

Technology Integration and Professional Development as Predictors of Teaching Competencies Among Secondary School Food Science Teachers in Mezam Division, Cameroon

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ABSTRACT

The quality of food science instruction increasingly depends on teachers' capacity to integrate educational technologies and participate in meaningful professional development. This study examined the relationships between teachers' technology integration in food science teaching, professional development, and teaching competencies among secondary school teachers in Mezam Division, Cameroon. The study adopted an explanatory sequential mixed-methods design, in which quantitative findings were followed by qualitative inquiry to provide contextual explanations and deeper interpretation of the statistical results. Quantitative data were obtained from 92 food science teachers, while qualitative evidence was elicited from four pedagogic inspectors (PI). Data were collected using a structured questionnaire and a semi-structured interview guide. The questionnaire demonstrated acceptable internal consistency (Cronbach's $\alpha = .84$). Quantitative data were analysed using descriptive statistics and simple linear regression, while qualitative data were subjected to thematic analysis and used to contextualise and triangulate the quantitative findings. Teachers reported generally positive technology integration ($M = 3.29$, $SD = 0.660$), particularly the use of digital tools such as videos and PowerPoint ($M = 3.51$, $SD = 0.587$). Technology integration was significantly associated with teaching competencies, $R = .294$, $R^2 = .086$, $F(1, 90) = 9.457$, $p = .003$, with a positive regression coefficient ($B = .377$, $\beta = .294$). Professional development also received a generally positive rating ($M = 3.20$), but its relationship with teaching competencies was weaker, $R = .261$, $R^2 = .068$, $F(1, 90) = 6.420$, $p = .013$, $B = .301$, $\beta = .261$. Qualitative findings indicated that technology use remained inconsistent because of limited ICT training and resource constraints, while professional development was considered too infrequent, generic, and poorly coordinated. The findings suggest that technology integration and sustained, context-specific professional development are significantly associated with teaching competencies, although their explanatory contributions are modest. The study recommends systematic digital-pedagogy training, improved ICT access, and continuous, practical, subject-specific professional development for food science teachers.

Keywords: food science education, technology integration, professional development, teaching competencies, secondary schools in Cameroon

INTRODUCTION

Food science is an interdisciplinary field drawing on biology, chemistry, nutrition, microbiology, physics, and engineering. Its teaching therefore requires more than transmission of theoretical knowledge. Teachers must create learning experiences that connect scientific concepts with practical applications, experimentation, problem solving, food processing, safety, and real-world contexts. The quality of such instruction depends substantially on teachers' pedagogical knowledge, professional learning opportunities, and capacity to use appropriate instructional resources. Technology has become an increasingly important component of contemporary teaching. Digital presentations, videos, online resources, virtual laboratories, simulations, learning-management systems, and online assessment platforms can provide opportunities for teachers to represent complex concepts in accessible ways. In food science, such tools can be particularly useful because some processes are difficult to demonstrate directly in ordinary classrooms. Technology can provide visual

representations of food-processing processes, simulations of laboratory procedures, and access to current instructional resources.

However, the availability of technology does not automatically result in effective teaching. Technology must be integrated pedagogically and aligned with instructional objectives. Mishra and Koehler's (2006) technological pedagogical content knowledge framework emphasizes the interaction between technological knowledge, pedagogical knowledge, and content knowledge. Similarly, Ertmer and Ottenbreit-Leftwich (2010) argue that teachers' knowledge, confidence, beliefs, and institutional culture influence the extent to which technology becomes meaningfully embedded in classroom practice. Professional development represents another important dimension of teacher competence. Teachers require continuous opportunities to update their subject knowledge, pedagogical strategies, assessment practices, and technological skills. Guskey (2002) conceptualizes professional development as a process through which changes in teachers' classroom practice and professional beliefs can emerge. Desimone (2009) similarly emphasizes the importance of coherent and sustained professional learning that is connected to teachers' instructional practice.

In food science education, professional development is particularly important because scientific knowledge, technologies, processing methods, and educational practices continue to change. Teachers therefore need opportunities to acquire new knowledge and practise new instructional strategies. Reicks et al. (2022) emphasize competency-based approaches in food science education, while Bhat et al. (2022) highlight emerging developments that require food science educators to remain professionally current. The context of Mezam Division presents particular challenges. The attached study indicates that food science teachers work within circumstances characterized by uneven access to technological resources, inadequate ICT training, and limited opportunities for continuous professional development. The study therefore investigated whether teachers' integration of technology and their professional development were associated with their teaching competencies. The present article isolates these two dimensions from the broader study in order to provide a focused examination of their contribution to food science teaching competencies. The source study's conceptualization of technology integration includes digital tools, multimedia, simulations, online platforms, and technology-supported teaching activities, while professional development includes workshops, training, professional learning communities, feedback, and continuous learning.

