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Technology Integration Models and Instructional Design Frameworks to Facilitate the Development of Teacher Training Programmes

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Abstract

In the digital age, equipping teachers with the skills and knowledge to integrate technology into their teaching is essential for improving student learning outcomes. This study conducts a systematic review of three technology integration models: 5WH1, TPACK, and WSTP and two instructional design frameworks: ADDIE and 4C-ID to explore their relevance in developing effective teacher training programmes. A total of 26 research articles published between 2000-2024 were reviewed, focusing on key themes namely major components and theoretical foundations, insights provided to design teacher training programmes and strengths and limitations of the models. The findings emphasize the need for an integrated approach that combines technology integration models with instructional design frameworks to enhance professional development programmes. This integrated approach ensures that teacher training is both systematic and adaptable, addressing the challenges of technology adoption while promoting effective instructional practices. By leveraging these models, training programmes can be designed to better equip teachers with the necessary competencies for meaningful technology integration in education.

Keywords: Technology integration models, instructional design models, professional development, digital technology adoption

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Introduction

As technology reshapes every aspect of modern life, integrating it into education is essential for preparing students to meet the challenges of a rapidly evolving global society. To ensure successful integration, it is crucial that teachers are equipped with the necessary skills and knowledge. Therefore, the development of effective teacher training programmes becomes a priority. Programme developers have utilized technology integration models and instructional designs to guide design, implementation, and evaluation of these training programmes. Technology integration models are theoretical models that are designed to help teachers, researchers, and others in the education field to think about technology integration in meaningful ways (Kimmons, 2020). The process of producing training materials and experiences that effectively promote learning and enhance performance is known as instructional design. It entails determining training objectives, choosing suitable instructional strategies and resources, designing and developing instructional materials, assessing the effectiveness of the instruction, planning and modifying the instruction as necessary, and assessing the needs of the learner and the characteristics of the target learning audience (Gupta,2023). These models provide a systematic approach to professional development, ensuring that teachers can effectively incorporate technology into their teaching practices. However, these models are sometimes applied uncritically or inconsistently (Kimmons & Hall, 2016). To get the best results from these models, it is important to use them carefully and step-by-step. These models help teachers and programme developers focus on major parts of training, such as understanding teachers' needs, creating the right training programmes, using them in classrooms, and checking if they work well.

Aim

This review aims to analyze several technology integration models and instructional design frameworks to explore their relevance in developing effective teacher training programmes for technology integration.

Specific Objectives

1. To examine the major components and theoretical foundations of selected technology integration models and instructional design frameworks in the context of teacher training
2. To find out how these models provide insights into designing teacher training programmes, aimed at integrating technology effectively in the teaching-learning process of teachers
3. To identify the strengths and limitations in using these models for designing and implementing teacher training programmes focused on technology integration

Methodology

This study employed a systematic literature review to examine selected technology integration models and instructional design frameworks relevant to teacher training programmes. The review aimed to ensure a comprehensive, structured, and unbiased synthesis of existing research in this field.

A total of 680 articles were initially identified through structured searches in ResearchGate, Google Scholar, ScienceDirect, and Web of Science, using keywords such as "technology integration," "instructional design," "teacher training," "teacher professional development," "TPACK," "ADDIE," "4C/ID," "5W1H," and "WSTP." After applying inclusion and exclusion criteria such as publications between 2000 and 2024, relevance to teacher training, and technology integration, a total of 26 articles were selected for detailed review. These included peer-reviewed journal articles, conference papers, book chapters, and credible reports. After screening, 26 articles were selected for in-depth analysis. The study followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework to ensure transparency in article selection.

The review focused on three technology integration models (5WH1, TPACK, and WSTP) and two instructional design frameworks (ADDIE and 4C-ID), selected based on their relevance to teacher training and technology integration. Data was analyzed using the thematic analysis. The analysis was based on the themes emerged from the literature and derived in line with the objectives of this review, namely, major components and theoretical foundations, insights provided to design teacher training programmes and strengths and limitations of the models. To strengthen the analysis, thematic tables and comparative matrices were used.

Results and Discussion

This section presents a comprehensive discussion of the key findings derived from the analysis of selected technology integration models, framed around three overarching themes: (1) Major

Components and Theoretical Foundations, (2) Insights Provided to Design Teacher Training Programmes, and (3) Strengths and Limitations of Each Model.

