

Development and Evaluation of AI-Integrated Digital Learning Modules for Food and Beverage Operations Under the Strengthened Senior High School Tech-Pro Curriculum

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ABSTRACT

This study developed and evaluated artificial intelligence (AI)-integrated digital learning modules for Food and Beverage Operations under the Strengthened Senior High School Tech-Pro Curriculum. Using a developmental-descriptive research design with a one-group pretest–posttest quasi-experimental component, it involved 84 Grade 11 learners and five TLE/TVL teachers from five public secondary schools in Agusan del Sur, together with three expert validators. The modules were examined in terms of instructional features, competency alignment, validity, and acceptability. Expert evaluation questionnaires, teacher and student acceptability questionnaires, and achievement tests supplied the data, which were analyzed using means, standard deviations, mean percentage scores, independent-samples t-tests, and a paired-

samples t-test. The six instructional feature dimensions were rated highly evident (means = 4.60–4.80), and the five validity dimensions were assessed as highly valid (means = 4.67–4.80). Teachers and students considered the modules highly acceptable, with no statistically significant differences in their ratings across the five dimensions (all $p > .05$). The reported mean percentage score rose from 69.4 on the pretest to 78.0 on the posttest. The paired comparison of achievement-test scores was statistically significant ($t = -11.303$, $p < .001$). The findings support the modules' suitability as supplementary, competency-aligned learning resources, while the one-group design limits causal interpretation. Continued refinement, responsible AI-use guidance, and testing in additional instructional settings are recommended.

Keywords: *artificial intelligence; Food and Beverage Operations; digital learning modules; competency-based instruction; Tech-Pro curriculum; instructional validation*

INTRODUCTION

Technical-vocational education must respond simultaneously to changes in occupational practice, the availability of learning resources, and the growing use of digital technologies in workplaces. The food service and hospitality sectors require graduates who can demonstrate service procedures, communicate effectively, maintain sanitation and safety, and adapt to changing service systems. Yet work-readiness and skills-alignment concerns continue to be documented in the sector (Pickles et al., 2025; Tee et al., 2024). For Philippine Senior High School learners, this challenge is particularly important because the Tech-Pro pathway seeks to connect school-based learning with practical occupational competencies (Yoshida, 2025).

Within the strengthened Senior High School curriculum, Food and Beverage Operations emphasizes competency-based learning, including proper use of tools and equipment, service principles, workplace hygiene, and operational safety. These expectations are closely related to Food and Beverage Services NC II training requirements. Nonetheless, the availability of appropriate instructional materials, guided simulations, and repeated opportunities for applying occupational knowledge can differ across schools. Philippine discussions of technical-vocational education have emphasized the importance of improving training and assessment quality and strengthening alignment between learning activities and competency requirements (Rosales et al., 2025; Hidalgo et al., 2025).

Artificial intelligence provides potential instructional functions such as immediate feedback, interactive explanations, adaptive practice, and independent learning support. Digital learning resources can also present organized multimedia content and structured tasks that learners can revisit outside demonstrations. Research grounded in cognitive load theory highlights that AI supports must be carefully designed for learning outcomes (Alam et al., 2026). However, purposeful instructional design remains essential: AI-assisted activities must support clearly defined learning outcomes, appropriate pedagogy, and safe practices rather than serve as decorative additions to a module (Celik, 2023; Fortuna et al., 2025; Ruiz-Rojas et al., 2023). For practical service subjects, teacher guidance and supervised hands-on performance remain necessary alongside technology-supported activities.

Although research has considered digital modules and AI-assisted instruction across different educational settings, the dissertation identified limited locally grounded evidence on AI-integrated modules designed specifically for TESDA-aligned Food and Beverage Operations in secondary-level Tech-Pro programs. This gap matters in the selected schools in Agusan del Sur, where access to contextualized instructional support is a practical concern. Recent evaluations of the strengthened Senior High School curriculum have described implementation concerns (Delos Santos et al., 2026). Scholarship on digital learning tools and vocational competency instruction indicates potential benefits but does not replace evaluation of a specific module with its actual users (Balco & Uy, 2023; Metreveli et al., 2025; Weng et al., 2024).