LITERATURE REVIEW

Technology Integration and Teaching Competencies

Technology integration involves the purposeful incorporation of digital tools and resources into teaching and learning. In the present study, technology integration included the use of digital tools such as videos and PowerPoint, virtual laboratories and simulations, online platforms for assessment and assignment, online teaching materials, and training in educational technology. These indicators reflect both access to technological resources and teachers' reported use of those resources in instruction. The technological pedagogical content knowledge framework provides a useful perspective for understanding technology integration. Mishra and Koehler (2006) argue that effective technology-supported instruction depends on the interaction among technological knowledge, pedagogical knowledge, and content knowledge. Thus, technology is not simply an additional teaching aid; its educational value depends on how teachers connect technological affordances with subject matter and instructional strategies.

Ertmer and Ottenbreit-Leftwich (2010) similarly emphasize that meaningful technology integration is influenced by teachers' knowledge, confidence, beliefs, and the institutional environment. This is particularly relevant to food science because teachers may have access to digital tools but lack the pedagogical knowledge necessary to use them effectively. The applied nature of food science provides several opportunities for technology-enhanced instruction. Digital simulations can represent food-processing procedures, videos can demonstrate techniques that are difficult to reproduce in class, and online resources can expose teachers and learners to current developments in food science. Bhat et al. (2022) identify technological development as an important feature of the future of food science education.

Nevertheless, technology cannot replace practical experiences entirely. Food science involves sensory, tactile, laboratory, and processing experiences that may not be fully reproduced through digital media. Therefore, technology is most appropriately regarded as a complement to practical instruction rather than a substitute for it. The attached study similarly reports that inspectors regarded technology use as useful when appropriately implemented but observed inconsistent adoption because of inadequate ICT preparation and resources.

Professional Development and Teaching Competencies

Professional development refers to formal and informal opportunities through which teachers acquire knowledge, skills, strategies, and professional dispositions that can strengthen instructional practice. Guskey (2002) emphasizes that teacher development is closely connected to changes in classroom practice, while Desimone (2009) stresses the importance of coherent professional learning opportunities. Food science teachers require professional development that is both subject-specific and pedagogically relevant. Training in food processing, food safety, nutrition, laboratory methods, technology, assessment, and contemporary instructional strategies can help teachers respond to the multidisciplinary demands of the subject. Reicks et al. (2022) emphasize competency-based learning in food science, while Bhat et al. (2022) identify emerging developments requiring educators to update their professional knowledge.

Professional development is most likely to influence teaching when it is sustained and connected to teachers' actual classroom needs. Generic workshops may have limited influence if they do not provide opportunities for teachers to practise new strategies, receive feedback, and apply new knowledge. The present study's qualitative evidence is consistent with this perspective: inspectors reported that professional development opportunities were infrequent and insufficiently coordinated, while practical and hands-on programmes were perceived as more useful.

Technology Integration and Professional Development in the Cameroonian Context

The importance of technology integration and professional development is amplified in resource-constrained educational contexts. Teachers may face limited internet connectivity, insufficient digital equipment, inadequate technical support, and few opportunities for technology-focused professional learning. Consequently, technology integration may remain concentrated on basic tools such as PowerPoint and videos rather than more interactive applications. The study conducted in Mezam Division provides empirical evidence within this context. Although teachers reported relatively positive technology use, the qualitative findings revealed inconsistencies in classroom application. Similarly, professional development was positively regarded but was characterized by relatively weak explanatory power and concerns regarding frequency and relevance. These findings suggest that improving teaching competencies requires attention not only to individual teachers but also to institutional conditions supporting their professional learning and technology use.

Statement Of The Problem

Food science education requires teachers who can combine subject knowledge with practical, pedagogical, technological, and professional competencies. Yet secondary school teachers in Mezam Division operate within a context in which technology resources and opportunities for continuous professional development are unevenly available. The increasing availability of digital technologies creates opportunities for improving food science instruction, but the educational value of technology depends on teachers' ability to select and apply appropriate tools. The source study found that teachers reported using digital tools, online resources, virtual laboratories, and online platforms, but student engagement through technology received the lowest mean among the technology indicators. Inspectors also reported that technology use was minimal or inconsistent among some teachers because of inadequate ICT training and resource limitations.

