Technology Integration Education Based on Distributed Cognitive Theory: Challenges and Teachers' Professional Development Path

Yuge Bai

Teachers College, Columbia University, New York, 11101, USA

Keywords: Distributed cognitive theory; technology integration, teacher professional development, cognitive load, collaborative learning

Abstract: Based on the distributed cognitive theory (Distributed Cognitive Theory, DCT), this paper discusses the challenges of educational technology integration and the path of teacher professional development. The study found that technology integration is not only the application of tools, but also the dynamic distribution of cognitive processes among teachers, students and technology tools, which needs to be realized through collaboration and environmental interaction. However, its effective implementation faces multiple challenges, including cognitive load, inadequate teacher preparation, resource inequality, and teaching method transformation. The study proposes that distributed cognitive theory provides a theoretical framework for technology integration, emphasizing technology as a cognitive intermediary that can promote collaborative knowledge construction (e. g., digital platform support group problem solving). At the same time, teachers need to redesign the classroom to integrate technology into social interactions (such as online communities to promote teacher-student collaboration). In teacher professional development, collaborative learning communities should be established, contextualized training, and technology to support reflective practice. Moreover, policy and resource support (such as infrastructure, technology mentors) is critical for systemic change. This paper provides a theoretical and practical bridge for the integration of educational technology, emphasizing that teacher development should be guided by DCT, and build an educational ecosystem that supports distributed cognition through collaborative, continuous contextualized learning and technology-enabling reflection.

1. Introduction

1.1 Background

In the modern educational landscape, the integration of technology has become an essential aspect of teaching and learning. The role of technology in education is multifaceted, influencing both teaching methodologies and student engagement. As digital tools and resources become increasingly prevalent in classrooms, it is crucial for educators to adapt to these changes and use technology effectively to enhance learning outcomes.

Distributed Cognitive Theory (DCT), developed by cognitive scientist Edwin Hutchins, posits that cognitive processes are not confined to an individual but are distributed across people, tools, and the environment. In other words, cognition is shared and extended through interaction with others and the use of tools, such as technology. In educational settings, this theory suggests that technology is not just a tool that students use independently but is an essential part of a broader cognitive system involving teachers, students, and other learning resources.

This view of cognition aligns with the notion of "technology integration," where educational tools and resources are embedded within the learning process, rather than being used in isolation. The seamless integration of technology, according to DCT, can create an environment where both teaching and learning are enhanced through shared cognitive efforts. However, as technology becomes an integral part of education, its successful implementation presents a range of challenges that need to be addressed.

  DOI: 10.25236/icssem.2025.002

1.2 Research Significance

The significance of technology in contemporary education cannot be overstated. Educational technologies, such as digital platforms, interactive software, and online learning environments, have transformed how both teachers and students interact with content and each other. These tools offer opportunities for greater accessibility, personalization, and engagement. However, despite these potential benefits, there remains a considerable gap between the availability of technology and its effective use in the classroom.

This gap can be attributed to several factors, including teachers' lack of adequate training, resistance to change, and insufficient access to necessary resources. These challenges are often compounded by the complexities of integrating new technologies into established educational frameworks. Understanding these issues requires a deeper exploration of how technology impacts cognitive processes in the classroom and how it can be effectively integrated into teaching practices.

By applying Distributed Cognitive Theory to the field of educational technology, this paper aims to highlight the challenges associated with technology integration in schools and propose solutions to address these issues. Additionally, this paper will explore the role of teacher professional development in overcoming these challenges. Teachers must be well-prepared to navigate the complexities of technology integration, and continuous professional growth is essential for ensuring that technology is used effectively.

1.3 Purpose of the Paper

The primary purpose of this paper is to investigate the challenges of integrating technology into educational settings through the lens of Distributed Cognitive Theory. This paper aims to:

Examine the Challenges of Technology Integration: Identify the key obstacles faced by teachers and students in using technology in the classroom, including issues related to cognitive load, teacher preparedness, access to resources, student engagement, and pedagogical changes.

Explore Teacher Professional Development: Analyze how DCT can inform professional development practices that support teachers in using technology effectively. By understanding the cognitive processes involved in learning and teaching with technology, professional development programs can be tailored to address the unique needs of educators.