Accordingly, the study developed AI-integrated digital learning modules for Grade 11 Food and Beverage Operations and evaluated their instructional features and components, expert validity, and teacher and student acceptability. It also compared acceptability ratings across respondent groups, examined student achievement before and after module use, and documented validators' proposals for refinement. By focusing on a defined learning area and local implementation context, the study aimed to contribute a usable instructional resource and descriptive evidence to inform competency-based practice under the Strengthened Senior High School Tech-Pro Curriculum.

Literature Review

Competency-Based Instruction and Food and Beverage Operations

Competency-based technical-vocational education organizes teaching and assessment around knowledge and performance expectations directly related to occupational tasks. For Food and Beverage Operations, learning entails more than recalling service terminology: learners must understand proper handling of tools, apply service sequences, observe hygiene requirements, and respond to authentic workplace scenarios. Reports on TVET assessment in the Philippines highlight the need to align instructional experiences with the practical expectations of competency certification (Rosales et al., 2025). Research on teaching strategies and Senior High School competency performance likewise underscores the importance of preparation that bridges classroom instruction and assessment tasks (Hidalgo et al., 2025).

The development of localized materials is relevant when instructional resources need to reflect students' experience and the equipment and service situations they are likely to encounter. Balco and Uy (2023) explored a localized module aligned with Food and Beverage Services Level II competencies; their study illustrates the

relevance of contextualization when developing instructional support for a specific vocational area. Digital employability skills are also increasingly relevant to vocational graduates as occupational roles incorporate digital tools and changing organizational practices (Kholifah et al., 2025).

These perspectives suggest that Food and Beverage Operations modules should combine measurable learning objectives, accurate procedural content, structured practice, and assessment activities aligned with prescribed competencies. The present research therefore treated alignment with Food and Beverage Operations competencies as an explicit feature for evaluation rather than assuming that any digital material would meet Tech-Pro requirements. That emphasis situates technological innovation within the existing educational purpose of practical, assessable occupational learning.

Artificial Intelligence Integration and Instructional Design

The educational promise of artificial intelligence depends on how it supports teaching decisions and learner activity. Celik (2023) described Intelligent Technological Pedagogical Content Knowledge (I-TPACK) as a way of considering teachers' professional knowledge in the ethical integration of AI-based tools. The framework encourages alignment between AI functions, subject content, and appropriate instructional strategies. A systematic review by Celik et al. (2022) also identified opportunities and challenges for teachers adopting educational AI, reinforcing the continuing importance of instructional oversight.

AI can extend access to explanation and guided practice, yet the suitability of an AI feature must be judged against its learning purpose and the developmental needs of students. Fortuna et al. (2025) synthesized advances in personalized AI learning, while Weng et al. (2024) reviewed connections between instructional design, AI integration, and student learning outcomes. Ruiz-Rojas et al. (2023) proposed an instructional-design matrix for using generative AI tools, a perspective compatible with designing activities in which the technology has a clear and limited function.

For a performance-oriented specialization, these insights favor AI-assisted prompts, additional explanations, feedback, and scenario-based exercises that complement teacher demonstrations and supervised practical tasks. They also support the importance of reviewing AI-generated suggestions against recognized food service procedures before learners act on them. Thus, the modules in the present study were designed and examined as pedagogical resources with AI-supported features, not as systems intended to replace the teacher or practical competency assessment.

Development, Validation, and Quality of Digital Modules

Systematic development processes make it possible to link learning needs, objectives, content, instructional activities, assessment, implementation, and evaluation. In a review of developmental research, Ibrahim (2016) described development as a structured process for producing and refining an educational intervention. Shakeel et al. (2022) demonstrated the use of ADDIE and rapid prototyping for developing and validating blended-learning instruction in a technical-vocational setting, supporting the relevance of iterative evaluation in the development of learning products.