Professional development presents a related challenge. Although teachers generally expressed positive views toward professional learning, the lowest-rated professional-development indicator concerned increased confidence as a food science teacher. Inspectors reported that some teachers experienced long intervals without training and described existing programmes as insufficiently frequent and coordinated. Although previous

literature recognizes the importance of technology integration and professional development, there remains a need for context-specific evidence concerning their relationships with teaching competencies among secondary school food science teachers in Mezam Division. This study therefore examined these two dimensions using quantitative and qualitative evidence.

Objectives of the Study

The study addressed the following two specific objectives:

1. To assess how teachers' integration of technology in teaching food science affects their teaching competencies.
2. To investigate the impact of teachers' professional development in food science on their teaching competencies.

Research Questions

1. What is the impact of teachers' integration of technology in teaching food science on their teaching competencies?
2. How can teachers' professional development in food science affect their teaching competencies?

Hypotheses

H₀₁: Teachers' integration of technology in teaching food science has no significant impact on their teaching competencies.

H_{a1}: Teachers' integration of technology in teaching food science has a significant impact on their teaching competencies.

H₀₂: Teachers' professional development in food science does not significantly affect their teaching competencies.

H_{a2}: Teachers' professional development in food science significantly affects their teaching competencies.

METHODOLOGY

The study adopted an explanatory sequential mixed-methods design, integrating a quantitative descriptive survey with a subsequent qualitative inquiry to provide a comprehensive understanding of the phenomenon. The design was appropriate because the qualitative phase was used to provide contextual explanations and deeper interpretation of the quantitative findings on technology integration, professional development, and teaching competencies among secondary school food science teachers. The population comprised 118 secondary school teachers responsible for food science in Mezam Division, from whom 92 teachers were selected through stratified random sampling to ensure representation across government, mission, and private secondary schools. Four food science pedagogic inspectors were purposively selected for the qualitative phase to provide professional and contextual perspectives that complemented the quantitative results.

Data were collected using a structured teacher questionnaire and a semi-structured interview guide for pedagogic inspectors. The questionnaire employed a four-point Likert scale ranging from Strongly Agree to Strongly Disagree. The technology-integration scale comprised seven items addressing the use of digital tools, technology-supported content delivery, virtual laboratories and simulations, online platforms and materials, student interest, and technology training. The professional-development scale comprised seven items covering workshops, in-service training, professional learning communities, application of new knowledge, feedback, encouragement for continuous development, and professional confidence. Teaching competencies were assessed

using seven indicators relating to lesson objectives, instructional methods, students' understanding, assessment, classroom organization, student engagement, and confidence in curriculum delivery.

Content validity was established through a review of relevant literature and conceptual frameworks, followed by expert evaluation by two university lecturers and two experienced food science educators. Their assessment focused on the clarity, relevance, coverage, and appropriateness of the questionnaire items. A pilot test was subsequently conducted with eight food science teachers who were not included in the final sample. The questionnaire yielded a Cronbach's alpha coefficient of .84, indicating satisfactory internal consistency. For data collection, questionnaires were physically administered to participating schools, with respondents given two weeks to complete them. Follow-up visits and reminders were used to improve the response rate. The pedagogic inspectors were interviewed face-to-face for approximately 30–45 minutes, with their consent, and the interviews were audio-recorded, transcribed, and anonymized.

Quantitative data were analysed using frequencies, percentages, means, standard deviations, Pearson product-moment correlation, and simple linear regression. The hypotheses were tested at the .05 level of significance. Qualitative data were analysed thematically through transcription, coding, categorization, and identification of recurring themes and patterns. The quantitative and qualitative findings were subsequently integrated through triangulation to examine areas of convergence, complementarity, and divergence. This integration enabled the statistical relationships identified among the study variables to be interpreted alongside the professional and contextual explanations provided by the pedagogic inspectors. Ethical principles were observed throughout the study, including obtaining informed consent from all participants, ensuring voluntary participation and the right to withdraw, maintaining confidentiality and anonymity, and using the collected data solely for academic purposes.

FINDINGS

Quantitative Findings

Research Question One: What is the impact of teachers' integration of technology in teaching food science on their teaching competencies?