Propose Pathways for Teacher Development: Suggest strategies and approaches for continuous teacher development that align with DCT principles. These pathways aim to support teachers in navigating the technological landscape and improving their teaching practices in a collaborative, reflective, and sustained manner.

Ultimately, the paper seeks to bridge the gap between the theoretical understanding of Distributed Cognitive Theory and its practical application in education. By doing so, it aims to contribute to the ongoing discourse on technology integration in schools and provide actionable insights for educators and policymakers.

2. Literature Review

2.1 Distributed Cognitive Theory

Distributed Cognitive Theory (DCT) was first articulated by Edwin Hutchins, this theory grounded in the idea that cognition does not reside solely within an individual's mind but is distributed across individuals, tools, and the environment. Hutchins (1995) introduced the concept in his study of navigation on a ship, where cognition was not confined to the individual sailor but was a product of interactions between the crew, the navigational tools, and the ship’s environment[1]. In educational contexts, this theory suggests that learning occurs not only through internal cognitive processes but through social interactions and external resources (such as technology) that extend cognitive capacities.

According to DCT, tools—whether physical objects or digital platforms—play a crucial role in shaping cognition. In a classroom setting, technology serves as a cognitive tool that facilitates

learning by mediating the interaction between the teacher, students, and the subject matter. For example, a digital platform may support collaborative learning, where students can co-construct knowledge, share ideas, and engage with complex problems in ways that are impossible without such tools. This perspective challenges the traditional view of cognition as being confined to the individual brain, highlighting the importance of collective knowledge construction and interaction with external artifacts (Salomon, 1993)[2].

This framework has broad implications for technology integration in education. Instead of merely using technology as a tool for presenting information, DCT encourages its use in ways that enable dynamic, interactive, and socially distributed learning[3]. However, while DCT offers a promising lens for understanding technology integration, it also presents challenges related to how educators can implement it effectively, especially given the complexities of modern classrooms and the diverse needs of students.(As shown in figure 1)

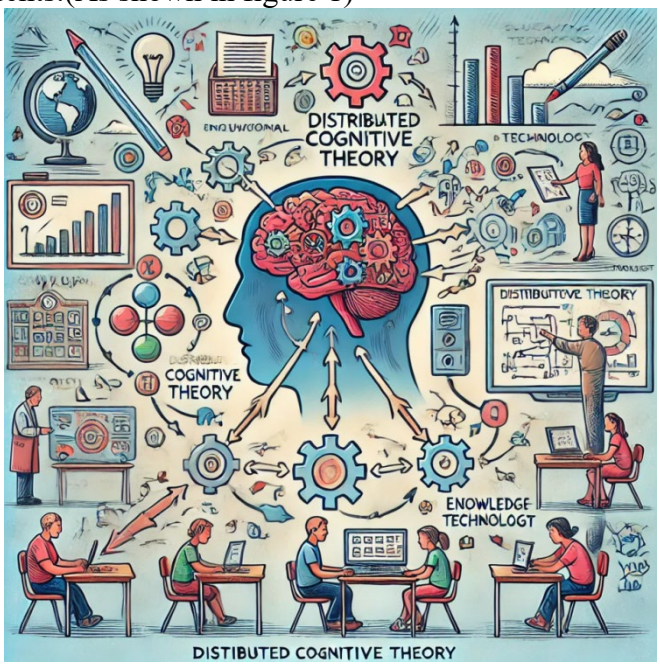

Figure 1. Conceptual Diagram of Distributed Cognitive Theory

2.2 Technology Integration in Education

Technology integration in education refers to the use of digital tools and platforms to enhance the teaching and learning experience. It encompasses a wide range of activities, including the use of multimedia, online platforms, educational apps, and virtual classrooms. The potential benefits of technology integration include increased access to resources, the ability to personalize learning, and opportunities for collaborative and interactive learning.

However, despite its potential, the integration of technology into classrooms has been met with challenges. According to a study by Ertmer (1999), teachers often face barriers such as a lack of training, insufficient time for planning, and resistance to change when integrating technology[4]. Furthermore, there is the issue of unequal access to resources, where some schools and teachers may not have the necessary infrastructure to fully leverage technology in their teaching. This digital divide exacerbates the gap between educational institutions and may contribute to unequal learning opportunities for students.

