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Advancing Experiential Learning in Digital Agriculture and Plant Phenotyping through the NSF ExLENT DAPPT Project

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Keywords

Experiential Learning, Digital Agriculture, Plant Phenotyping, AI in Agriculture, Workforce Development, Community College Pathway

1. Introduction

Digital agriculture is increasingly defined by sensing, automation, and analytics that connect field operations with data driven decisions. National data shows substantial adoption of digital agriculture technologies in major cropping systems, with continued growth in data intensive practices such as yield monitoring, soil mapping, and variable rate applications (McFadden et al., 2023). As technology adoption expands, workforce demand also shifts toward higher skill roles that can install, maintain, and interpret sensor and automation systems. An industry survey of the precision agriculture workforce identifies changing knowledge, skills, and abilities and reports persistent difficulty in finding qualified personnel (Erickson et al., 2018). In parallel, advances in imaging and machine learning have accelerated plant phenotyping, enabling new forms of high throughput monitoring for stress, disease, and growth (Gill et al., 2022; Xu and Li, 2022).

These trends create an education challenge. Many learners who could enter digital agriculture pathways lack access to authentic field testbeds, advanced sensors, and interdisciplinary mentoring that bridges engineering methods with agricultural practice. The Digital Agriculture and Plant Phenotyping Technologies (DAPPT) project responds by designing a structured, cohort-based experiential learning model that builds practical competence through iterative practice, peer learning, and deliverable driven projects. The approach is grounded in experiential learning theory (Kolb, 1984) and evidence that active learning improves student outcomes in engineering education (Prince, 2004).

2. Project Overview and Design

DAPPT is an NSF ExLENT project (award no. 2322535) implemented through a three-institution partnership. The project goal is to provide experiential learning opportunities in digital agriculture and plant phenotyping technologies, with a particular emphasis on community college to university pathways and industry engagement. The project design integrates (1) cohort-based learning cycles with consistent routines for planning, building, testing, and communicating results; (2) authentic testbeds including vineyards and row crop research sites; and (3) a shared Peer Learning Agricultural Network (PLAN) platform for documentation, data sharing and visualization, and cross site discussion. DAPPT partners contribute complementary assets, including community college recruitment and cohort training, field scale sensing and imaging deployments, and access to advanced phenotyping facilities and industry-oriented workshops.

3. Experiential Learning Activities

DAPPT activities are organized around recruitment, structured training modules, deliverable based projects, and cross-cohort communication. Major activities during the first two years included recruitment workshops at partner community colleges, semester-based research and development internships, summer immersive internship cohorts, and a series of technical lectures and facility tours. Cross site meetings were used to align expectations and support peer exchange, including a multi-institution meeting in May 2024 and joint cohort presentations in August 2024 and August 2025.

Table 1. Summary of cohort activities, technical focus areas, and key deliverables across DAPPT partner sites.

Site/Cohort	Key Activities	Technical Focus	Key Deliverables
Florida	Recruitment, internships, specialty crop testbed training, outreach	Pi imaging, telemetry, IoT, irrigation and disease sensing, AI workflows	Prototypes, integrated sensors, camera systems, training artifacts, outreach demos
Nebraska	Recruitment, Summer internship, raw crop testbed training, outreach, deployment expansion	Pi programming, custom cameras, IoT, telemetry, soil moisture sensing, AI workflows	Camera systems, image datasets, integrated sensors, outreach demos
Indiana	Recruitment, workshops, facility tours, technical lectures	Phenotyping sensors, imaging, AI modeling, IoT, data systems	Workshop participation, facility exposure, shared training content
Cross-site	Joint meetings, presentations, shared planning and communication	Peer learning, data sharing, visualization, reflection	Joint presentations, shared documentation, learning community

3.1 Florida Cohort Activities

One partner site implemented multiple recruitment events at a regional community college and maintained strong applicant demand. Year 1 recruitment resulted in more than 30 applications for semester-based and summer opportunities. The Spring 2024 cohort trained nine learners. The Summer 2024 cohort recruited eleven learners, primarily from community college pathways. In Year 2, the site hosted additional recruitment workshops and received 26 applications. Training modules covered building field ready imaging and telemetry systems, including Raspberry Pi based camera units for Muscadine grape canopy and disease monitoring and microcontroller telemetry over NB IoT and LoRa, sensor networks for precision irrigation management, field imaging, data analysis, and AI workflows for time series and image data processing, with field activities conducted at a viticulture research testbed.