1.) 5W1H ("Who," "Why," "How," "What," "Where," and "When") Model

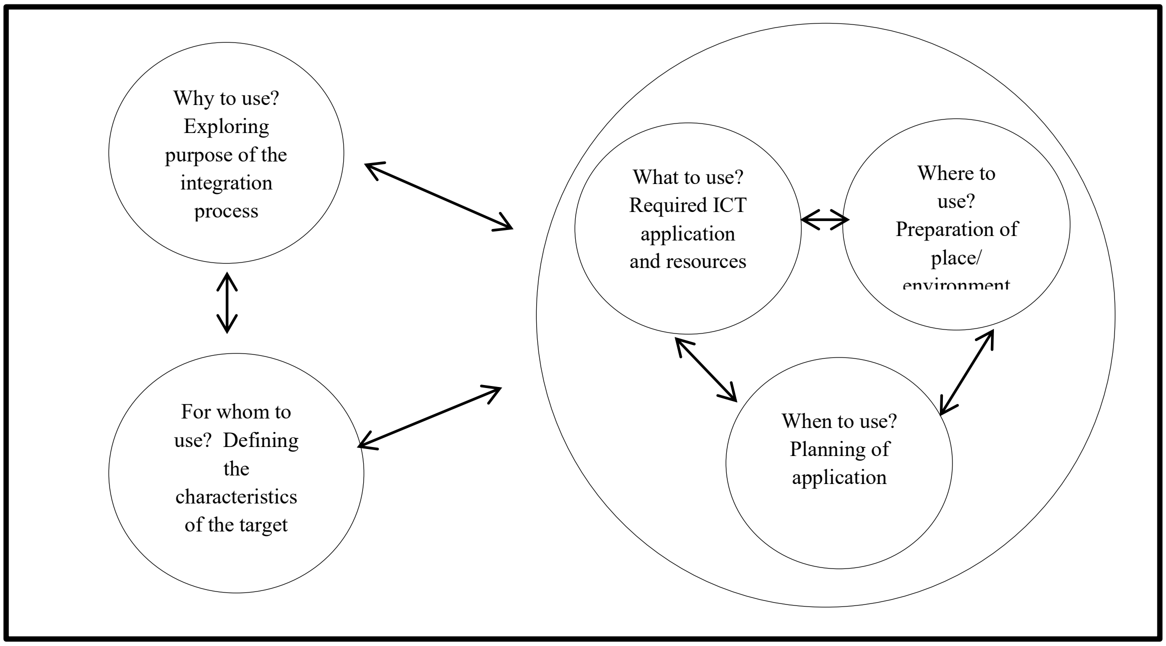
The 5W1H ("Who," "Why," "How," "What," "Where," and "When**")** model provides a structured approach to planning for teacher training programmes by addressing key questions. The 5W1H method, also known as the Kipling Method, is named after Rudyard Kipling, the British author and poet who introduced it. In his poem "The Elephant's Child," Kipling employed these 5W questions to narrate the story of an inquisitive elephant exploring its surroundings. Building on Kipling's original concept, the 5W1H Technology Integration Model was developed by Haslaman et al. (2008) to enhance student learning and assess the integration of information technology (Kesik & Bas, 2022).

Major components and theoretical foundations

Understanding the major components and theoretical foundations of each technology integration model is essential to evaluate their relevance and applicability to teacher training programmes. Each model is built upon specific conceptual frameworks and design principles that guide how technology can be integrated into teaching and learning.

Figure 01

5W1H Model



The model is grounded in inquiry-based learning and emphasizes structured questioning to explore all critical aspects of technology integration. It revolves around six interrelated questions: *Who* identifies the learners and their characteristics; *Why* clarifies the rationale and objectives for integration; *How* focuses on delivery strategies; *What* determines the tools and content; *Where* defines the learning environment; and *When* addresses the scheduling and timing of the programme (Haşlaman et al., 2008). This cyclical questioning strategy encourages a deeper understanding of the context and aligns with the principles of instructional design and strategic planning.

Insights provided for development of teacher training programmes

Who? - The model begins by identifying the learners, specifically the teachers, who will be integrating technology into their instructional practices. It is essential to understand their ICT skills, interests, individual needs, learning styles, and other personal characteristics (Haşlaman et al., 2008). Recognizing whether the target audience includes newly appointed teachers, experienced teachers, or school administrators helps in customizing the training to suit their unique backgrounds and requirements. This learner-centreed focus ensures that the programme content is relevant and supportive of their specific skill levels and teaching contexts.

How? - Integrating ICT tools with suitable teaching methods and strategies is key to ensuring effective training delivery. The model emphasizes the importance of designing learning environments that reflect both the goals of the training and characteristics of the learners (Haşlaman et al., 2008). For this reason, teacher training should include hands-on, practical sessions that mirror real classroom scenarios. These opportunities allow participants to apply their knowledge, experiment with tools, and receive feedback in a structured setting that promotes confidence and skill development.

What/Which? - Selecting appropriate digital tools and resources is another critical insight from the model. Decisions about what technology to introduce must align with the teaching strategies, learning goals, and students' needs (Haşlaman et al., 2008). Therefore, training should concentrate on equipping teachers with tools that support their instructional objectives and evaluation methods. This targeted approach makes the training more meaningful and ensures that the tools introduced are practical, usable, and beneficial within the classroom context.

Where? - The learning environment plays a crucial role in the success of ICT integration. The model suggests that ICT can be applied in various settings—classrooms, laboratories, libraries, homes, online platforms, or even museums (Haşlaman et al., 2008). Thus, teacher training programmes should consider the accessibility and suitability of these locations. Planning where the training sessions will be held, ensuring the availability of required infrastructure, and arranging for technical support are all necessary steps to create conducive learning space for participants.

When? - Timing is another vital consideration in planning teacher training. The model proposes that the use of ICT should be integrated into the overall lesson plan with careful attention to when and how often it is used (Haşlaman et al., 2008). For teacher training, this means designing a schedule that fits within teachers' existing work commitments and school calendars. Determining the appropriate time for introducing new tools and planning follow-up sessions for reinforcement help maintain momentum and allows for continued development. By considering each of these six questions, teacher training programmes can be designed with a clear structure, relevant content, and practical delivery strategies.

By addressing each component of the 5W1H model, teacher training programmes can be more focused, context-aware, and responsive to teachers' actual needs. This structured approach enhances the effectiveness and relevance of technology integration efforts.

Strengths and Limitations

One of the main strengths of the 5W1H method is its simplicity, clarity, and versatility. Imarah and Jaelani (2020) emphasized that it is a powerful tool for asking the right questions, broadening the investigation, and gathering essential information, which leads to better and more effective solutions. Similarly, Fitzgerald (2023) highlighted that the model helps users understand a topic more clearly by guiding them through six basic questions ensuring that critical areas are not overlooked. This structured approach simplifies complex planning processes and makes it practical for various educational contexts. Its adaptability also allows it to be applied to different training goals, as it encourages thoughtful planning based on learner needs, teaching methods, available tools, timing, and learning environments. These strengths make the 5W1H model especially valuable during the early stages of teacher training programme design.