Table 1: Descriptive Statistics on Teachers' Integration of Technology in Teaching Food Science

S/N	Statement	SA	A	D	SD	SA/A	SD/D	Mean	Std Dev
1	I use digital tools (e.g., videos, PowerPoint) in teaching food science.	54	32	5	1	86	6	3.51	0.587
2	Technology helps me deliver content more effectively.	40	38	10	4	78	14	3.24	0.707
3	I incorporate virtual labs and simulations into lessons.	43	37	9	3	80	12	3.31	0.658
4	I use online platforms to assess or assign food science tasks.	41	39	8	4	80	12	3.28	0.672
5	I access teaching materials online to enhance content delivery.	45	40	5	2	85	7	3.41	0.615
6	Students show more interest when I use technological tools.	34	40	13	5	74	18	3.12	0.745
7	I have received training on educational technology in food science.	49	35	6	2	84	8	3.43	0.631
Overall Mean of Responses								3.29	0.660

Table 1 shows that teachers generally integrate technology into food science teaching, although the level of use varies across practices. The highest-rated item was the use of digital tools such as videos and PowerPoint (M = 3.51, SD = 0.587), followed by training in educational technology (M = 3.43, SD = 0.631) and access to online

teaching materials ($M = 3.41$, $SD = 0.615$). Use of virtual laboratories and simulations ($M = 3.31$, $SD = 0.658$) and online platforms for assessment and assignments ($M = 3.28$, $SD = 0.672$) was comparatively lower, suggesting less consistent use of advanced technological applications.

The overall mean of 3.29 ($SD = 0.660$) indicates generally positive technology integration. Although teachers perceived technology as useful for content delivery ($M = 3.24$, $SD = 0.707$), student interest recorded the lowest mean ($M = 3.12$, $SD = 0.745$) and greatest variability, suggesting differences in its perceived effect on engagement. Overall, the findings indicate that technology is widely used to support instruction, but continued training, improved access to digital resources, and more purposeful integration of interactive technologies are needed to strengthen its contribution to teaching competencies.

H₀₁: Teachers' integration of technology in teaching food science has no significant impact on their teaching competencies.

H_{a1}: Teachers' integration of technology in teaching food science has a significant impact on their teaching competencies.

Table 2: Model Summary on Teachers' Integration of Technology in Teaching Food Science and Their Teaching Competencies

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.294 ^a	.086	.076	3.065
a. Predictors: (Constant), Teachers' Integration of Technology in Teaching Food Science				

Table 2 shows a correlation coefficient (R) of 0.294, indicating a weak to moderate positive relationship between technology integration and teaching competencies. The R Square value of 0.086 suggests that only about 8.6% of the variance in teaching competencies is explained by teachers' integration of technology. While this percentage is relatively low compared to other predictors such as content knowledge and practical skills, it still suggests some level of influence. The adjusted R Square of 0.076 further confirms the modest explanatory power of the model, and the standard error of estimate of 3.065 indicates some degree of prediction error.

Table 3: ANOVA on Teachers' Integration of Technology in Teaching Food Science and Their Teaching Competencies

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	88.960	1	88.960	9.457	.003 ^b
	Residual	859.445	90	9.549		
	Total	948.405	91			
a. Dependent Variable: Teaching Competencies						
b. Predictors: (Constant), Teachers' Integration of Technology in Teaching Food Science						

Table 3 provides the ANOVA results, where the F-statistic is 9.457 with a significance level ($p = .003$). This p-value is less than the conventional threshold of 0.05, indicating that the regression model is statistically significant. In other words, the model including teachers' technology integration significantly predicts teaching competencies, and we can reject the null hypothesis that there is no effect. Although the F-value is relatively small compared to previous models, it still confirms the model's overall significance.

Table 4: Regression Coefficients on Teachers' Integration of Technology in Teaching Food Science and Their Teaching Competencies

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	12.523	1.642		7.714	.000	9.402	15.928
	Teachers' Integration of Technology in Teaching Food Science	.0377	.123	.294	3.075	.003	0.133	0.621
a. Dependent Variable: Teaching Competencies								

Table 4 details the regression coefficients. The unstandardized coefficient (B) for teachers' integration of technology is 0.377, meaning that for each unit increase in technology integration, teaching competency increases by approximately 0.38 units, assuming other variables remain constant. The standardized Beta coefficient of 0.294 suggests a weak to moderate effect size. The t-value of 3.075 and the p-value of .003 indicate that this predictor is statistically significant, reinforcing the conclusion that technology integration is positively associated with teaching competencies. The 95% confidence interval (0.133 to 0.621) excludes zero, further supporting the reliability of the estimate.