In the context of Distributed Cognitive Theory, technology serves as a cognitive tool that can extend the cognitive capabilities of students and teachers. For example, students may use educational software to analyze complex data, or teachers may use digital whiteboards to facilitate collaborative problem-solving[5]. However, for these tools to be effective, they must be seamlessly integrated into the curriculum, pedagogical strategies, and classroom environment. Simply having access to technology does not guarantee that it will enhance learning outcomes (Koehler & Mishra, 2009)[6]. This highlights the importance of understanding how cognitive processes are distributed

within the classroom and how technology can mediate those processes.

2.3 Teacher Professional Development

Teacher professional development (TPD) refers to the ongoing process by which educators improve their knowledge, skills, and practices to enhance their teaching effectiveness. Effective TPD programs are crucial for supporting teachers in adapting to new educational technologies and approaches. In the context of technology integration, TPD is even more critical, as teachers need to acquire both technical skills and pedagogical knowledge to use technology effectively.

Research suggests that traditional forms of professional development—such as one-time workshops or seminars—are insufficient for fostering meaningful change in teachers' practices. According to Desimone (2009), effective professional development must be sustained, content-focused, and grounded in the actual classroom context[7]. Additionally, it should promote active engagement and opportunities for collaboration among teachers, allowing them to share insights, experiences, and best practices.

Incorporating Distributed Cognitive Theory into TPD can enhance its effectiveness by emphasizing the role of collaborative learning. DCT suggests that teachers can learn from each other, share cognitive tools, and reflect on their teaching practices in a social, distributed context. For instance, teachers may collaborate to develop new lesson plans that incorporate technology, observe each other's classroom practices, and provide feedback. Such collaborative practices can promote collective learning and allow teachers to build upon each other's experiences.

2.4 Technology Integration and Teacher Professional Development

The intersection of technology integration and teacher professional development is where DCT has the most potential to inform practice. The integration of technology in the classroom is not solely about teachers adopting new tools, but also about rethinking pedagogical practices, designing new ways of interacting with students, and creating learning environments where technology is seamlessly embedded.

Studies have shown that the effective use of technology requires a shift in teachers' pedagogical approaches. For example, teachers need to move away from traditional, teacher-centered methods to more student-centered approaches that leverage technology for collaboration, problem-solving, and inquiry-based learning (Shulman & Shulman, 2004)[8]. This shift is often difficult for teachers, as it requires them to embrace new teaching methodologies, often without sufficient support or preparation.

Incorporating DCT into teacher professional development can help teachers navigate this shift. By focusing on collaborative, context-based learning, teachers can engage in a continuous cycle of reflection, experimentation, and adaptation. Professional development programs that embrace DCT principles emphasize not only the use of technology but also the social and collaborative aspects of teaching and learning. Teachers can use technology to enhance their practice while also sharing and reflecting on their experiences with colleagues.

For instance, technology-supported professional development platforms, such as online communities of practice, can enable teachers to collaborate in a distributed cognitive environment. In these settings, teachers can share resources, discuss challenges, and co-create learning materials. This approach aligns with DCT's emphasis on distributed cognition, where learning is not an individual activity but a collaborative one that extends beyond the classroom.

2.5 Linking DCT to Educational Technology

The connection between Distributed Cognitive Theory and educational technology is integral to understanding how technology can be used to enhance teaching and learning. DCT emphasizes the importance of tools and social interaction in the cognitive process, which is highly relevant when considering how technology mediates learning. However, the successful application of DCT in education depends on how well technology is integrated into the learning environment.

One of the challenges in applying DCT in education is the complexity of the cognitive systems involved. Teachers, students, and technology tools interact in dynamic ways that can influence the

effectiveness of technology integration. This interaction requires careful consideration of how each element—individuals, tools, and the learning environment—works together to support cognitive processes[9]. Additionally, it requires educators to understand how to use technology in a way that enhances, rather than disrupts, these cognitive processes.

To make the best use of technology, educators must be able to design learning experiences that align with the principles of DCT. This involves creating environments where students can engage with technology, collaborate with their peers, and interact with teachers in ways that extend their cognitive abilities. Furthermore, teachers must be equipped with the knowledge and skills to use technology effectively, which underscores the importance of ongoing professional development.