Expert validation is particularly important when a module includes practical and safety-related procedural content. Validation considers whether lessons are accurate, suitably sequenced, instructionally coherent, and aligned with what students are expected to demonstrate. Lasala (2023) presented the development and validation of a self-directed interactive module, illustrating the value of obtaining evidence about an instructional resource before wider classroom use. Kozan et al. (2025) also considered how instructional designers integrate generative AI in professional practice, drawing attention to the responsibilities involved in designing meaningful AI-supported learning experiences.

Taken together, these studies support evaluating more than the visual presentation of the developed product. The present study therefore assessed learning objectives, content organization, instructional activities, assessment components, AI-integrated features, and competency alignment. It separately examined expert judgments of

content relevance, instructional design, assessment quality, technical usability, and the appropriateness of AI integration, which provided a basis for planned revisions.

User Acceptability and Learning Performance

Even a well-designed module must be understandable, accessible, relevant, and usable for those who teach and learn with it. User perceptions of usefulness and ease of use provide practical evidence concerning whether a learning resource can function in its intended setting. Digital learning research has associated technology-supported materials with engagement and achievement while emphasizing the conditions under which learners interact with these resources (Uzorka & Odebiyi, 2025). Acceptability therefore warrants direct assessment from both teachers, who facilitate the activities, and students, who use the materials to learn.

Prior work on electronic modules has explored their roles in motivation, independent learning, and academic performance. Delita et al. (2022) considered the effects of e-modules on self-efficacy, motivation, and learning outcomes, while Alyusfitri et al. (2024) examined interactive multimedia-based e-modules and student responses. Tarigan et al. (2023) also examined digital learning modules in relation to academic performance and memory retention. These studies provide reasons to examine both learners' appraisal of an intervention and changes in measured achievement, rather than treating favorable ratings alone as evidence of learning gains.

The dissertation consequently used a one-group pretest–posttest comparison alongside expert validation and teacher–student acceptability ratings. Such a design can identify whether scores changed after use of the developed module, but without a concurrent control group it does not isolate the module from all other influences on performance. This distinction is important when interpreting the findings and framing the practical contribution of a supplementary educational material.

Ethical AI Use and Synthesis of the Research Framework

Responsible AI integration entails accurate information, respect for learner privacy, transparency about AI-generated support, and human evaluation of any automated advice. Airaj (2024) similarly discussed ethical AI adoption in educational practice. Tang and Su (2024) reviewed ethical implications of classroom AI, while Yan et al. (2025) identified governance concerns and policy gaps. These issues are especially pertinent in an educational setting involving minors and learning activities connected to occupational health and safety.

The dissertation drew on the ADDIE model, I-TPACK, and experiential learning (Kolb, 1984) to inform design and classroom implementation. ADDIE structured the development and evaluation process; I-TPACK directed attention to instructional appropriateness; and experiential learning emphasized the practice, reflection, and application required by vocational competencies. The theoretical and policy components were also related to Republic Act No. 10533, Republic Act No. 10968, and the Food and Beverage Services NC II training regulations, as depicted in the original dissertation figure.

Synthesizing these strands, the study positioned module quality, expert validation, end-user acceptability, and student achievement as complementary measures of an instructional innovation. Its contribution lies not in claiming that AI alone produces learning, but in evaluating whether a locally developed resource integrates AI assistance in a structured, competency-aligned, and acceptable form. The study's original theoretical framework is reproduced below, immediately before the methodology.

