Tallahassee, FL.

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

Kotrlik, J. K., Redmann, D. H., & Douglas, B. B. (2003). Technology integration by agriscience teachers in the teaching/learning process. *Journal of Agricultural Education 44*(3), 78–90. doi: 10.5032/jae.2003.03078

Laskin, A. V., & Avena, J. (2015). Introduction of mobile media into formal classroom learning environments. *Journalism & Mass Communication Educator, 70*(3), 276–285. doi:10.1177/1077695815601170

Lenhart, A., Ling, R., Campbell, S., & Purcell, K. (2010). Teens and mobile phones. *Pew Research Center*. Retrieved from http://pewinternet.org/Reports/2010/Teens-and-Mobile-Phones.aspx

Lin-Siegler, X., Dweck, C. S., & Cohen, G. L. (2016). Instructional interventions that motivate classroom learning. *Journal of Educational Psychology, 108*(3), 295–299. doi:10.1037/edu0000124

Liu, M. C., & Huang, Y. M. (2015). Collaborative experience sharing with the support of M-Learning 2.0: A fundamental framework, a case study and research issues. *International Journal of Mobile Learning and Organisation, 9*(1), 21–37. doi: 10.1504/ijmlo.2015.069711

Liu, M., Scordino, R., Renata, G., Navarrete, C., Yujung, K., & Lim, M. (2015). A look at research on mobile learning in K-12 education from 2007 to the present. *Journal of Research on Technology in Education*, *46*(4), 325–372. doi: 10.1080/15391523.2014.925681

Means, T., Jonassen, D., & Dwyer, F. (1997). Enhancing relevance: Embedded ARCS strategies vs. purpose. *Educational Technology Research and Development, 45*(1)*,* 5–17. doi: 10.1007/bf02299610

Muthén, B. O. (1994). Multilevel covariance structure analysis. *Sociological Methods and Research, 22*(3), 376–398. doi: 10.1177/0049124194022003006

National Research Council (2000). *How people learn.* Washington D.C.: National Academy Press.

Peugh, J. L. (2010). A practical guide to multilevel modeling. *Journal of School Psychology*, *48*(1), 85–112. doi: 10.1016/j.jsp.20.09.09.002

Phares, E. J. (1976). *Locus of control in personality*. Morristown, NJ: General Learning Press.

Prensky, M. (2001). Digital natives, digital immigrants. *On the Horizon 9*(5), 1–6. doi: 10.1108/10748120110424816

Raudenbush, S., & Bryk, A. (2002). *Hierarchical linear models: Applications and data analysis methods*. Chicago, IL: Sage Publications Ltd.

Reis, S. M., & McCoach, D. B. (2000). The underachievement of gifted students: What do we know and where do we go? *Gifted Child Quarterly, 44*(3), 152–170. doi: 10.1177/001698620004400302

Romero, J. J. (2011). *NO. 1 Smartphones*. IEEE Spectrum, *48*(1), 28–31.

Rotter, J. B. (1954). *Social learning theory and clinical psychology.* New York, NY: Prentice-Hall.

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Boston, MA: Houghton, Mifflin and Company.

Sharma, P. (2013). Evolution of mobile wireless communication networks-1G to 5G as well as future prospective of next generation communication network. *International Journal of Computer Science and Mobile Computing*, *2*(8), 47–53. Retrieved from https://pdfs.semanticscholar.org/8e32/4078c7b0848c5e8c573861878cdbe417e89e.pdf

Shuler, C. (2009). *Pockets of potential: Using mobile technologies to promote children's learning.* New York, NY: The Joan Ganz Cooney Center at Sesame Workshop.

Smith, H. E., Blackburn, J. J., Stair, K. S., & Burnett, M. F. (2018). Assessing the effects of the smartphone as a learning tool on the academic achievement of school-based agricultural education students in Louisiana. *Journal of Agricultural Education, 59*(4), 270–285. doi: 10.5032/jae.2018.04270

Smith, H. E., Stair, K. S., Blackburn, J. J., & Easley, M. (2018). Is there an app for that? Describing smartphone availability and educational technology adoption level of Louisiana school-based agricultural educators. *Journal of Agricultural Education, 59*(1), 238–254. doi: 10.5032/jae.2018.10238

Sperber, D., & Wilson, D. (1986). *Relevance: communication and cognition*. Cambridge, MA: Harvard University Press.

Su, C. H., & Cheng, C. H. (2015). A mobile gamification learning system for improving the learning motivation and achievements. *Journal of Computer Assisted Learning, 31*(3), 268–286. doi: 10.1111/jcal.12088

Thomas, K., & Muñoz, M. A. (2016). Hold the phone! High school students' perceptions of mobile phone integration in the classroom. *American Secondary Education*, *44*(3), 19–37. Retrieved from http://eds.b.ebscohost.com/eds/pdfviewer/pdfviewer?sid=bf89607f-cfa8-4db4-8dc6-2f894d47e42f%40sessionmgr120&vid=2&hid=114

Williams, M. R., Warner, W. J., Flowers, J. L., & Croom, D. B. (2014). Accessibility and usage of technology by North Carolina agriculture teachers. *Journal of Agricultural Education 55*(4), 191–205. doi: 10.5032/jae.2014.04191

Whitmore, J. R. (1982). Recognizing and developing hidden giftedness. *The Elementary School Journal, 82*(3), 274–283. doi: 10.1086/461265

Yamamoto, N., & Wakahara, T. (2013). An interactive learning system using smartphone for improving students' learning motivation. *Proceedings of the 2013 Information Technology Convergence*, 305–310. doi: 10.1007/978-94-007-6996-0_32