However, the 5W1H model has some limitations. Fitzgerald (2023) pointed out while they offer a broad understanding, they may not fully address complex issues. Additionally, she highlighted the potential for subjectivity, where the interpretation of questions and responses could lead to biases or incomplete information, affecting the reliability and depth of the findings. Moreover, the model does not support ongoing improvements to the programme once it has been created. This lack of flexibility is a significant limitation, especially since continuous improvement is vital for keeping the training programme relevant and effective over time. To address these limitations, it may be beneficial to combine the 5W1H model with other approaches, like the ADDIE model, which emphasizes evaluation and revision throughout the training process. Following the 5W1H model, which emphasizes structured planning through key questions, the

WSTP model offers a different perspective by focusing on four interrelated dimensions that influence technology integration: Will, Skill, Tool, and Pedagogy.

2.) WSTP (Will, Skill, Tool, and Pedagogy) Model

The WSTP model, originally developed by Knezek and Christensen, is grounded in a simplified environmental model known as WST—Will, Skill, and Tool—which outlines the key elements that influence technology-supported student learning (Knezek et al., 2000).

Major components and theoretical foundations

The model emphasizes three major components: Will, referring to positive attitudes and willingness to use technology; Skill, reflecting self-perceived preparedness and confidence in using technology; and Tool, indicating access to and utilization of technological resources. These elements help predict the level of technology integration in classroom settings. The theoretical roots of the model can also be traced to earlier works such as Klausmeir and Goodwin (1975), who outlined 37 traits related to classroom learning with technology. Later, Knezek and Christensen (2016) expanded the model to forecast the impact of technology integration on student outcomes.

The WST model offers a practical framework for identifying key areas that need to be strengthened in teacher training programmes. To improve its predictive and practical value, the model was later extended to include a fourth component “Pedagogy” resulting in the WSTP model. Pedagogy refers to teaching styles and instructional strategies that shape how technology is applied in classrooms to enhance student learning (Woltran et al., 2022). This addition recognizes that even when teachers have the will, skill, and tools to use technology, its impact depends on how well these elements align with their teaching practices. The inclusion of pedagogy highlights the importance of considering constructivist or behaviourist approaches when integrating technology into lessons.

Insights provided for development of teacher training programmes

Will - The "Will" component emphasizes the importance of teachers' attitudes toward technology. Meelissen (2008) and Christensen and Knezek (2006) found that younger teachers often exhibit more positive attitudes toward computers, making them more likely to integrate technology in classrooms. Attitudes such as fear, enjoyment, or confidence in using computers significantly influence actual use, as shown by Marshall and Cox (2008). Pamuk and Peker (2009) also reported that anxiety about technology can lead to negative attitudes and limited usage. Therefore, when designing teacher training programmes, it is important to go beyond technical training and address emotional and psychological readiness. Programmes should include sessions that boost confidence, reduce anxiety, and promote positive attitudes through interactive workshops, sharing success stories, and offering consistent support to foster a positive perception of technology integration.

Skill - Technology competency is another key pillar of the WSTP model. Sang et al. (2010) describe it as the ability to perform specific tasks using digital tools. Teachers with strong technology skills are more confident and effective in integrating technology, while those with limited skills often feel frustrated and anxious (Smarkola, 2008). This highlights the difference between basic computer literacy and full technological competence, the latter being essential for meaningful integration into teaching (Looney et al., 2004). Professional development programmes must, therefore, focus on building both basic and advanced competencies. Providing differentiated training based on existing skill levels, offering hands-on practice, and ensuring continuous technical support can empower teachers to use technology creatively and confidently in their instruction.

Tool - The availability and effective use of digital tools form the third component of the WSTP model. Gurcan-Namlu and Ceyhan (2003) emphasized that frequency of use, ownership, and time spent using devices are key indicators of technology use. In developing countries, limited access to devices is a common barrier, as highlighted by Aguti and Fraser (2006). Access not only influences the use of technology but also affects attitudes and skill development. Therefore, training programmes must ensure that teachers have adequate access to devices and know how to use them meaningfully. Furthermore, training should include opportunities for real-time interaction with devices and tools, allowing teachers to apply what they learn directly to classroom scenarios.

Pedagogy - The addition of pedagogy as the fourth component of the WSTP model broadens its relevance. According to Watkins and Mortimore (1999), pedagogy involves any deliberate action taken to improve another person's learning. In the WSTP framework, pedagogy refers to teachers’ ability to align their teaching styles—whether constructivist or behaviourist—with the use of technology to enhance student outcomes (Woltran et al., 2022). Petko (2012) found that when teaching styles are taken into account, the predictive power of the model significantly improves, explaining more variance in the frequency of ICT use. Training programmes, therefore, should not treat technology as separate from pedagogy. Instead, sessions should guide teachers on how to integrate digital tools into their existing teaching methods, using strategies that fit their instructional goals. The WSTP model provides a holistic foundation for designing effective teacher training by addressing attitudes, competencies, access to tools, and pedagogical alignment. Considering all four elements ensures that training programmes support sustainable and meaningful technology integration in classrooms.

Strengths and Limitations

The WSTP model's strength lies in its holistic approach, which addresses attitudes, competencies, access to tools, and pedagogy, providing a well-rounded perspective on technology integration. The model effectively highlights how these components predict teachers' proficiency in using technology. The addition of the pedagogy component further enriches the model by ensuring that teaching strategies align with technology use. Knezek et al., (2003) found that between 1999 and 2001, 70% to 84% of teachers' levels of technology integration could be predicted by their will, skill, and access to tools. Morales et al. (2005) analyzed data from 2001 to 2005 and found that Will, Skill, and Tools accounted for 64% to 83% of teachers' proficiency in technology integration.

The WSTP model primarily focuses on the individual teacher's attitude, skills, access to tools, and pedagogical strategies, but it does not sufficiently consider institutional and systemic factors. It also lacks an explicit mechanism for continuous monitoring, reflection, or iterative improvement. To overcome the WSTP model's limitation of not sufficiently considering institutional and systemic factors, a more holistic approach can be adopted by integrating the contextual analysis phase from the ADDIE model or incorporating the Systems Thinking approach, which considers the broader environment, including leadership, policies, and available resources.