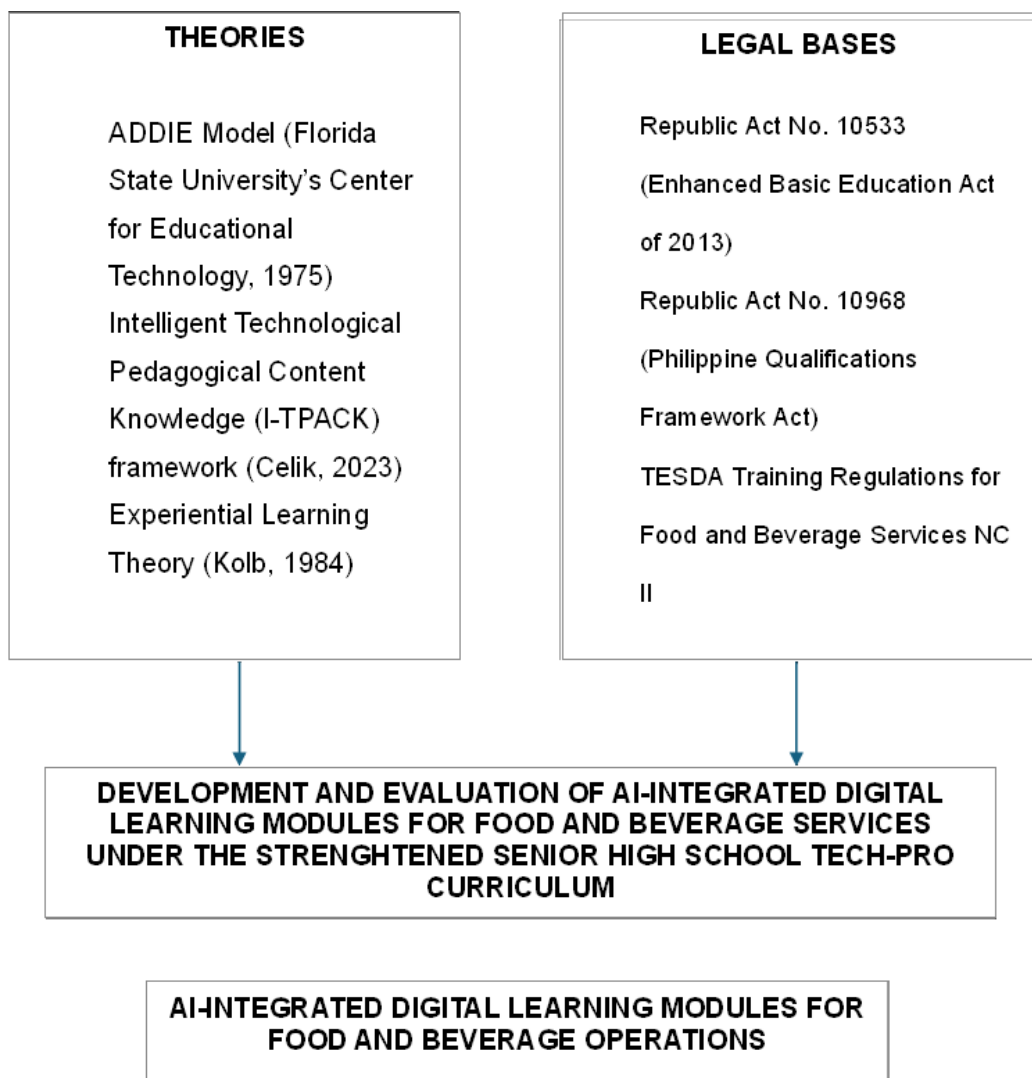


Figure 1. *Theoretical Framework of the Study (reproduced from the dissertation).*

METHODS

Research Design

The study employed a developmental-descriptive design with a one-group pretest–posttest quasi-experimental component. The developmental phase involved preparing AI-integrated digital learning modules based on Food and Beverage Operations competencies and obtaining expert evaluation and recommendations. The descriptive phase assessed module characteristics, validity, and acceptability. The pretest–posttest component compared the same students' achievement before and after their use of the developed learning materials. The teacher–student rating comparison was observational and did not involve randomized allocation or a separate control group (Ibrahim, 2016; Shakeel et al., 2022).

Research Locale

The study was conducted during School Year 2026–2027 in five public secondary schools in Agusan del Sur offering Food and Beverage Operations in the Tech-Pro track: Sibagat National High School of Home Industries, Esperanza National High School, Afga National High School, Patin-ay National High School, and Agusan del Sur National High School. These sites were selected because their teachers and learners were directly involved in the specialization for which the modules were developed.