Therefore, while the influence of teachers' integration of technology on their teaching competencies is statistically significant, the effect size and explained variance are relatively modest. Therefore, we reject the null hypothesis (H_{01}) and accept the alternative hypothesis (H_{a1}), acknowledging that technology integration does have a significant but limited impact on teaching competencies in food science. This suggests that although technology use contributes to teaching effectiveness, other factors likely play a more dominant role, highlighting the need for continued investment in both technology and complementary professional development areas.

Research Question Two: How can teachers' professional development in food science affect their teaching competencies?

Table 5: Descriptive Statistics on Teachers' Professional Development in Food Science

S/N	Statement	SA	A	D	SD	SA/A	SD/D	Mean	Std Dev
8	I attend food science workshops and training regularly.	28	34	20	10	62	30	3.15	0.792
9	In-service training has improved my teaching approaches.	30	42	15	5	72	20	3.29	0.618
10	I participate in professional learning communities related to food science.	35	40	12	5	75	17	3.33	0.612
11	I apply new knowledge from training sessions to my classroom practice.	36	38	15	3	74	18	3.28	0.591
12	I receive feedback from trainers that helps me improve.	34	36	16	6	70	22	3.25	0.634
13	I am encouraged to pursue continuous development in my field.	30	37	18	7	67	25	3.22	0.656
14	Professional development has increased my confidence as a food science teacher.	22	31	25	14	53	39	2.89	0.872
Overall Mean of Responses (Out of 28)								3.20	2.682

The findings indicate that professional development is generally perceived as beneficial to teaching competencies, although its overall influence is moderate ($M = 3.20$). The highest-rated items were participation in professional learning communities ($M = 3.33$, $SD = 0.612$), improvement in teaching approaches through in-

service training ($M = 3.29$, $SD = 0.618$), and application of knowledge gained from training to classroom practice ($M = 3.28$, $SD = 0.591$). These results suggest that collaborative professional learning and practical application of training are important aspects of teachers' professional growth.

However, confidence in teaching food science recorded the lowest mean ($M = 2.89$, $SD = 0.872$), while regular attendance at workshops and training also showed a comparatively lower mean ($M = 3.15$, $SD = 0.792$). The relatively high standard deviations indicate differences among teachers in their access to, participation in, and perceived benefits of professional development. Overall, the findings suggest that professional development contributes positively to teaching competencies, but its impact is not uniform. More regular, accessible, and targeted professional development opportunities may therefore strengthen teachers' confidence and application of acquired knowledge.

H₀₂: Teachers' professional development in food science does not significantly affect their teaching competencies.

H_{a2}: Teachers' professional development in food science significantly affects their teaching competencies.

Table 6: Model Summary on Teachers' Professional Development in Food Science and Their Teaching Competencies

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.261	.068	.058	2.962
a. Predictors: (Constant), Teachers' Professional Development in Food Science				

Table 6 shows a correlation coefficient (R) of 0.261, which represents a weak positive relationship between teachers' professional development and their teaching competencies. The R Square value of 0.068 indicates that approximately 6.8% of the variance in teaching competencies can be explained by the level of professional development received in food science. The adjusted R Square, which accounts for the number of predictors in the model, is slightly lower at 0.058, reaffirming the modest strength of this relationship. The standard error of the estimate is 2.962, suggesting a moderate level of prediction error in the model.

Table 7: ANOVA on Teachers' Professional Development in Food Science and Their Teaching Competencies

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	56.314	1	56.314	6.420	.013 ^b
	Residual	797.542	90	8.861		
	Total	853.856	91			
a. Dependent Variable: Teaching Competencies						
b. Predictors: (Constant), Teachers' Professional Development in Food Science						

Table 7 presents the ANOVA summary, revealing an F -statistic of 6.420 and a p -value of .013. Since the p -value is less than the standard significance level of 0.05, the regression model is statistically significant. This implies that teachers' professional development in food science has a meaningful impact on their teaching competencies. Although the explained variance is relatively small, the model does reliably predict changes in teaching competencies based on professional development activities, providing sufficient statistical grounds to reject the null hypothesis.

