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# Analyzing the Impact of Adaptive Teaching, Technological Integration, and Educational Change on Teachers' Professional Competencies: A Structural Equation Modelling (SEM) Approach

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## Abstract

This study investigates how adaptive teaching, technological integration, curriculum strategies, assessment and innovation, professional development, student engagement, and educational change influence teachers' professional competencies in secondary schools. Using a quantitative survey design and structural equation modelling (SEM) on data from 260 teachers, the research identifies technological integration, curriculum strategies, student engagement, and educational change as significant predictors of professional competence. Findings highlight gaps in assessment practices and interdisciplinary approaches but underscore the need for modernized, engagement-driven pedagogy. Results provide actionable insights for policymakers and educators to enhance teacher effectiveness through targeted professional growth and systemic educational reforms.

***Keywords:*** *Adaptive Teaching, Technology, Curriculum, Assessment, Development, Engagement, Change*.

## 1. Introduction

Education today faces transformative challenges driven by rapid technological advancement, diverse learner needs, and shifting societal expectations. The quality of an education system ultimately depends on the professional competencies of its teachers, which encompass their pedagogical adaptability, technological proficiency, curriculum expertise, assessment literacy, and capacity for continuous improvement. As classrooms evolve into dynamic learning ecosystems, teachers must integrate technology effectively, foster student engagement, and align instructional strategies with 21st-century skills. These evolving expectations require an evidence-based understanding of the factors shaping teacher performance. Professional competency is not a static attribute but a composite of multiple interrelated domains. *Adaptive Teaching* ensures instructional flexibility that accommodates diverse learning styles. *Technological Integration* empowers teachers to use digital tools for collaborative and personalized learning. *Curriculum Strategies* emphasize interdisciplinary and experiential approaches that connect theory with practice. *Assessment and Innovation* support critical thinking through formative feedback, while *Professional Development* provides opportunities for continual skill enhancement. Likewise, *Student Engagement* and *Educational Change* reflect both classroom-level and systemic influences that sustain quality improvement. This study therefore investigates how these seven constructs Adaptive Teaching, Technological Integration, Curriculum Strategies, Assessment & Innovation, Professional Development, Student Engagement, and Educational Change—collectively influence teachers' *Professional Competencies* in secondary and senior-secondary schools. Through employing a structured survey and analyzing the data through descriptive and inferential statistics, particularly Structural Equation Modelling (SEM), the research aims to identify which factors most significantly predict teacher effectiveness. The findings will guide policymakers, administrators, and educators in designing targeted interventions that enhance teaching quality, promote innovation, and align professional growth with contemporary educational demands.

## 2. Related Reviews

**Konyeme and Alordiah (2024)** emphasize that traditional assessments in science education, focused on rote learning and memorization, fail to measure students' real understanding and application of knowledge. They advocate for authentic evaluation, which involves real-world, inquiry-based tasks fostering critical thinking, creativity, and problem-solving skills. The study highlights that authentic assessments enhance student engagement and align better with 21st-century learning goals but face challenges such as limited resources, teacher resistance, and reliability concerns. The authors recommend professional training, supportive policies, and further research to integrate authentic assessment effectively into science education for meaningful learning outcomes.

**Gentile et al. (2023)** The integration of artificial intelligence (AI) into educational settings has significantly transformed the traditional role of educators. A detailed examination through a comprehensive literature review revealed that the education sector has only partially recognized the pressing need to address the complex challenges introduced by AI. The findings highlighted a general lack of preparedness and strategic planning in adapting to AI-driven changes, especially in redefining educators' responsibilities. To address this gap, the researchers proposed a guiding framework or manifesto aimed at reshaping the educator's role in alignment with the changing technological landscape. Drawing on Thomas Kuhn's concept of paradigm shifts, they argued that the current transition mirrors a fundamental transformation in the structure of educational practice. Just as scientific revolutions redefine foundational assumptions, the integration of AI calls for a complete re-evaluation of teaching methods, classroom dynamics, and professional identities. The manifesto emphasizes the need for educators to embrace new roles as facilitators, co-learners, and ethical guides within AI-enhanced environments. It also stresses the importance of critical engagement with technology rather than passive acceptance.