3.2 Nebraska Cohort Activities

A second partner site recruited community college students for a full-time summer internship (May to August 2024) at a research and extension center. Training included programming Raspberry Pi devices, developing and deploying custom cameras for weed detection and disease monitoring, and building wireless telemetry systems using microcontroller boards for NB IoT and LoRa communications. Learners also participated in field sampling activities and delivered outreach demonstrations for youth camps and a field day. In 2025, the team expanded deployments and dataset development, including collection and labeling images for disease detection workflows and development of multiple soil moisture sensing units for near real time monitoring.

3.3 Indiana Cohort Activities

A third partner site hosted an industry facing workshop in September 2024 that provided expert lectures on plant phenotyping, imaging, AI, data infrastructure, and IoT for agriculture, along with tours of phenotyping and crop sensor facilities. Twenty-one students and industry professionals attended. The site also contributed technical lectures to a Summer 2025 experiential learning internship, covering phenotyping sensors, data modeling, AI for image processing, and communication protocols.

4. Participation and Pathway Outcomes

Throughout the first two years, DAPPT demonstrated sustained interest from community college learners and created multiple entry points into digital agriculture training. Recruitment workshops generated repeated application cycles and supported cohort formation that mixed learner levels, enabling near peer mentoring among participants at different stages. The project structure emphasized clear routines, scaffolded project milestones, and multiple engagement formats, including semester-based internships, summer immersions, and industry workshops.

5. Learning Deliverables and Technical Results

DAPPT emphasizes verifiable, practice aligned deliverables. Across sites, learners produced sensor deployments and dashboards, custom camera and imaging systems, labeled datasets, and documentation artifacts shared through the PLAN platform. Examples include microcontroller-based soil moisture telemetry units, camera systems for field detection tasks, and field protocols for sampling and sensor installation. These deliverables provide concrete evidence of learning progression and support communication of results through presentations, posters, and outreach demonstrations.

6. Evaluation Approach and Formative Evidence

DAPPT evaluation follows a formative approach focused on learning environment quality and evidence of skill development. Core indicators include (1) recruitment and retention metrics across cohorts, (2) completion and quality of deliverables using common rubrics, and (3) participant self-reports of confidence and career interest aligned with digital agriculture skills. Because cohort sizes are intentionally modest in the early years, the current analysis emphasizes triangulation of evidence from deliverables, presentations, and mentor observations.

In future cohorts, we will strengthen quantitative evaluation by implementing a common cross site assessment plan with pre and post surveys, standardized rubric scoring for selected technical artifacts, and shared participation and retention metrics across partner sites. Planned cross site outcome comparisons will summarize skill gains, confidence shifts, and deliverable completion patterns by site and activity format (for example, internship cohorts versus workshop centered training), while accounting for cohort size and participant background. These additions will support clearer quantitative reporting and more interpretable comparisons of outcomes across institutions.

7. Discussion and Lessons Learned

Two implementation insights stand out. First, cohort-based routines supported consistent progress in settings where participant schedules and prior preparation vary. Regular check ins, documentation expectations, and short presentations helped normalize engineering communication and made learning visible. Second, cross site interaction expanded participants' perspectives on how similar digital agriculture tools translate across production systems. The shared platform concept, coupled with cross cohort meetings, helped create an identity as a distributed learning community rather than isolated internships.

8. Conclusion and Next Steps

DAPPT demonstrates an experiential learning model for workforce development in AI enabled agriculture by connecting community colleges and university partners through authentic testbeds, cohort-based training, and a shared peer learning platform. Over two years, the project delivered repeated recruitment cycles, multiple cohorts, and industry engagement, and it produced measurable technical artifacts that document learning. Next steps include expanding cohort size where feasible, strengthening common assessment instruments across partners, and developing reusable modules that can be adopted by other programs seeking to build digital agriculture and plant phenotyping workforce pathways.

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