Additionally, to address the absence of continuous monitoring and improvement in the WSTP model, the reflection loops in the Design-Based Research (DBR) approach can be incorporated, ensuring that ongoing assessment and iterative refinement take place throughout the implementation of the training programme. This combination would help create a more comprehensive and sustainable framework for effective technology integration in educational settings. While the WSTP model highlights the conditions necessary for technology integration, the TPACK-in-Practice model shifts focus toward how teachers apply technological, pedagogical, and content knowledge in authentic classroom situations, making the integration more subject-specific and context-driven.

3.) TPACK (Technological Pedagogical Content Knowledge) - in - Practice Model

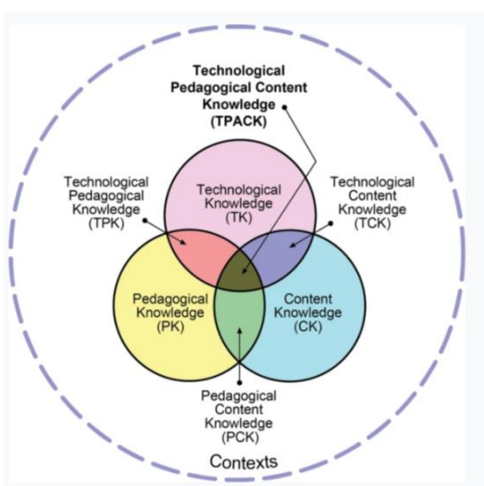
TPCK is an integration of technology knowledge, subject content knowledge and pedagogical knowledge developed by Mishra and Koehler (2006). To simplify the pronunciation, the acronym was renamed by adding letter "A" so that it becomes TPACK. This framework was built on Shulman's (1986) idea of pedagogical content knowledge (PCK). PCK is about blending what teachers know with how they teach to make learning more effective. Over time, the focus has expanded to include technology, which wasn't as prominent when Shulman first developed PCK. Mishra and Koehler (2006) argue that technology should not be treated as a separate knowledge area but integrated with content and pedagogy. So, they proposed the concept of Technological Pedagogical and Content Knowledge (TPACK), which includes PCK but also incorporates technology. It highlights the importance of blending content, pedagogy, and technology and provides insights into how this integration can be approached at theoretical, pedagogical, and methodological levels (Schmidt et al., 2019).

Major components and theoretical foundations

The TPACK framework consists of seven components that together help teachers effectively integrate technology into their teaching. These include: Technology Knowledge (TK), Content Knowledge (CK), Pedagogical Knowledge (PK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical Content Knowledge (TPACK), which integrates all these components for effective teaching (Mishra & Koehler, 2006; Schmidt et al., 2019)

Figure 02

TPACK Model



Source:(https://tpack.org/tpack-image/)

Several TPACK-based models have been developed to enhance teachers' ability to integrate technology effectively into their teaching practices. The TPACK-IDDIRR model (Lee & Kim, 2014) introduces a structured approach, guiding teachers through a cycle of Introduce, Demonstrate, Develop, Implement, Reflect, and Revise, which emphasizes collaboration and continuous improvement. Similarly, the TPACK-COIR model (Jang, 2010) focuses on Comprehension, Observation, Instruction, and Reflection, using peer coaching and interactive whiteboards to improve teachers' technological pedagogy. The TPACK-COPR model (Jang & Chen, 2010) also combines theory and practice, promoting teachers' Comprehension, Observation, Practice, and Reflection to help them develop effective technology-based lessons. Finally, the TPACK-SQD model (Tondeur et al., 2012) synthesizes insights from multiple studies, highlighting key themes such as role modeling, collaboration, and hands-on experience.

While TPACK models are theoretically strong, they don’t always clearly show how these ideas work in real classroom settings. To address this, researchers (Figg & Jaipal, 2009, 2012; Jaipal & Figg, 2010a, 2010b, 2012) conducted long-term studies with both new and experienced teachers. The TPACK-in-Practice framework (Jaipal & Figg, 2015) aims to bridge the gap between theoretical understanding and practical application of technology in teaching through a structured, four-stage process:

1. Modeling technology-enhanced activities: Teachers use technology to support content learning.

2. Integrating pedagogical dialogue: Teachers reflect on how technology integrates with content and pedagogy.
3. Developing technical skills: Teachers receive targeted training to build necessary technical skills.
4. Applying TPACK in an independent task: Teachers design and implement their own technology-enhanced lessons.

The TPACK-in-Practice framework provides a comprehensive approach to bridging the gap between theoretical knowledge and practical application of technology in teaching.

Insights provided for development of teacher training programmes

1. Modeling technology-enhanced activities: Teachers first engage in activities where they use technology in a student role, helping them experience how it can support content learning objectives. The focus here is on understanding the technology's role in enhancing content rather than mastering its technical functions (Jaipal & Figg, 2015). Trainers can set up sessions allowing them to experience how it functions and supports specific learning objectives by helping teachers understand how to integrate technology effectively into their lessons, focusing on its application for achieving content goals rather than just technical proficiency.

2. Integrating pedagogical dialogue: After experiencing technology in the classroom, teachers discuss how it was used in the lesson. These reflective discussions allow teachers to connect the technology with both content and pedagogy, with more experienced teachers focusing on strategies for integration and novice teachers focusing on planning and execution of tech-enhanced lessons (Jaipal & Figg, 2015). This stage can be used by facilitating discussions where

teachers reflect on their experience with technology-enhanced activities. This helps them connect the technology with content and teaching methods.

3. Developing technical skills: Teachers then receive targeted, "just-in-time" training that teaches the specific technical skills needed for the activities they are using. These short, focused demonstrations provide hands-on learning, emphasizing the immediate application of the skills, often accompanied by real-life examples from other teachers (Jaipal & Figg, 2015). In training, the developing technical skills stage can be used by offering targeted, "just-in-time" training sessions. These sessions should focus on the specific technical skills teachers need for their lessons, providing practical, hands-on demonstrations.