**Smékalová et al. (2021)** The Erasmus+ KA201 project, "CATCH 21st Skills – Changing the Approach to Teaching in Higher Education," presented insights from a qualitative study aimed at aligning academic instruction with current labor market needs. Researchers conducted semi-structured interviews with six human resource managers from private companies in the Czech Republic to explore the transferable skills most valued in graduates. The findings highlighted the significance of 21st-century skills, which were categorized into four major competence areas. Among these, communication and cooperation emerged as the most crucial skill clusters sought by employers. The study also emphasized the need for a shift in the higher education system to better prepare students for the evolving demands of the job market. It advocated for a transformation in teaching strategies, suggesting practical approaches and resources that universities could adopt to nurture essential skills in students.

**Oecd's Talis (2019**) reported that teachers' participation in targeted PD (e.g., ICT in instruction) correlates with higher self-efficacy and more frequent use of student-centered practices. Barriers include time, cost, and limited relevant offerings, particularly in under-resourced schools. The survey underscores the role of leadership and collaborative cultures (e.g., peer observation) in sustaining change. For competencies, systemic supports—time for collaboration, mentoring, and technical assistance—are prerequisites for translating training into classroom practice.

**Tomlinson (2014)** synthesized decades of classroom differentiation research, arguing that responsive adjustments to content, process, and product grounded in ongoing assessment raise access and achievement for diverse learners. Evidence across subject areas shows differentiated tasks, flexible grouping, and formative feedback improve engagement and outcomes, particularly for students at the margins. The work also highlights implementation challenges: teacher planning load, assessment literacy, and the need for professional learning communities. For competency development, Tomlinson positions adaptive routines as core skills—diagnosing readiness, adjusting scaffolds, and designing multiple pathways directly aligning with professional standards for inclusive pedagogy.

**Freeman et al. (2014)** meta-analyzed 225 STEM studies, showing active learning reduces failure rates and modestly increases exam performance versus traditional lectures. Gains were robust across class sizes and topics. The findings generalize key engagement mechanisms frequent retrieval, peer instruction, and feedback—that map to competencies in lesson design and facilitation. The authors caution that implementation quality matters; superficial activities without accountability or feedback yield limited benefits, reinforcing the need for teacher expertise in structuring collaborative work and assessment.

**Desimone (2009**) synthesized evidence on effective PD, identifying core features: content focus, active learning, coherence with standards, sufficient duration, and collective participation. PD with these features improves instructional practice and, indirectly, student achievement. The review recommends measuring teacher knowledge and classroom enactment, not attendance alone. For competencies, PD must connect to teachers' curricular and assessment challenges, include modeling and cycles of practice-feedback, and be situated in communities of practice aligning institutional support with measurable shifts in pedagogy.

**Hmelo-Silver, Duncan, and Chinn (2007)** reviewed inquiry and problem-based learning, concluding that well-scaffolded designs enhance conceptual understanding, reasoning, and transfer. Misconceptions that inquiry equals "minimal guidance" are addressed; effective models provide prompts, representations, and formative checks. For teacher competencies, the review underscores planning for evidence of learning, orchestrating collaboration, and leveraging technology for modeling and feedback. Implementation hinges on teacher assessment literacy and classroom management of open-ended tasks skills that connect directly to curriculum strategy and assessment-innovation construct.

**Fullan (2007)** framed educational change as a complex, multi-level process requiring capacity building, coherence, and continuous improvement. Sustainable reform depends on teacher learning cultures, data use, and leadership that reduces initiative overload. The book documents cases where technology or assessment reforms failed without alignment to pedagogy and professional learning. For competencies, Fullan positions teacher collaboration, inquiry cycles, and evidence-informed adaptation as central—linking the EC construct to concrete practices that elevate professional skill and student outcomes.

**Mishra and Koehler (2006)** proposed TPACK, positing that effective technology integration requires intersecting knowledge of content, pedagogy, and technology. Studies using the framework show that targeted PD can increase teachers' confidence designing tech-enhanced tasks that fit disciplinary epistemologies rather than layering gadgets onto lessons. The review notes uneven measurement of TPACK constructs and calls for performance-based assessments. For competencies, TPACK operationalizes what "integration" looks like in practice (e.g., task redesign, representation tools, assessment alignment), making it a practical lens for building and evaluating teacher capability in digital pedagogy.

