Integrating Scaffolding Strategies with Environmental Monitoring Systems to Enhance Learning and Practical Skills in Agricultural Education

Haiqiao LIU[a], Tsubasa MINEMATSU[b], Chengjiu YIN[c],Shuqing LIU[a],Sijie XIONG[a] & Atsushi SHIMADA[a,*]

[a]*Department of Faculty of Information Science and Electrical Engineering, Kyushu University, Japan*

[b]*Department of. Data-Driven Innovation Initiative, Kyushu University, Japan*

[c]*Department of Institute for Information Technology, Kyushu University, Japan*

* *liu.haiqiao.966@s.kyushu-u.ac.jp*

Abstract: Scaffolding supports students by guiding them step-by-step toward mastering complex concepts. In agricultural education, students often struggle with abstract topics like humidity or soil composition due to limited real-world context. To address this, we introduce a field environment digest system that connects theoretical knowledge with field data. This study proposes a teaching approach combining scaffolding strategies and the digest system to enhance agricultural learning. A quasi-experimental design is applied in a high school setting. The experimental group uses the combined approach, while the control group follows traditional methods. We collect data through questionnaires measuring students' learning interest, confidence, and skill development. Results show that the experimental group scores significantly higher on post-tests. Students also report greater motivation and confidence in understanding agricultural topics. The findings suggest that integrating scaffolding with real-world systems improves both academic performance and engagement.

Keywords: Scaffolding, Agricultural education, Student engagement and confidence,

1.Introduction

Scholars emphasize the importance of student-centered learning for enhancing engagement and academic performance (Agbatogun, 2014). Among these strategies, scaffolding is highly effective, as it offers adaptive support and fosters active classroom interaction (Kamarainen et al., 2013). Teachers adjust guidance based on students' understanding, gradually reducing support as learners gain independence (Loewen, 2018; Reiser, 2018). However, in agricultural education, abstract concepts such as humidity, temperature, and soil conditions often lack concrete context, making them difficult for high school students to grasp (Fleck & Hachet, 2016; Smith & Rayfield, 2017). To address this challenge, we introduce the Field Environment Digest System, which visualizes real-time data like soil moisture and air temperature (Shiga et al., 2023). This system helps transform abstract concepts into accessible, experience-based knowledge. In this study, we integrate scaffolding strategies with the digest system to support experiential learning and improve motivation. We conduct a quasi-experimental study comparing students using this integrated approach with those in traditional classrooms.

Research Questions:

Q1: Does the integration of scaffolding and environmental systems enhance high school students' comprehension of agricultural knowledge?

Q2: Does it improve students' mastery of agricultural skills compared to traditional teaching?

2. Pedagogical design

This study integrates a scaffolding-based instructional approach with a field monitoring system to improve agricultural learning outcomes. The system uses real-time environmental data to connect theory with practice, enhancing both understanding and motivation. The instructional process follows three structured phases. First, students answer subject-specific questions without support to assess baseline understanding. Second, they use the monitoring system to verify and refine their responses by linking data with theory. Finally, students engage in group discussions to share strategies and explore applications of their knowledge. This stepwise process promotes deeper thinking and effective system use in agricultural contexts.

Table 1. *Independent Samples T Test of Pre-test Questionnaire*

		N	Mean	SD	t	p
Understanding Environment Data	Class A	36	3	1.31	0	1
	Class B	36	3	1.17		
Used Monitoring Systems	Class A	36	2.33	1.53	1.129	0.263
	Class B	36	1.97	1.16		
Improves Farming Skills	Class A	36	3.58	1.23	1.691	0.095
	Class B	36	3.11	1.14		
Effective Technology Learning	Class A	36	3.61	1.23	1.053	0.296
	Class B	36	3.31	1.24		
Enhances Farming Operations	Class A	36	3.31	1.39	1.73	0.088
	Class B	36	2.81	1.04		

Table 2. *Pre- and post-test questionnaires for paired-sample tests in the control group*

		N	Mean	SD	t	p
Understanding Environment Data	Pre-test	36	3.00	1.31	1.281	0.208
	Post-test	36	2.69	1.06		
Used Monitoring Systems	Pre-test	36	2.33	1.53	0.347	0.731
	Post-test	36	2.25	1.13		
Improves Farming Skills	Pre-test	36	3.58	1.23	-0.473	0.639
	Post-test	36	3.69	1.01		
Effective Technology Learning	Pre-test	36	3.61	1.23	-0.865	0.393
	Post-test	36	3.81	1.01		
Enhances Farming Operations	Pre-test	36	3.31	1.39	0.105	0.917
	Post-test	36	3.28	1.11		

3. Experiments and results analysis

In this study, 72 first-year students from an agricultural high school in Fukuoka are divided into two groups: Class A (control) and Class B (experimental), each with 36 students. Both classes follow the same crop cultivation curriculum, including lectures, fieldwork, and summary sessions. While Class A uses the standard method, Class B applies scaffolding and a field summary system in the last 20 minutes. Over two months (six sessions), students complete pre- and post-tests and questionnaires to assess prior knowledge and evaluate the system's instructional impact.

SPSS is used to analyze test scores and questionnaire responses. Although 40 students participate in each group, 36 complete all tasks. Table 1 compares baseline knowledge and skill use between the two groups. Independent-samples t-tests reveal no significant pre-intervention differences in environmental understanding or tool use, indicating both groups begin at a similar level.

To address RQ1, we examine post-test results in Table 2. The experimental group shows significant improvement in understanding environmental data ($t = -0.6952$, $p < 0.001$), suggesting enhanced conceptual learning. For RQ2, Table 3 shows improved monitoring tool use and skill mastery in the experimental group. Students report higher confidence and better

performance. Overall, the integration of scaffolding and field systems improves knowledge, skills, and motivation, providing an effective model for agricultural education.

Table 3. *Pre- and post-test questionnaires for paired-sample tests in experimental group*

		N	Mean	SD	t	p
Understanding Environment Data	Pre-test	36	3.00	1.17	-6.952	<0.001
	Post-test	36	4.36	0.59		
Used Monitoring Systems	Pre-test	36	1.97	1.16	-8.657	<0.001
	Post-test	36	4.25	0.84		
Improves Farming Skills	Pre-test	36	3.11	1.14	-5.508	<0.001
	Post-test	36	4.19	0.58		
Effective Technology Learning	Pre-test	36	3.31	1.24	-3.332	0.002
	Post-test	36	4.11	0.79		
Enhances Farming Operations	Pre-test	36	2.81	1.04	-5.391	<0.001
	Post-test	36	3.97	0.88		

4. Conclusion

This study shows that integrating scaffolding with environmental monitoring systems improves students' understanding of agricultural concepts and practices. The approach is especially effective when teaching content aligns with system functions, supporting the transfer of ill-structured knowledge. Students express high satisfaction with the learning tools and report increased engagement. However, the study takes place in a specialized agricultural high school, which may limit generalizability. Future research should include more diverse educational contexts and examine additional factors that affect the impact of such integrated strategies.

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