4. Applying TPACK in an independent task: In the final stage, teachers design and implement their own technology-enhanced lessons or activities, reinforcing their learning and applying TPACK knowledge in a real classroom setting. This stage ensures that teachers are able to confidently integrate technology with pedagogy and content, supporting their development of technology-based teaching practices (Jaipal & Figg, 2015). This stage can be used by having teachers design and implement their own technology-enhanced lessons or activities.

The TPACK-in-Practice model offers a clear, step-by-step framework to help teachers move from theory to practice in technology integration. By engaging teachers in modeling, reflection, targeted skill building, and independent application, the model promotes confident and effective use of technology in teaching.

Strengths and Limitations

The TPACK-in-Practice model offers a practical, step-by-step framework that effectively bridges the gap between theory and practice. It supports hands-on, contextualized learning through modeling, reflection, targeted technical training, and independent application. This helps teachers build confidence and competence in integrating technology with pedagogy and content. The model is also flexible and adaptable to different subjects, grade levels, and teacher experience levels.

Despite its strengths, the model depends heavily on "just-in-time" training, which may not provide sufficient ongoing support especially, for novice teachers who require more foundational guidance. Its successful implementation relies on skilled facilitators and can be time-consuming and resource-intensive.

To enhance the effectiveness of the TPACK-in-Practice model, teacher training programmes can include ongoing support through regular follow-up sessions and mentoring systems to ensure continuous development beyond initial training. Differentiating sessions based on teachers' technological skill levels helps address varying proficiencies, allowing both novice and experienced teachers to progress effectively. Conducting needs assessments prior to training enables customization of content to suit local teaching contexts, while introducing action research tasks allows teachers to apply TPACK principles in real scenarios and reflect on outcomes that build confidence and reduce the gap between theory and practice.

Until this point, the focus has been on technology integration models. The review now moves toward instructional design models, which offer practical guidance for how to design and deliver training programmes that can develop those competencies in a systematic and sustainable manner.

4.) ADDIE (Analysis, Design, Development, Implementation, and Evaluation) Model

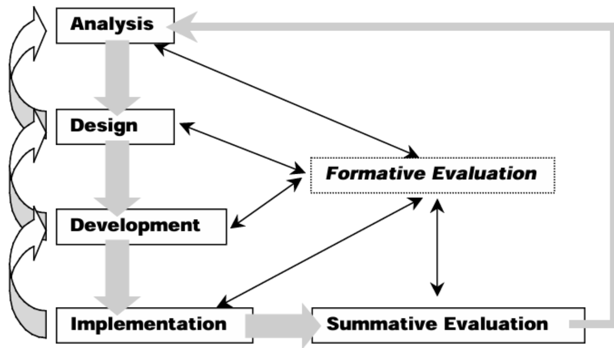
The ADDIE model serves as a structured approach to creating teacher training programmes, guiding each phase from identifying needs to assessing outcomes, ensuring continuous enhancement of teaching practices. Florida State University first developed the ADDIE model for the US military in the 1970s in response to the increasing demand for uniform training techniques across all branches. The concept has changed throughout time and been widely accepted in a variety of fields and educational environments. An instructional design framework called the ADDIE model offers a methodical way to create training and educational initiatives that work. For developers, teachers, trainers, and especially students, the entire process is essential to obtaining a fruitful and educational learning outcome (Oana, 2022).

Major components and theoretical foundations

ADDIE model consists of five key phases: Analysis, Design, Development, Implementation, and Evaluation. Each phase plays a crucial role in ensuring the success of the instructional design process (Branch, 2009).

Figure 03

ADDIE Model



(Source: Mcgriff, 2001)

The ADDIE model is widely recognized for designing and evaluating learning experiences, educational courses, and content due to its strong theoretical and philosophical foundations (Trust & Pektas, 2018). The model is also grounded in Behaviourist Theory, which emphasizes learning through practice, feedback, and observable outcomes. In terms of knowledge type, ADDIE mainly focuses on developing procedural knowledge—helping learners understand how to perform specific tasks step-by-step.

Insights provided for development of teacher training programmes

1. Analysis phase – This phase focuses on validating the performance gap, setting instructional goals, identifying the target audience, determining required resources, selecting delivery systems with cost estimates, and creating a project management plan. To validate the performance gap, current performance is assessed through observation, testing, interviews, and data collection, while desired performance is confirmed through best practices and stakeholder input. The causes of the gap such as lack of resources, motivation, or necessary skills are then identified (Branch,

2009). In a teacher training programme, it can be ensured that there is a genuine need for the training by verifying performance gaps and identifying the desired outcomes. The training goals can be established, and the needs of the target audience can be understood. Necessary resources and delivery methods can be determined, and a project management plan can be prepared to ensure that the training is effectively organized. Finally, the causes of the performance gap can be determined, such as lack of resources, motivation, or knowledge and skills.

2. Design phase – In the Design phase, the aim is to plan how to achieve the desired performance and establish testing methods. This involves conducting a task inventory to list and analyze all necessary tasks, composing performance objectives to set clear goals for the instruction, generating testing strategies to develop methods for evaluating the instruction's effectiveness, and calculating the return on investment to ensure that the benefits will outweigh the costs (Branch, 2009). For a teacher training programme, this phase can be used to plan how to achieve the desired performance outcomes. It can involve listing and analyzing all required tasks, setting clear performance goals, developing strategies to evaluate the training effectiveness, and calculating the return on investment to confirm that the benefits of the training will outweigh the cost.

3. Development phase - In the Develop phase, learning materials can be created and tested. This involves generating content, selecting or creating supporting media, developing instructions for both students and teachers, making improvements based on feedback, and testing the materials with a small group to ensure they work effectively (Branch, 2009). In this phase, the training materials for a teacher training programme can be created and refined, including content and media. Guidance for both teachers and students can be developed; revisions can be made based

on feedback; and the training materials can be tested with a small group to ensure their effectiveness before full implementation.