3. Challenges in Technology Integration

3.1 Introduction

While the integration of technology into education presents numerous opportunities for enhancing teaching and learning, it also introduces a set of significant challenges that hinder its effective use in classrooms. These challenges are multifaceted, affecting not only the technical aspects of implementing digital tools but also the pedagogical, organizational, and cognitive aspects of teaching. This chapter explores these challenges, including cognitive load, teacher preparedness, access to resources, student engagement, and changes in pedagogical approaches. By examining these obstacles, we can better understand how to address them through professional development programs and the application of Distributed Cognitive Theory (DCT).

3.2 Cognitive Load and Technology Use

Cognitive load refers to the mental effort required to process information during learning. According to cognitive load theory (Sweller, 1988), learning is most effective when the cognitive load is balanced—neither too high nor too low. When students are overloaded with extraneous information or have to manage too many cognitive tasks at once, their learning becomes less effective.

In the context of technology integration, cognitive load can be increased if digital tools are not designed or used properly. For instance, poorly designed educational software with overly complex interfaces can confuse students, distracting them from the learning material itself. Similarly, when technology is used excessively or inappropriately, it can cause cognitive overload by demanding too much attention from students, making it difficult for them to focus on the core concepts being taught.

DCT offers a useful perspective on managing cognitive load in technology-enhanced learning environments. Since cognition is distributed across tools, people, and environments, the key to effective technology integration lies in using digital tools in ways that reduce cognitive load and help students focus on meaningful learning tasks. Teachers must be mindful of the cognitive demands placed on students when using technology and design learning experiences that strike the right balance between cognitive load and the potential for technology to extend cognitive capacities.

3.3 Teacher Preparedness and Training

One of the most significant barriers to successful technology integration in education is the lack of adequate teacher preparedness and training. Teachers often lack the technical skills and pedagogical knowledge required to effectively integrate technology into their teaching. According to a study by Ertmer (1999), many teachers struggle with using technology due to insufficient training, a lack of confidence, and the absence of a clear pedagogical framework for integrating technology.

For technology to be used effectively, teachers must possess both technical skills (e.g., familiarity with software and hardware) and pedagogical knowledge (e.g., understanding how to integrate technology in ways that align with learning objectives). However, many teachers have not received sufficient professional development opportunities that equip them with the knowledge and

skills required for effective technology integration. As a result, teachers may resort to using technology in superficial or ineffective ways, such as merely using digital tools to present information rather than fostering interactive or collaborative learning.

In the framework of Distributed Cognitive Theory, teacher preparedness involves not only individual knowledge and skills but also the ability to collaborate and share cognitive tools with peers. Teachers must be supported through ongoing professional development programs that focus on both the technical and pedagogical aspects of technology integration. These programs should foster a community of practice where teachers can learn from one another, exchange ideas, and collaboratively design technology-rich learning experiences.

3.4 Access to Resources

Access to resources is another critical challenge in technology integration. While the availability of technology in schools has increased in recent years, access remains uneven across schools and regions, leading to disparities in the ability of teachers and students to utilize digital tools effectively. This digital divide is particularly pronounced in underfunded schools or in rural areas, where schools may lack the infrastructure or financial resources to invest in the latest technology.

Access to technology does not only refer to the physical presence of devices but also to the availability of reliable internet connections, software applications, and technical support. Even in schools with well-equipped classrooms, teachers may encounter barriers such as outdated hardware, slow internet speeds, or inadequate technical support, which can limit the effectiveness of technology integration. Furthermore, students may have limited access to devices at home, creating an additional layer of inequality.

The uneven distribution of resources can result in a "two-tier" education system, where some students benefit from advanced technology tools, while others are left behind. To address this challenge, schools must ensure equitable access to both hardware and software and provide adequate technical support for teachers and students. This also emphasizes the need for policies that promote the equitable distribution of educational resources, particularly in under-resourced schools.

4. Teacher Professional Development in the Context of Distributed Cognitive Theory

4.1 Introduction

Teacher professional development (TPD) plays a pivotal role in enabling educators to effectively integrate technology into their teaching practices. However, the challenges associated with technology integration cannot be overcome solely through technical training. To address these challenges, teacher professional development must be comprehensive, sustained, and grounded in the principles of Distributed Cognitive Theory (DCT). DCT emphasizes the role of collaboration, reflection, and shared cognitive resources in learning, suggesting that teacher development should extend beyond individual growth and embrace the collective, social nature of teaching and learning.