Table 8: Regression Coefficients on Teachers' Professional Development in Food Science and Their Teaching Competencies

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	10.721	1.089		9.840	.000	8.560	12.882
	Teachers' Professional Development in Food Science	0.301	0.119	.261	2.530	.013	0.065	0.537
a. Dependent Variable: Teaching Competencies								

In Table 8, the unstandardized coefficient (B) for professional development is 0.301, indicating that for every one-unit increase in professional development, there is an expected 0.301 increase in teaching competency scores. The standardized Beta coefficient is 0.261, confirming a weak but statistically meaningful effect. The t-value of 2.530, alongside a p-value of .013, confirms that the predictor is statistically significant. Additionally, the 95% confidence interval for the B value (0.065 to 0.537) does not include zero, reinforcing the reliability of this effect. Hence, although the relationship between teachers' professional development in food science and their teaching competencies is not particularly strong, it is statistically significant. Therefore, we reject the null hypothesis (H_{02}) and accept the alternative hypothesis (H_{a2}), concluding that professional development in food science does have a significant positive effect on teaching competencies. This underscores the importance of continuous, subject-specific professional development initiatives as a means to enhance teaching quality and overall instructional effectiveness.

Qualitative Findings

The qualitative data were analyzed using Braun and Clarke's (2006) thematic-analysis framework. Initial coding of the four inspector interviews generated categories related to technology access and use, ICT preparedness, the instructional value of digital resources, the frequency and relevance of professional development, the application of training in practice, feedback, and teacher motivation. Through iterative comparison and consolidation across transcripts, these categories were organized into two overarching themes: (1) technology integration was perceived as instructionally useful but remained inconsistent because of resource and training constraints; and (2) professional development was valued but was perceived as insufficiently frequent, coordinated, and practice-oriented.

Technology Integration and Teaching Competencies

The qualitative findings provided important contextual explanations for the quantitative results. Inspectors indicated that technology use was present but uneven across teachers and instructional contexts. PI1 and PI3 described technology use as minimal among some teachers, suggesting that the availability of digital resources did not necessarily translate into regular classroom application. PI1 explained, *"Some teachers do not use technology regularly in their lessons. In some cases, they use it only occasionally, when the equipment is available or when they have somebody to assist them."* PI3 similarly emphasized the limited integration of ICT into everyday teaching: *"The use of ICT is still very limited among some teachers. Even when the facilities are there, some teachers are not confident enough to use them effectively in their lessons."* The accounts further suggested that inadequate ICT preparation was an important constraint. PI3 noted, *"One of the problems is that many teachers have not received enough training on how to use ICT for teaching. Having a computer or other equipment is not enough if the teacher does not know how to use it pedagogically."*

At the same time, inspectors recognized the instructional value of appropriately selected digital resources. PI2 particularly highlighted the usefulness of visual materials and food-processing videos: *"When teachers use videos, especially videos showing food processing, students can see what is being explained instead of only hearing about it. This makes the lesson more interesting and helps them to understand the content better."* PI2 further indicated that such resources could stimulate students' engagement: *"The students become more interested when they see practical things on the screen. They pay more attention because the lesson is no longer only theoretical."* Taken together, these accounts indicate that technology was not perceived as ineffective; rather, its pedagogical potential was constrained by uneven access, inadequate ICT preparation, and inconsistent classroom application. The qualitative evidence therefore helps explain why technology integration could be positively associated with teaching competencies while the strength of the relationship remained modest.

Professional Development and Teaching Competencies

Professional development was similarly characterized by positive potential alongside substantial structural limitations. Inspectors described existing opportunities as infrequent, generic, and poorly coordinated. PI1 observed, *"The training opportunities are not frequent enough. Some teachers can spend several years without attending any training that is directly related to what they are expected to teach."* PI2 similarly emphasized the generic nature of some training activities: *"Sometimes the training is organized, but it is too general. It may not address the specific difficulties teachers are facing in their classrooms."*

The interviews also highlighted weaknesses in coordination and continuity. PI1 explained, *"There is not always a continuous programme for professional development. Teachers may attend one training and then wait for a long time before they have another opportunity to update what they learned."* These accounts suggest that the challenge was not simply the existence of professional development but its frequency, continuity, specificity, and connection to classroom practice. Importantly, PI3 and PI4 considered practical, hands-on training particularly valuable. PI3 explained, *"The training is more useful when teachers are given the opportunity to practise what they are learning. When they actually demonstrate the teaching strategy and receive guidance, they are more likely to use it in the classroom."* PI4 similarly stated, *"Practical training has a greater impact because teachers can see how the strategy works and how they can adapt it to their own classrooms. After some of these trainings, teachers became more motivated and changed the way they approached their lessons."*

The qualitative findings therefore suggest that professional development was perceived as most beneficial when it moved beyond the transmission of information to include demonstration, practice, feedback, and opportunities for classroom application. This distinction is important because participation in professional development does not necessarily imply that teachers have acquired or applied new competencies. Overall, the qualitative evidence portrays technology integration and professional development as potentially important components of instructional improvement, but their contribution to teaching practice appears to depend on the conditions under which they are implemented. Technology was viewed as capable of enhancing students' understanding and interest, particularly through visual and practical resources, but its use remained inconsistent where ICT preparedness and resources were inadequate. Similarly, professional development was valued, particularly when practical and relevant, but its potential was constrained by infrequency, generic content, weak coordination, and limited opportunities for sustained application.