4. Implementation Phase – This phase involves the actual delivery of the training programme or instructional process, ensuring that the designed materials and strategies are effectively put into practice (Branch, 2009). During the implementation of a teacher training programme, the focus shifts from planning to actual delivery. The learning environment is prepared, and teachers are actively engaged in the training process. This phase includes delivering the training sessions, following the teaching plan, and ensuring both teachers and students are ready for the learning experience.

5. Evaluation Phase – The Evaluation phase focuses on assessing the effectiveness of instructional process and the instruction through formative evaluation during the development process and summative evaluation after implementation, facilitating continuous improvement of both teachers and students (Branch, 2009). The effectiveness of the teacher training programme can be assessed both before and after implementation. Evaluation criteria can be set, tools can be selected, and evaluations can be conducted to identify successes, recommend improvements, and finalize the programme. The evaluation plan can outline the purpose, tools, timing, and responsible parties for evaluations, and if approved, the ADDIE process can be concluded.

Strengths and Limitations

The ADDIE model helps identify best-practice steps for designing training programmes. Since the process is systematic, it can support the design and development of many high-quality training courses (Dick et al., 2009). According to Mayfield (2011), the ADDIE process has become an extremely popular framework for the creation of training programmes. It also helps instructional designers create well-organized programmes, with clear learning objectives and materials (Allen & Sites, 2012).

According to Strickland et al., the limitations of the ADDIE model are primarily centreed around the importance of the Analyze and Design phases. If these phases are not thoroughly executed, the subsequent stages (Develop, Implement, and Evaluate) may not be effective. The model also works best when used in a team-based approach, which can be challenging for institutions with limited resources. While ongoing improvements to the model are necessary, maintaining stability in the early stages is crucial to avoid issues later in the process. Additionally, the model's structured nature, with its many detailed tasks, can limit flexibility and hinder creativity.

To use the ADDIE model effectively for teacher training while overcoming its limitations, trainers can focus on teamwork and communication to ensure that the Analyze and Design phases are done well, even if resources are limited. They can include regular feedback during the training to make timely changes, and by overlapping the development and implementation phases, they can quickly respond to participants' needs. Designing the programme in smaller parts can help teachers with different experience levels learn at their own pace. Additionally, simplifying tasks like using available tools or spending less time on planning can make the model easier for smaller organizations to use. By following these strategies, the ADDIE model can be more adaptable and useful for improving teacher training programmes.

While ADDIE outlines the stages of instructional design, the 4C/ID model goes deeper into how to teach complex professional skills. It focuses on designing realistic learning tasks and supports teachers to develop practical abilities needed for effective technology integration.

4.) 4C/ID (Four-Component Instructional Design) model

The 4C/ID model, created by Van Merriënboer in 1997, is the recommended instructional design framework for developing skills. This model received significant attention due to its alignment with current educational trends, such as focusing on developing complex skills or professional competencies, enhancing the transfer of knowledge learned in school to new situations, including the workplace, and fostering the development of 21st-century skills essential for lifelong learning. The 4C/ID model is rooted in cognitive psychology and constructivist learning theories, particularly focusing on how learners acquire and apply complex skills. The 4C/ID model assists instructional designers in creating educational programmes aimed at teaching complex skills or professional competencies.

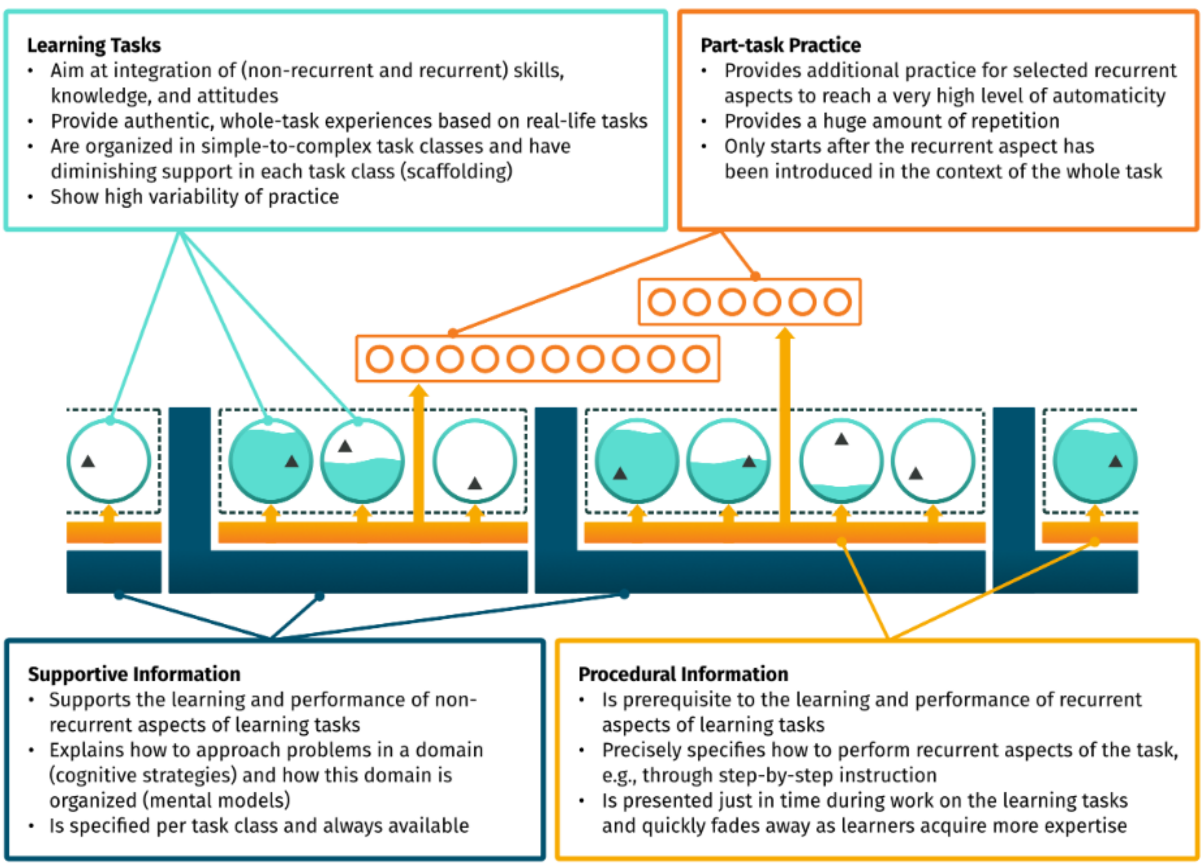
Major components and theoretical foundations