This chapter explores how DCT can inform and enhance teacher professional development in the context of technology integration. It examines the role of reflection, collaboration, and continuous learning in the professional growth of educators and proposes strategies to align teacher development programs with the principles of DCT.

4.2 The Role of Reflection in Teacher Development

Reflection is a key component of professional growth. Teachers who reflect on their practice are more likely to identify areas for improvement, adapt their teaching strategies, and embrace new approaches. Reflection allows teachers to critically analyze their teaching methods, assess the effectiveness of technology in the classroom, and make adjustments based on student needs and learning outcomes.

Distributed Cognitive Theory provides a framework for understanding reflection as a socially distributed process. Rather than being an isolated activity, reflection is enhanced when teachers engage in collaborative discussions with colleagues, share their experiences, and gain insights from

others. This aligns with the DCT perspective that cognition is distributed across individuals and tools. In the context of teacher development, this means that reflective practice should involve interaction with peers, mentors, and external resources.

Professional development programs can incorporate reflective activities that encourage teachers to analyze their technology use and its impact on student learning. For example, teachers can use video recordings of their lessons to reflect on how technology is integrated into their teaching. Peer observations and feedback sessions can also provide opportunities for teachers to reflect on their practice in a supportive, collaborative environment. By engaging in reflective practices, teachers can continuously improve their use of technology in ways that align with their teaching goals and the cognitive needs of their students.

4.3 Collaborative Learning and Communities of Practice

A central tenet of Distributed Cognitive Theory is the idea that learning is a social process, facilitated through collaboration and the sharing of cognitive resources. This concept is highly relevant for teacher professional development, where collaboration among teachers is essential for effective technology integration. In traditional models of professional development, teachers often work in isolation, attending workshops or courses without the opportunity for ongoing collaboration or sharing of ideas.

Communities of practice (CoP) are a powerful model for teacher development that aligns with DCT principles. A CoP is a group of individuals who share a common interest or goal and engage in regular, collaborative learning. In the context of technology integration, CoPs allow teachers to share their experiences, exchange resources, and collaborate on designing lessons that incorporate technology. These communities can exist within a school or across schools and can include both face-to-face and online interactions.

Research by Lave and Wenger (1991) emphasizes the importance of CoPs in fostering professional learning. Teachers in a CoP are not only participants but also contributors, sharing their knowledge and learning from others. This collective form of learning is particularly effective in helping teachers navigate the complexities of technology integration. Through ongoing collaboration, teachers can gain new insights into the best practices for using technology and build confidence in their ability to use digital tools in the classroom.

For effective professional development, schools and districts should foster the creation of CoPs focused on technology integration. These communities can provide a platform for teachers to learn from one another, solve problems collaboratively, and experiment with new tools and teaching strategies.

4.4 Mentoring and Peer Support

Mentoring is another important strategy for supporting teachers in their professional growth. In the context of technology integration, mentoring can help teachers gain confidence in using new tools and strategies. Experienced teachers or instructional coaches can provide guidance, answer questions, and offer feedback on how to incorporate technology into teaching practices.

DCT suggests that learning occurs not only within the individual but also through interactions with others. In this sense, mentoring represents a form of distributed cognition, where the mentor provides cognitive resources, such as knowledge, experience, and advice, that help the mentee navigate the challenges of technology integration. This relationship can be reciprocal, with both the mentor and mentee learning from each other.

Mentoring can take various forms, from one-on-one coaching to group mentoring sessions. The key is that it provides teachers with personalized support and opportunities for collaborative learning. Peer mentoring, where teachers collaborate and support one another, can be particularly effective in fostering a culture of continuous learning. By sharing successes and challenges, teachers can build a supportive network that encourages experimentation and innovation with technology.

5. Pathways for Professional Development

5.1 Introduction

Effective teacher professional development (TPD) is essential for overcoming the challenges associated with technology integration in education. As discussed in previous chapters, these challenges include cognitive load, teacher preparedness, access to resources, student engagement, and pedagogical shifts. In response to these challenges, it is necessary to develop structured and ongoing pathways for teacher professional development that empower educators to leverage technology effectively in their classrooms. These pathways should be flexible, collaborative, and designed to foster continuous growth and reflection.