**Venkatesh et al. (2003)** unified prior acceptance models into UTAUT, identifying performance expectancy, effort expectancy, social influence, and facilitating conditions as core predictors of technology use, moderated by experience and voluntariness. Education studies applying UTAUT find that perceived usefulness and institutional support strongly shape teachers' sustained classroom technology use. The model's emphasis on infrastructure and support resonates with professional competencies by linking skill enactment to organizational enablers (training, time, technical help). UTAUT also explains neutral or resistant attitudes found in many schools where policy signals are weak or tools misaligned with curricular goals.

**Guskey (2002)** argued PD efficacy should be evaluated across five levels: participants' reactions, learning, organizational support, classroom practice, and student outcomes. Many initiatives fail by ignoring organizational conditions and classroom transfer. The framework encourages backward design—starting from desired student results and aligning PD content, coaching, and assessment. For competencies, it emphasizes observable instructional changes (e.g., differentiation, formative use of data) and the enabling role of school policies, schedules, and leadership—bridging individual skill with systemic.

**Shulman (1986)** introduced Pedagogical Content Knowledge (PCK), highlighting the distinctive knowledge teachers need to transform subject matter for learners—common misconceptions, representations, and explanations. Subsequent research validated PCK as predictive of instructional quality and student understanding. For competency frameworks, PCK operationalizes expertise beyond generic methods, aligning with curriculum strategy, assessment design, and adaptive teaching. Building PCK requires content-focused PD, collaborative planning, and iterative reflection on student evidence.

## 3. Research Methodology

### 3.1 Research Design and Approach

The study employed a quantitative, cross-sectional survey design to examine how Adaptive Teaching (AT), Technological Integration (TI), Curriculum Strategies (CS), Assessment & Innovation (AI), Professional Development (PD), Student Engagement (SE), and Educational Change (EC) influence Professional Competencies (PC) among teachers. The design, grounded in a positivist paradigm, enabled the testing of theory-driven relationships through Structural Equation Modelling (SEM). Quantitative methods ensured objectivity, replicability, and generalizability of findings.

### 3.2 Objectives

The study aimed (1) to assess the reliability and validity of measurement constructs; (2) to analyze teachers' perceptions through descriptive statistics; and (3) to evaluate causal relationships among predictors and PC using SEM.

### 3.3 Population and Sample

The target population comprised teachers from government and private senior-secondary schools. A multi-stage stratified random sampling technique selected schools by management type and locale, followed by systematic sampling of teachers. A total of 260 responses were analyzed—adequate for SEM requirements ($\geq$ 200 cases). The sample size ensures statistical power for detecting medium effects with acceptable fit indices.

### 3.4 Instrument and Measures

A structured questionnaire measured eight latent constructs using a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree).

- AT (4 items): adaptive instruction, responsiveness, and feedback use.
- TI (6 items): integration confidence, training adequacy, tool exploration.
- CS (4 items): interdisciplinary and experiential learning emphasis.
- AI (3 items): innovation, critical thinking assessment, and tech support.
- PD (4 items): relevance, institutional support, and impact.
- SE (4 items): motivation, collaboration, engagement.
- EC (3 items): perceived policy responsiveness and systemic change.

- PC (4 items): instructional versatility, assessment design, and technological competence.
  Face and content validity were confirmed by subject experts; a pilot (n = 30) verified clarity and preliminary reliability.

### 3.5 Reliability and Validity

Reliability was verified through Cronbach's Alpha (0.756–0.888), confirming internal consistency. CFA validated construct adequacy: factor loadings ≥ 0.50, CR ≥ 0.70, and AVE ≥ 0.50 demonstrated convergent validity. Fornell–Larcker and HTMT ≤ 0.85 ensured discriminant validity. Model fit indices ($\chi^2/df \leq 3$, CFI/TLI ≥ 0.90, RMSEA ≤ 0.08) confirmed measurement robustness.

### 3.6 Data Collection and Ethics

Data were collected both online and offline over four weeks, following institutional approval. Participation was voluntary; anonymity and confidentiality were guaranteed. Respondents provided informed consent, and data were encrypted and used solely for academic purposes, adhering to ethical standards.