These findings provide useful contextual explanations for the statistically significant but modest quantitative relationships. They suggest that technology integration and professional development operate within a broader institutional environment in which resources, teacher preparedness, training continuity, practical application, and instructional support may shape the extent to which these practices are reflected in teaching competencies. The qualitative findings should therefore be interpreted as contextual and explanatory rather than causal; they illuminate the circumstances surrounding the observed quantitative associations but do not establish that technology integration or professional development independently causes improvements in teaching competencies.

Triangulation of Findings

The quantitative and qualitative strands demonstrated substantial convergence while providing complementary perspectives on technology integration and teaching competencies. Quantitatively, teachers reported relatively positive levels of technology integration and a statistically significant association with teaching competencies. Qualitatively, inspectors similarly acknowledged the instructional value of technology, particularly its potential to enhance students' understanding and engagement, but emphasized that its classroom application remained inconsistent. They attributed this uneven implementation partly to inadequate ICT preparation and resource constraints. Thus, the qualitative evidence contextualizes the quantitative finding by suggesting that positive perceptions of technology do not necessarily translate into consistent pedagogical use.

A similar pattern emerged for professional development. Teachers reported generally positive professional-development experiences, while inspectors acknowledged its value but identified limitations in frequency, coordination, specificity, and practical orientation. Inspectors particularly emphasized the usefulness of hands-on training and opportunities to apply new strategies in classroom settings. The convergence across strands therefore suggests that technology integration and professional development are positively related to teaching competencies, while also indicating that their potential is shaped by the institutional conditions in which they are implemented. Importantly, the qualitative evidence provides contextual explanation for the quantitative associations but does not establish causal effects.

DISCUSSION OF FINDINGS

Technology Integration and Teaching Competencies

The finding that technology integration was significantly associated with teaching competencies suggests that teachers who make greater use of digital technologies tend to report stronger teaching competencies. This pattern is theoretically consistent with the technological pedagogical content knowledge (TPACK) framework of Mishra and Koehler (2006), which conceptualizes effective technology use as the interaction of technological, pedagogical, and content knowledge rather than the mere presence of digital tools. In food science education, digital resources can support the representation of practical and otherwise difficult-to-observe processes through videos, demonstrations, simulations, and other multimedia resources. However, the explanatory contribution of technology integration was modest, accounting for 8.6% of the variance in teaching competencies. This finding is important because it indicates that technology integration constitutes one component of teaching competence rather than a sufficient condition for effective teaching. Competence in food science instruction is multidimensional and is also likely to encompass disciplinary knowledge, practical expertise, pedagogical knowledge, classroom management, assessment competence, and the capacity to respond to contextual demands.

The descriptive and qualitative findings further clarify the nature of this association. Teachers reported relatively strong use of basic digital resources, particularly videos and PowerPoint presentations, but comparatively lower ratings for indicators related to student interest. This pattern cautions against equating technology exposure with technology-enhanced pedagogy. As Ertmer and Ottenbreit-Leftwich (2010) argue, meaningful technology integration depends not only on access to technological tools but also on teachers' knowledge, confidence, pedagogical beliefs, and the conditions within which technology is used. The qualitative evidence converged with this interpretation: inspectors acknowledged the instructional value of digital resources but reported inconsistent classroom application and identified inadequate ICT preparation and resource limitations as important constraints. The findings therefore point to a distinction between the availability or use of digital tools and their pedagogically purposeful integration. In this context, strengthening teaching competencies may require professional support that enables teachers to move beyond basic technology use toward deliberate integration of digital resources with disciplinary content and instructional objectives.

Professional Development and Teaching Competencies

Professional development was also significantly associated with teaching competencies, although its explanatory contribution was modest, accounting for 6.8% of the variance in teaching competencies. This finding is broadly

consistent with Guskey's (2002) argument that professional development is more likely to influence teaching practice when teachers have opportunities to translate professional learning into classroom practice. It also accords with Desimone's (2009) emphasis on coherent professional learning that is connected to teachers' instructional work and sustained through meaningful engagement. Such professional learning is particularly pertinent in food science education, where teachers may need to continually update both disciplinary and pedagogical knowledge in response to developments in technology, food-processing practices, curriculum expectations, and instructional approaches.