This model has four components: Learning Tasks, Supportive Information, Procedural Information, and Part-Task Practice (Van Merriënboer, 2019)._The "Ten Steps to Complex Learning," introduced by Van Merriënboer and Kirschner in 2007, offer a practical and updated version of the original 4C-ID model from 1997. This guide is designed to help teachers, domain experts, and less experienced instructional designers create effective educational and training programmes for acquiring complex cognitive skills. It provides a step-by-step approach to develop programmes that can range from several weeks to years, making the complex 4C-ID model more accessible and usable in real-world educational settings. Each four components correspond with specific design steps.

A blueprint for the 4C/ID model can be presented diagrammatically as follows:

Figure 04

4C-ID Model



Source : (4C/ID Home - Four-Component Instructional Design, 2024)

According to Kirschner & Merriënboer (2007), the ten steps to complex learning are as follows:

Table 01

Ten Steps to complex learning

The Four Blueprint Components of 4C-ID
and the Ten Steps to Complex Learning

Blueprint Components of 4C-ID	*Ten Steps to Complex Learning*
Learning Tasks	1. Design Learning Tasks
	2. Sequence Task Classes
	3. Set Performance Objectives
Supportive Information	4. Design Supportive Information
	5. Analyze Cognitive Strategies
	6. Analyze Mental Models
Procedural Information	7. Design Procedural Information
	8. Analyze Cognitive Rules
	9. Analyze Prerequisite Knowledge
Part-Task Practice	10. Design Part-Task Practice

Source: (Kirschner & Merriënboer,2007).

Insights provided for development of teacher training programmes

1. Designing Learning Tasks – This step focuses on identifying real-life tasks that reflect the complex skills learners need to master. These tasks serve as the backbone of the learning process and help ensure that the training stays focused on meaningful, authentic outcomes (Kirschner & Van Merriënboer, 2007). Tasks such as creating interactive lessons and conducting virtual classes can be designed. These tasks can provide teachers with hands-on experience in real-life classroom scenarios that require technology integration.

2. Sequencing Task Classes – Tasks should be organized from simple to complex. Beginners start with easy tasks and gradually progress to more challenging ones as they develop confidence and competence (Kirschner & Van Merriënboer, 2007). Tasks can be sequenced starting with basic skills such as logging into and navigating a learning management system (e.g., Google Classroom),

progressing to more complex tasks like creating quizzes, managing student data online, or using video editing tools to enhance lesson content.

3. Setting Performance Objectives – Performance objectives help measure how well learners complete tasks and determine when they are ready for more advanced challenges. This approach ensures clear expectations throughout the training (Kirschner & Van Merriënboer, 2007). Clear objectives such as "The teacher should be able to design and deliver a 15-minute technology integrated lesson using an interactive tool" should be set. These objectives guide the learning process and help trainers assess when teachers are ready for more advanced tasks.

4. Designing Supportive Information – This step provides learners with the background knowledge they need to solve problems and perform non-routine tasks. This may involve guides, case studies, or explanations (Kirschner & Van Merriënboer, 2007). Supportive materials, such as tutorials on pedagogy for digital tools, case studies of technology use in classrooms, and articles about 21st-century learning, should be provided. These resources help teachers understand not only how the tools work but also why and how they should integrate technology into their teaching.

5. Analyzing Cognitive Strategies – Identify how experts solve problems and think through challenges, then teach these strategies to learners (Kirschner & Van Merriënboer, 2007). Model how experienced teachers use technology to enhance collaborative learning or differentiate instruction. Explaining their reasoning, decision-making processes, and planning strategies helps new teachers adopt similar cognitive approaches when integrating technology.

6. Analyzing Mental Models – Understand how experts mentally organize knowledge and link ideas, then help learners develop similar conceptual frameworks (Kirschner & Van Merriënboer,

2007). Teachers can be encouraged to form mental models about how technology integrates with pedagogy and content knowledge, using frameworks like TPACK. Concept maps showing how tools fit into various teaching strategies can help deepen their understanding.

7. Designing Procedural Information – Create clear instructions for routine tasks and deliver them just-in-time when needed (Kirschner & Van Merriënboer, 2007). Step-by-step guides or video tutorials on how to use specific tools can be created. These resources can be accessed by teachers during practice to ensure that they can effectively navigate technology.

8. Analyzing Cognitive Rules – Identify and teach the rules experts follow for predictable tasks, such as "if-then" strategies (Kirschner & Van Merriënboer, 2007). Cognitive rules, such as "If students are disengaged, then use an interactive whiteboard app to re-engage them," can be introduced to help teachers make quick and effective decisions when using technology in the classroom.

9. Analyzing Prerequisite Knowledge – Determine what background knowledge is necessary before learners can effectively perform tasks or apply rules (Kirschner & Van Merriënboer, 2007). Basic skills such as navigating the internet, managing files, and using essential software should be developed first. These foundational skills can then be expanded upon before moving on to more complex tools like digital assessment platforms or content creation apps.

10. Designing Part-Task Practice – Focus additional practice on specific parts of the skill that need to become automatic, especially where accuracy and speed are important (Kirschner & Van Merriënboer, 2007). Tasks like setting up projectors, operating smartboards, or creating quick formative assessments should be practiced repeatedly. These technical skills must become automatic so teachers can focus on instruction during their lessons.