### 3.7 Data Preparation and Analysis

Incomplete responses (> 20 % missing) were discarded. Minor missing values (< 5 %) were treated using expectation-maximization. Normality was checked through skewness, kurtosis, and Mardia's test.
Analyses used SPSS (for descriptives & reliability) and AMOS/SmartPLS (for SEM). Descriptive statistics summarized response patterns; CFA validated measurement; SEM tested hypotheses. Fit indices (GFI ≥ 0.85, AGFI ≥ 0.80, RMSEA ≤ 0.08, SRMR ≤ 0.08) guided evaluation. Significant paths ($p < 0.05$) indicated strong predictive relationships.

### 3.8 Common Method Bias and Robustness

Procedural remedies (anonymity, reverse-worded items) and statistical checks mitigated bias. Harman's single-factor test and CFA-marker technique verified no dominant factor. Bootstrapping (5,000 resamples) confirmed path stability and model robustness.

### 3.9 Operational Definitions

- Adaptive Teaching: tailoring instruction to student needs.
- Technological Integration: use of digital tools for effective teaching.
- Curriculum Strategies: interdisciplinary and experiential approaches.
- Assessment & Innovation: formative, creative evaluation methods.
- Professional Development: training enhancing teacher efficiency.
- Student Engagement: active involvement and collaboration.
- Educational Change: system adaptability to new demands.
- Professional Competencies: multidimensional teaching skills, technology readiness, and assessment literacy.

### 3.10 Limitations and Delimitations

The study assumes truthful responses and represents regional teachers. Limitations include self-report bias, cross-sectional design, and geographic scope. Delimitations restrict the study to secondary-level teachers and the selected constructs. Future research could expand to longitudinal data and comparative state analyses.

## 4. Data Analysis and Result

This section 4 presents a comprehensive analysis of the data collected through the structured survey instrument. This section details the statistical procedures employed, including descriptive statistics, frequency analysis, and structural equation modelling (SEM). The analysis examines teachers' perceptions on key constructs—Adaptive Teaching (AT), Technological Integration (TI), Curriculum Strategies (CS), Assessment & Innovation (AI), Professional Development (PD), Student Engagement (SE), and Educational Change (EC)—and their impact on Professional Competencies (PC). Detailed tables and interpretative commentary elucidate trends and relationships among variables. These findings provide critical insights into current teaching practices, highlighting areas of strength and potential improvement, and serve as a foundation for future educational reforms.

**Tables: Independent and Dependent Variables**

| Variable Type | Variable | Abbreviation |
|---|---|---|
| Independent Variable | Adaptive Teaching | AT |
| Independent Variable | Technological Integration | TI |
| Independent Variable | Curriculum Strategies | CS |
| Independent Variable | Assessment & Innovation | AI |
| Independent Variable | Professional Development | PD |
| Independent Variable | Student Engagement | SE |
| Independent Variable | Educational Change | EC |
| Dependent Variable | Professional Competencies | PC |

### 4.1 Reliability Analysis

**Table: Reliability (Cronbach's Alpha)**

| Variable | Abbreviation | Cronbach's Alpha | Number of Items |
|---|---|---|---|
| Assessment & Innovation | AI | 0.756 | 3 |
| Adaptive Teaching | AT | 0.871 | 4 |
| Curriculum Strategies | CS | 0.768 | 4 |
| Student Engagement | SE | 0.818 | 4 |
| Professional Competencies | PC | 0.846 | 4 |
| Educational Change | EC | 0.791 | 3 |
| Technological Integration | TI | 0.888 | 6 |
| Professional Development | PD | 0.859 | 4 |

### 4.2 Frequency Analysis (Selected Items)

**Table: AI1 — Assessment Methods Measure Critical Thinking & Problem-Solving**

| Response | Frequency | Percent |
|---|---|---|
| A | 2 | 0.8 |
| NAND | 26 | 10.0 |
| D | 120 | 46.2 |
| SD | 112 | 43.1 |

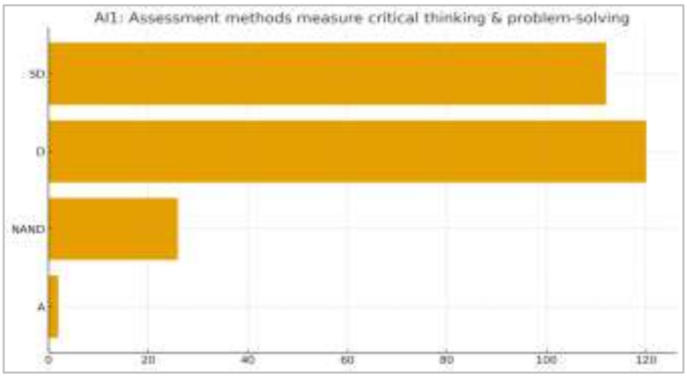


Figure: AI1: Assessment Methods Measure Critical Thinking & Problem-Solving

Table: AT1 — Regularly Modify Teaching for Diverse Learning Needs

| Response | Frequency | Percent |
|---|---|---|
| SA | 2 | 0.8 |
| A | 13 | 5.0 |
| NAND | 96 | 36.9 |
| D | 86 | 33.1 |
| SD | 63 | 24.2 |