Participants and Sampling Technique

The participants included 84 Grade 11 students taking Food and Beverage Operations and five TLE/TVL teachers handling the learning area. The dissertation reported total enumeration of eligible students and teachers in the participating schools, given the manageable population. Three expert evaluators separately reviewed the modules for features and validity. Students completed achievement testing and assessed acceptability; teachers assessed acceptability; and experts evaluated the instructional product. The distribution of students and teachers is shown in Table 1.

Table 1. *Distribution of Study Respondents by Participating School*

Participating school	Students	Teachers
Sibagat National High School of Home Industries	15	1
Esperanza National High School	15	1
Afga National High School	10	1
Patin-ay National High School	13	1
Agusan del Sur National High School	31	1
Total	84	5

Note. Three expert validators were involved separately in the validation process.

Research Instrument

Researcher-developed questionnaires and achievement tests were used. An expert-evaluation instrument addressed six feature/component dimensions and five validity dimensions. Teacher and student acceptability instruments measured usefulness, ease of use, clarity of content, learner engagement, and relevance to Food and Beverage Operations. A five-point Likert response scale was used for the evaluation instruments. An open-ended comments and suggestions component provided feedback for revisions. A pretest and posttest assessed student knowledge of Food and Beverage Operations content; both tests were described as containing 50 items in the dissertation. The instruments were reviewed by qualified experts for clarity, relevance, and appropriateness prior to administration.

Data Gathering Procedure

The researcher secured permission from the concerned school division and participating school heads and coordinated schedules with the TLE/TVL teachers. The AI-integrated modules and instruments were prepared and reviewed by expert validators, and revisions were undertaken in response to their comments. The student participants completed a pretest before implementation. They subsequently engaged with the modules, supported by their teachers, and completed a posttest after the learning activities. Teachers and students also completed the acceptability questionnaire. Completed responses were organized, checked, coded, tabulated, and prepared for statistical analysis.

Data Analysis

The study summarized component ratings, validity, and acceptability using means and standard deviations. Mean percentage scores were used to describe pretest and posttest performance levels. Independent-samples t-tests compared teachers' and students' acceptability ratings in each dimension. A paired-samples t-test tested the

difference between pretest and posttest scores of the same student group. Statistical decisions followed a .05 significance threshold. Interpretation of these tests was limited to the variables, participant groups, and data reported in the original dissertation.

Ethical Consideration

The dissertation reported obtaining authorization from school authorities and informed consent from participating teachers. For the Grade 11 learners, parental permission and student assent were obtained because the students were minors. Respondents were informed that participation was voluntary and that they could withdraw without penalty. Participant identities were protected by the use of codes, with data used for research purposes and stored securely. Students were guided in responsible AI use, and the activities did not require the submission of sensitive personal information to AI-supported tools.

RESULTS AND DISCUSSION

Features and Components of the Developed Modules

The completed instructional product was organized around three Food and Beverage Operations learning areas: proper use, maintenance, and handling of tools, equipment, and materials; principles of service; and legislation and safety measures in Food and Beverage Operations. The modules combined learning objectives, lesson content, guided activities, assessment tasks, and AI-assisted learning support. Teacher-approved AI tools were intended to help learners review explanations and outputs while encouraging them to verify AI suggestions against established service procedures and classroom materials.

Table 2. *Expert Assessment of Instructional Features and Components*

Component	Mean	SD	Interpretation
Learning objectives	4.60	0.51	Highly Evident
Content organization and presentation	4.73	0.46	Highly Evident
Instructional activities	4.67	0.49	Highly Evident
Assessment components	4.80	0.41	Highly Evident
AI-integrated features	4.73	0.46	Highly Evident
Alignment with F&B competencies	4.80	0.41	Highly Evident

As summarized in Table 2, expert assessments described each instructional component as highly evident; the dimension means ranged from 4.60 to 4.80. Assessment components and competency alignment received the highest means (both 4.80), followed by organization, AI-integrated features, instructional activities, and learning objectives. These ratings suggest that the developed product represented more than a digitized reading resource: validators recognized the presence of assessments, interactive learning supports, and explicit connections to Food and Beverage Operations competencies.