Strengths and Limitations

The 4C/ID model offers a structured and comprehensive framework for designing training programmes, breaking the process into four core components to effectively teach complex skills. Its gradual learning approach and clear performance standards help learners build competence step-by-step. The inclusion of targeted support and detailed procedural information ensures smooth transitions and accurate task performance. Additionally, the model's adaptability allows it to be customized for various contexts and learner needs, making it versatile for different training domains. Sunardi and Doringin (2020) conducted a qualitative case study to reveal that the 4Cs model significantly enhances teachers' enthusiasm and impact in classroom activities. Their research highlights that the 4Cs model accelerates teachers' technological competencies and underscores the importance of the element communication, creativity, collaboration, and critical thinking in effective teaching practices.

However, the model has certain limitations. The 4C/ID model can be complex making it challenging for less experienced designers in resource-limited settings. It may not address simpler skills well and, it relies heavily on expert input, which could limit its applicability. The model also focuses more on task design than on learner engagement and motivation. According to Güney (2019), this model is particularly effective in developing complex technical skills, such as those needed for software programming, due to its focus on advanced skill development. The 4C/ID model requires deep expertise and significant performance improvements. Additionally, developing effective learning environments based on this model can be time-consuming and challenging. Rhodes et al. (2024) emphasize that the model is very complex and takes a lot of time to be understood and used effectively. Rhodes et al. (2024) recommend several improvements for designing teacher professional development (TPD) programmes using the 4C/ID model. They suggest incorporating team training to foster collaboration among teachers and enhance learning experiences. Additionally, they advocate for opportunities for classroom enactment between TPD meetings, allowing teachers to apply new skills in practice and receive feedback for reflection. Concrete examples, such as videotaped modeling of competencies, should be included to boost engagement and motivation. Finally, they emphasize addressing the varying levels of prior knowledge and experience among teachers, providing additional support if needed to ensure effective participation in the programme.

Table 2 shows a comparison of the above discussed models.

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Table 2

Comparison of technology integration models and instructional design models

Aspect	5W1H (Who, What, When, Where, Why, How)	TPACK-in-Practice	WSTP (Will, Skill, Tool, Pedagogy)	ADDIE (Analyze, Design, Develop, Implement, Evaluate)	4C/ID (Four-Component Instructional Design)
Focus	Analyzing the context and need for technology integration.	Interaction between technology, pedagogy, and content knowledge, with a focus on practical application in the classroom.	Teacher attitudes, skills, access to tools, and pedagogical methods.	Systematic instructional design process for training programmes.	Breaking down complex tasks into manageable learning components.
Strengths	Provides a comprehensive framework for identifying the essential aspects of technology integration.	Encourages hands-on, practical application of TPACK in real teaching scenarios, enhancing teacher confidence and skills.	Highlights teacher attitudes and accessibility to resources in addition to technical skills.	Clear, structured, step-by-step process that ensures thorough planning and evaluation.	Focused on task analysis and hands-on practice, ideal for developing competency.
Limitations	Lacks specificity in addressing practical challenges in technology integration.	Relies on "just-in-time" training, which may not provide ongoing support for teachers' evolving needs after initial training. Teachers with lower technological proficiency may also struggle.	Lacks a structured design process for professional development programmes.	Can be time-consuming and requires careful implementation and adjustments.	Can be complex for simpler tasks or shorter training programmes.

Application	Useful for initial assessments of technology integration needs and developing a strategic plan.	Helps teachers bridge the gap between theory and practice by applying TPACK principles directly in classroom settings.	Addresses emotional readiness and practical barriers to technology integration, such as access to tools and skills development.	Employed for developing structured training programmes, including phases for analysis, design, and continuous improvement.	Best suited for breaking down complex skills related to technology into small, actionable tasks.
Training Design	Guides the identification of goals and context for technology integration in educational settings.	Supports practical implementation and reflection on how technology, pedagogy, and content intersect in real-world teaching.	Highlights the importance of will, skills, and tool availability, helping to identify gaps.	Ensures systematic development and evaluation of training programmes, adapting to teacher needs.	Provides detailed task analysis and feedback, ensuring mastery of technology-related skills.
Adaptability	Flexible framework for various educational contexts but not a direct implementation model.	Flexible for different teaching contexts but may not provide a clear path for follow-up support or adaptation beyond the initial training phase.	Adaptable for addressing individual teacher needs but not ideal for structured design.	Highly adaptable across various training contexts, including teacher professional development.	Effective for skill mastery, although may be too detailed for simple training sessions.

The study found that each model reviewed, i.e. 5W1H, WSTP, TPACK-in-Practice, ADDIE, and 4C-ID, offers specific foundations that are valuable for designing teacher training programmes. The 5W1H model supports context-based planning by addressing key questions like who, what, when, where, why, and how. The WSTP model focuses on teacher readiness, including attitudes (Will), skills (Skill), access to tools (Tool), and pedagogical strategies (Pedagogy). TPACK emphasizes the integration of technology with pedagogy and content knowledge. ADDIE provides a structured approach to instructional design through its five phases: Analysis, Design, Development, Implementation, and Evaluation. The 4C-ID model supports the development of complex teaching skills through real-life learning tasks, supportive information, and practice. Together, these models contribute to both the planning and effective implementation of teacher training programmes aimed at improving technology integration. While these models offer valuable guidance, each has its strengths and limitations. Understanding these strengths and weaknesses helps in choosing the right model or combining models to design better teacher training programmes. An integrated approach that combines technology integration models with instructional design frameworks provides a more comprehensive solution for designing teacher training programmes.

Conclusion

The integration of technology models and instructional designs is essential for developing effective technology-based teacher training programmes. By combining these models, training programmes can effectively address teachers' needs, enhance their technology skills, and ultimately improve student learning outcomes. This integrated approach ensures that both the theoretical and practical aspects of technology integration are addressed, resulting in more effective and adaptable teacher development programmes.

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