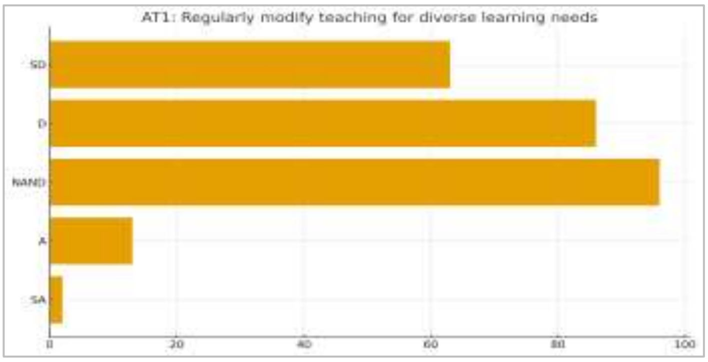


Figure: AT1: Regularly Modify Teaching for Diverse Learning Needs

Table: CS1 — Curriculum Integrates Interdisciplinary Approaches

| Response | Frequency | Percent |
|---|---|---|
| SA | 1 | 0.4 |
| A | 8 | 3.1 |
| NAND | 49 | 18.8 |
| D | 127 | 48.8 |
| SD | 75 | 28.8 |

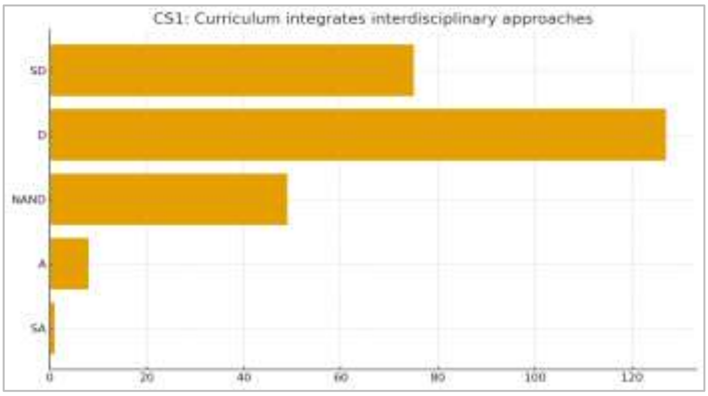


Figure: CS1: Curriculum Integrates Interdisciplinary Approaches

**Table: SE1 — Actively Participate in Class Discussions and Activities**

| Response | Frequency | Percent |
|---|---|---|
| SA | 1 | 0.4 |
| A | 2 | 0.8 |
| NAND | 36 | 13.8 |
| D | 130 | 50.0 |
| SD | 91 | 35.0 |

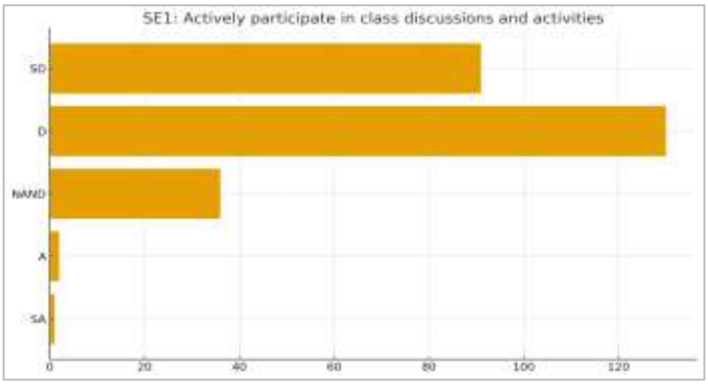


**Figure: SE1: Actively Participate in Class Discussions and Activities**

**Table: PC1 — Confident Using Varied Strategies for Different Learning Styles**

| Response | Frequency | Percent |
|---|---|---|
| A | 13 | 5.0 |
| NAND | 72 | 27.7 |
| D | 122 | 46.9 |
| SD | 53 | 20.4 |