A coherent relationship among objectives, instruction, and assessment is consistent with systematic module-development approaches used in technical-vocational settings (Shakeel et al., 2022). The competency-specific emphasis is also relevant to localized vocational resources (Balco & Uy, 2023). These findings describe the validators' assessment of the modules' features; they do not on their own establish the level of practical skill mastery achieved by learners.

Expert Validation of the Developed Modules

Table 3. *Expert Validity Assessment of the AI-Integrated Modules*

Validation dimension	Mean	SD	Interpretation
Content accuracy and relevance	4.73	0.46	Highly Valid
Instructional design	4.67	0.49	Highly Valid
Assessment quality	4.80	0.41	Highly Valid
Usability and technical quality	4.73	0.46	Highly Valid
Appropriateness of AI integration	4.80	0.41	Highly Valid

The three expert evaluators assessed all five validity dimensions as highly valid (Table 3). The highest dimension ratings were reported for assessment quality and appropriateness of AI integration (both 4.80), while instructional design received a mean of 4.67. Evaluators also gave favorable ratings to content accuracy and relevance, usability, and technical quality. Together these results supported the dissertation's conclusion that the developed modules were appropriate for use as supplementary instructional resources.

Nevertheless, expert validation is an assessment of the material rather than direct proof of learning effectiveness. The distinction is important because the experts evaluated different dimensions from those measured by students' achievement tests. The favorable validity ratings align with the emphasis on structured design and quality review in developmental educational research (Ibrahim, 2016; Lasala, 2023) and with the need to judge AI features by their pedagogical appropriateness (Celik, 2023; Kozan et al., 2025).

Teacher and Student Acceptability

Table 4. *Acceptability Ratings and Independent-Samples Comparisons*

Dimension	Student M	Teacher M	t	p
Usefulness	4.61	4.56	0.28	.783
Ease of use	4.54	4.52	0.13	.894
Clarity of content	4.60	4.56	0.23	.822
Learner engagement	4.55	4.64	-0.62	.539
F&B competency relevance	4.40	4.44	-0.21	.836

Note. All five dimensions were interpreted as *Highly Acceptable* by each respondent group; none of the between-group differences was significant at $\alpha = .05$. M = mean.

Teachers and students generally evaluated the modules positively, and both groups rated all five acceptability dimensions as highly acceptable (Table 4). Students rated usefulness highest (4.61) and relevance to Food and Beverage Operations lowest (4.40); teachers rated learner engagement highest (4.64) and relevance lowest (4.44). Although all categories remained favorable, comparatively lower relevance ratings point to an area for further strengthening the connection between digital activities, realistic service tasks, and competencies students practice in school.

The independent-samples tests indicated no statistically significant differences between teacher and student ratings in any dimension, with reported p-values from .539 to .894. The findings therefore did not provide evidence to reject the corresponding null hypothesis. This pattern shows agreement in the overall favorable appraisal of the resource, but the small teacher group and observational design warrant caution in generalizing the comparison beyond the participating schools. The attention given to usability, usefulness, and engagement is consistent with research on learners' experiences of digital tools and e-modules (Delita et al., 2022; Uzorka & Odebiyi, 2025).

Students' Pretest and Posttest Performance

Table 5. *Reported Mean Percentage Scores Before and After Module Use*

Assessment	MPS	Original interpretation
Pretest	69.4	Moving towards mastery
Posttest	78.0	Moving towards mastery

Table 6. *Paired-Samples Test of Achievement Scores*

Comparison	Pretest mean	Posttest mean	t	p
Same student group (n = 84)	27.74	31.20	-11.303	< .001

The dissertation reported improvement in students' performance following exposure to the AI-integrated modules. The reported descriptive mean percentage score increased from 69.4 to 78.0, an 8.6-percentage-point gain (Table 5). The dissertation's own verbal scale placed both scores in the "Moving towards mastery" range, indicating continued scope for further instructional support even after improvement. In the paired analysis, the reported mean raw score increased from 27.74 to 31.20 and the test yielded $t = -11.303$, $p < .001$ (Table 6), supporting rejection of the stated no-difference null hypothesis.