The modest explanatory contribution, however, suggests that participation in professional development should not be interpreted as sufficient, in itself, to account for variation in teaching competencies. The qualitative evidence provides important context for this finding. Inspectors described professional-development opportunities as relatively infrequent, insufficiently coordinated, and sometimes insufficiently connected to teachers' immediate classroom needs, while identifying practical and hands-on training as particularly valuable. The comparatively low rating for increased teacher confidence is also noteworthy. It suggests that exposure to training may not automatically translate into the confidence required to implement new practices. Professional learning may be more consequential when teachers can engage with new approaches through demonstration, guided practice, feedback, reflection, and subsequent classroom application. The findings therefore support a view of professional development as an ongoing process of professional learning and application rather than a series of isolated training events. Importantly, the observed association should not be interpreted causally; rather, it indicates that professional development and teaching competencies vary together within a broader institutional context in which the quality, continuity, relevance, and practical orientation of professional learning may matter as much as participation itself.

Implications Of the Findings

The findings imply that technology integration should be treated as a pedagogical competence in food science education. Teacher-development programmes should therefore link digital tools to specific learning objectives, while schools and education authorities provide appropriate resources, technical support, and context-sensitive solutions. Since technology alone does not account for all differences in teaching competencies, it should form part of a broader instructional-improvement framework.

The professional-development findings imply the need for continuous, subject-specific, and practice-oriented teacher learning. Professional learning communities, mentoring, peer collaboration, classroom application, and constructive feedback should complement formal training. Given the variability in professional-development experiences, effective instructional supervision and supportive school environments are also necessary to strengthen teachers' confidence and competencies.

RECOMMENDATIONS

Based on the technology-integration findings, pre-service and in-service programmes should incorporate practical digital pedagogy for food science, including the use of videos, presentation software, simulations, virtual laboratories, online resources, and digital assessment tools. Schools and education authorities should provide appropriate ICT facilities, technical support, and context-sensitive solutions for resource-constrained settings. Technology should be used to complement, rather than replace, practical, laboratory, and experiential activities that are essential to food science education.

Based on the professional-development findings, education authorities and schools should establish regular, subject-specific, and practice-oriented professional-development programmes that include professional learning communities, mentoring, peer learning, lesson sharing, and classroom-based feedback. Teachers should be supported to apply newly acquired knowledge in their classrooms and reflect on its effectiveness, while pedagogic inspectors should provide constructive supervision and help identify teachers' specific development needs.

Limitations Of The Study

The cross-sectional design limits causal interpretation. Although technology integration and professional development were significantly associated with teaching competencies, the findings cannot establish temporal or causal relationships. Longitudinal or experimental studies are needed to examine whether changes in these factors produce corresponding changes in teaching competencies.

The quantitative findings relied primarily on teachers' self-reports, which may be affected by social desirability, recall, or response biases. Although inspector interviews provided complementary perspectives, the study did not include systematic classroom observations or objective measures of technology use and teaching performance. Future research could strengthen the evidence through observational and performance-based measures.

Despite these few limitations, the study provides useful convergent evidence that technology integration and professional development are associated with teaching competencies, while highlighting the importance of institutional support, ICT preparedness, and practice-oriented professional learning.

CONCLUSION

This study examined the relationships between technology integration, professional development, and teaching competencies among secondary school food science teachers in Mezam Division, Cameroon. The findings demonstrated statistically significant positive relationships between both technology integration and professional development and teachers' teaching competencies. Technology integration showed a significant relationship with teaching competencies, $R = .294$, $p = .003$, and explained 8.6% of the variance. Teachers particularly reported using videos, PowerPoint, and online teaching resources. However, qualitative evidence indicated that technology use remained inconsistent because of ICT-training and resource limitations.

Professional development was also significantly related to teaching competencies, $R = .261$, $p = .013$, explaining 6.8% of the variance. Teachers valued professional learning opportunities, particularly professional learning communities and the application of new knowledge, but inspectors reported limitations concerning frequency, coordination, and practical relevance. The findings therefore indicate that technology integration and professional development are important dimensions of food science teaching competence, but neither should be regarded as sufficient in isolation. Their contribution is more appropriately understood within a broader system involving teacher knowledge, practical competence, pedagogical preparation, resources, supervision, and institutional support. For secondary food science education in Mezam Division, sustained professional learning and pedagogically meaningful technology integration provide important avenues for strengthening teachers' instructional practice.

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