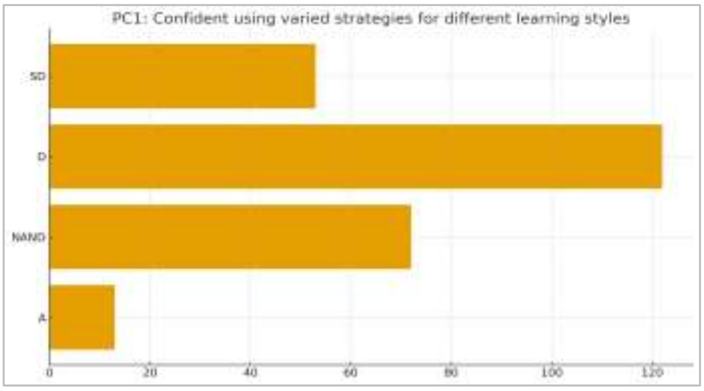


**Figure: PC1: Confident Using Varied Strategies for Different Learning Styles**

**Table: EC1 — System Evolving to Meet Needs of Modern Learners**

| Response | Frequency | Percent |
|---|---|---|
| A | 12 | 4.6 |
| NAND | 54 | 20.8 |
| D | 137 | 52.7 |
| SD | 57 | 21.9 |

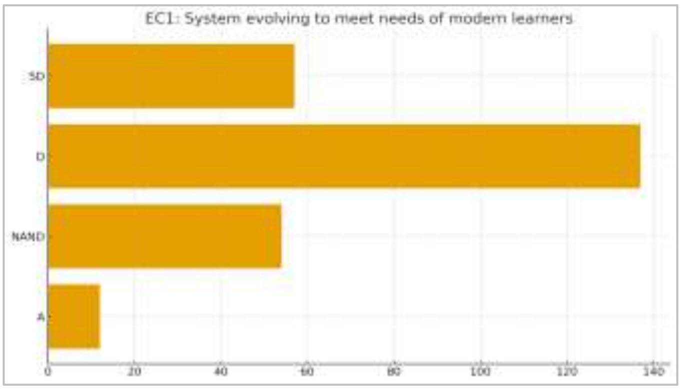


**Figure: EC1: System Evolving to Meet Needs of Modern Learners**

**Table: TI2 — Regularly Incorporate Digital Tools in Lesson Plans**

| Response | Frequency | Percent |
|---|---|---|
| SA | 21 | 8.1 |
| A | 69 | 26.5 |
| NAND | 108 | 41.5 |
| D | 49 | 18.8 |
| SD | 13 | 5.0 |

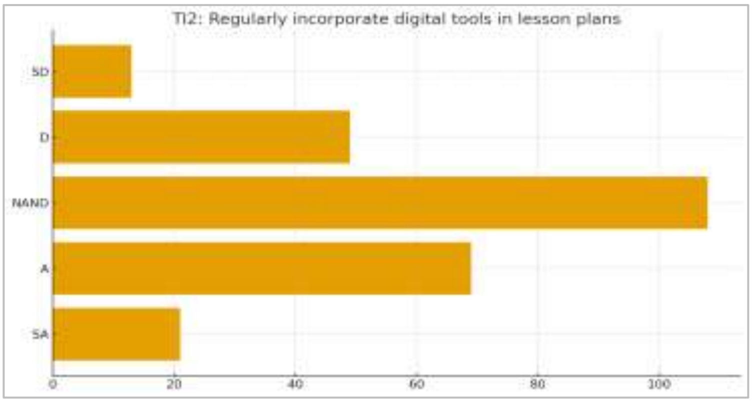


**Figure: TI2: Regularly Incorporate Digital Tools in Lesson Plans**

**Table: PD2 — Institution Supports My PD Participation**

| Response | Frequency | Percent |
|---|---|---|
| SA | 36 | 13.8 |
| A | 96 | 36.9 |
| NAND | 38 | 14.6 |
| D | 63 | 24.2 |
| SD | 27 | 10.4 |