The direction of the two reported score summaries is consistent, but their numerical scales are not reconciled in the source dissertation for a 50-item test; the values are therefore presented separately rather than recalculated or treated as interchangeable. The statistically significant difference indicates that students scored higher after module exposure. It does not, by itself, establish that the modules caused the improvement because the investigation used a one-group pretest–posttest design without a concurrent comparison group.

The observed posttest improvement provides preliminary, context-specific support for the usefulness of a structured, competency-oriented digital learning resource. Earlier studies of interactive e-modules and digital learning have also examined improved achievement outcomes (Alyusfitri et al., 2024; Tarigan et al., 2023). Further controlled and performance-based evaluation would be needed to establish the contribution of AI-supported module features apart from teacher instruction, testing familiarity, and practice effects.

Validator-Recommended Enhancements and Practical Implications

Alongside favorable numerical judgments, validators recommended three concrete refinements. First, they suggested considering an additional AI tool, such as Copilot, only where it provided a relevant and accessible form of support. Second, they requested complete citations for learning content and visual materials used in the modules. Third, they recommended reviewing the construction of multiple-choice questions to improve clarity, alignment, and the quality of response alternatives. These observations guided the dissertation's recommendations for revision before broader deployment.

The comments are consistent with treating AI as an instructional aid subject to human oversight, source checking, and ongoing quality assurance. Recent syntheses emphasize the need for ethical safeguards and informed professional judgment when AI technologies are used in education (Tang & Su, 2024; Yan et al., 2025). In Food and Beverage Operations, this means verifying generated explanations against recognized service and safety procedures and retaining opportunities for teacher demonstrations, simulated practice, and direct assessment of practical competencies.

The findings are relevant to teachers, school administrators, curriculum supervisors, and vocational training partners seeking practical supplements to instruction. They do not establish general effectiveness across schools, regions, or other Tech-Pro specializations. The study's primary contribution is a locally developed, expert-reviewed resource supported by favorable end-user assessments and evidence of within-group improvement, with identifiable technical and pedagogical areas still requiring refinement.

CONCLUSION

The study developed AI-integrated digital learning modules for Food and Beverage Operations under the Strengthened Senior High School Tech-Pro Curriculum and evaluated their principal instructional and technological characteristics. Expert validators judged the modules' features highly evident and their content, instructional design, assessment quality, technical usability, and AI integration highly valid. Teachers and students rated the resource highly acceptable, with no significant between-group differences in any of the assessed dimensions. The Grade 11 participants demonstrated improved scores after using the modules, and the paired-samples test indicated a statistically significant pretest–posttest difference.

These findings support the developed modules' suitability as supplementary resources for competency-based Food and Beverage Operations instruction in the participating Agusan del Sur schools. Their contribution lies in combining structured learning content, practical skill-oriented activities, formative assessment, and AI-supported assistance within a locally evaluated instructional product. The evidence is limited to the present participants and the one-group intervention design; conclusions regarding independent causal effects or transfer to other schools require further research.

Recommendation

Tech-Pro teachers and participating schools may continue using the modules as supplementary learning resources alongside demonstrations, supervised practice, and direct competency assessment. Teachers should provide explicit guidance for responsible AI use, require learners to check AI-produced information against appropriate Food and Beverage Operations sources, and prioritize practice activities where posttest performance still indicates a need for further mastery.

Before wider distribution, the module developer and school reviewers should incorporate complete source acknowledgments for text and illustrations, review the quality of multiple-choice items, and evaluate any proposed additional AI tool against clear instructional and accessibility criteria. Administrators and curriculum supervisors may support teacher orientation, appropriate digital access, and periodic monitoring of student use and feedback.

Future researchers may involve larger and more varied samples, include a comparable group that does not use the modules, and investigate retention, performance-based skills, and the contribution of individual AI-supported features. Reconciliation of the source dissertation's raw test-score means and reported mean percentage scores is also necessary before final publication of the numerical achievement results.

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