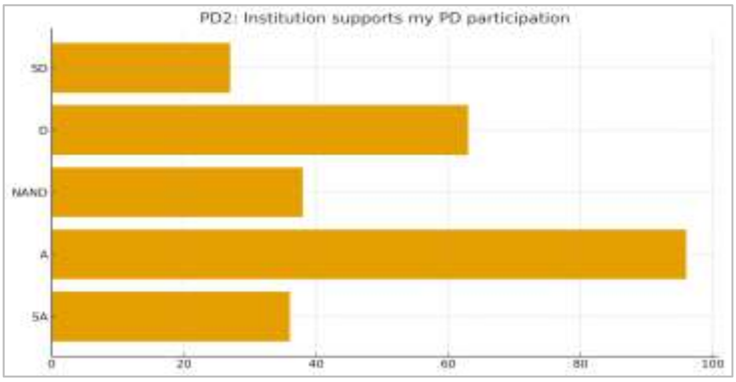


**Figure: PD2: Institution Supports My PD Participation**

### 4.3 SEM Analysis

This structural equation model depicts how seven latent factors—AT, TI, CS, AI, PD, SE, and EC—predict Professional Competencies (PC). Curved arrows represent correlations among predictors, while straight arrows indicate direct effects on PC. Overall, higher AT, TI, CS, AI, PD, SE, and EC scores are modeled to positively influence PC.

**Table: Model Fit Statistics**

| Statistic | Value |
|---|---|
| Distinct sample moments | 465 |
| Parameters estimated | 88 |
| Degrees of freedom | 377 |
| Chi-square ($\chi^2$) | 502.175 |
| DF ($\chi^2$) | 377 |
| p-value | < .001 |

**Table: SEM Regression Weights**

| DV | IV | Estimate | S.E. | C.R. | p |
|---|---|---|---|---|---|
| PC | AT | 0.006 | 0.051 | 0.109 | 0.913 |
| PC | SE | 0.205 | 0.096 | 2.141 | 0.032 |
| PC | CS | 0.241 | 0.082 | 2.962 | 0.003 |
| PC | AI | -0.117 | 0.062 | -1.873 | 0.061 |
| PC | TI | 0.218 | 0.041 | 5.276 | *** |
| PC | PD | 0.002 | 0.027 | 0.075 | 0.941 |
| PC | EC | 0.327 | 0.069 | 4.756 | *** |

**Table: CMIN Summary**

| Model | NPAR | CMIN | DF | P | CMIN/DF |
|---|---|---|---|---|---|
| Default | 88 | 502.175 | 377 | .000 | 1.332 |
| Saturated | 465 | 0.0 | 0 | — | — |
| Independence | 30 | 3890.402 | 435 | .000 | 8.943 |

**Table: RMR, GFI, AGFI, PGFI**

| Model | RMR | GFI | AGFI | PGFI |
|---|---|---|---|---|
| Default | 0.034 | 0.888 | 0.862 | 0.72 |
| Saturated | 0.0 | 1.0 | | |
| Independence | 0.187 | 0.349 | 0.304 | 0.326 |

### 4.4 Findings

The analysis confirms acceptable internal consistency across constructs (Cronbach's $\alpha$ = 0.756–0.888). Frequency distributions reveal pronounced dissatisfaction regarding assessment practices, limited interdisciplinary integration, relatively low student engagement, and mixed experiences with professional development. SEM results identify Technological Integration, Educational Change, Curriculum Strategies, and Student Engagement as significant positive predictors of Professional Competencies. Adaptive Teaching and Professional Development exhibit negligible direct effects in the model. Overall fit (CMIN/DF = 1.332; GFI = 0.888; AGFI = 0.862) is acceptable, supporting the hypothesized structure and emphasizing modernization of technology use, curriculum redesign, engagement-oriented pedagogy, and systemic educational change.

## 5. Conclusion

The study concludes that teachers' professional competencies are multidimensional, shaped by both individual practices and systemic conditions. Among the seven examined constructs, Technological Integration, Curriculum Strategies, Student Engagement, and Educational Change emerged as the strongest predictors of professional effectiveness. These findings highlight the need to modernize classroom practices through technology-driven, interdisciplinary, and student-centered pedagogy. While Professional Development and Adaptive Teaching showed limited direct effects, their indirect influence underscores the importance of continuous learning and responsive instruction. Overall, fostering innovation, engagement, and institutional support will be vital for enhancing teacher competencies and aligning education with 21st-century learning goals.

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