In this chapter, we explore different models and strategies for professional development that align with the principles of Distributed Cognitive Theory (DCT). We will focus on personalized learning, collaborative learning communities, and school-based support systems as critical pathways for teacher development in the context of technology integration.

5.2 Personalized Learning for Professional Development

Personalized learning is an approach that tailors professional development to the individual needs, skills, and preferences of each teacher. This pathway recognizes that teachers have diverse levels of experience with technology, different teaching contexts, and unique professional growth goals. Personalized learning allows teachers to engage in professional development at their own pace and select the topics and formats that best suit their needs.

In the context of technology integration, personalized learning enables teachers to explore new digital tools, pedagogical strategies, and technological platforms that align with their subject area and teaching style. For instance, a teacher specializing in STEM (Science, Technology, Engineering, and Mathematics) might focus on integrating interactive simulations and data analysis software into their lessons, while a language arts teacher might explore tools for collaborative writing and peer feedback.

DCT emphasizes that cognition is distributed across individuals, tools, and the environment. Personalized learning can incorporate these principles by providing teachers with a variety of digital resources and tools to support their learning. Digital platforms such as online courses, webinars, and instructional videos can be utilized to deliver content, while interactive forums and virtual communities can provide opportunities for teachers to engage with peers and mentors.

Key components of personalized learning for teachers include:

Choice and Autonomy: Teachers can select the learning paths and resources that align with their professional goals and interests. This autonomy fosters a sense of ownership over their development and encourages sustained engagement.

Differentiation: Professional development opportunities are differentiated based on the teacher's level of experience, knowledge, and technology proficiency. Newer teachers may need foundational training on basic digital tools, while experienced educators may seek advanced strategies for integrating technology into project-based learning or inquiry-based teaching.

Flexible Formats: Personalized learning pathways should be available in various formats, such as face-to-face workshops, online courses, or self-paced modules. This flexibility ensures that teachers can access professional development opportunities that fit their schedules and learning preferences.

5.3 Collaborative Learning Communities

Distributed Cognitive Theory underscores the importance of social interaction and collaboration in the learning process. In the context of teacher professional development, collaboration among educators is essential for sharing resources, discussing challenges, and co-constructing knowledge. Collaborative learning communities, or communities of practice (CoPs), provide a structure for teachers to work together, exchange ideas, and build collective knowledge.

In a CoP, teachers collaborate on solving problems related to technology integration, share best practices, and reflect on their experiences. These communities can exist within a single school or across multiple schools, and they can take both physical and digital forms. Online platforms such as

discussion boards, social media groups, and collaborative document-sharing tools can facilitate ongoing collaboration among teachers, allowing them to continue their learning outside of formal professional development sessions.

Some key features of collaborative learning communities include:

Shared Goals: Teachers in a CoP share common interests and professional goals, such as enhancing technology integration or improving student engagement through digital tools. This shared purpose strengthens the community and creates a sense of accountability.

Peer Learning: Teachers engage in peer-to-peer learning, sharing their experiences, successes, and challenges. This collaborative exchange promotes problem-solving and encourages teachers to experiment with new ideas in a supportive environment.

Ongoing Dialogue: CoPs foster continuous, open dialogue among teachers, providing opportunities for reflection and feedback. This ongoing interaction allows teachers to refine their practices and continuously improve their use of technology.

Mentorship and Support: Within CoPs, more experienced teachers can mentor their less experienced peers, providing guidance and sharing expertise. This mentorship reinforces the distributed nature of learning, as teachers benefit from the cognitive resources provided by their colleagues.

By fostering a culture of collaboration, CoPs help teachers build confidence, share innovative strategies, and stay motivated to integrate technology in meaningful ways.

5.4 School-Based Support Systems

School-based support systems are crucial for providing ongoing professional development and ensuring that technology integration is sustained over time. These systems can include school leadership, instructional coaches, and dedicated time for professional learning within the school day. The success of technology integration depends on the support teachers receive from their school administration, as well as the resources available within the school environment.

Some key components of school-based support systems include:

Instructional Coaching: Instructional coaches can provide personalized support to teachers, offering guidance on how to use technology effectively in the classroom. Coaches work closely with teachers to model the use of digital tools, observe classroom practices, and provide feedback on how to improve technology integration.

Dedicated Time for Collaboration: Schools can allocate time during the school day for teachers to collaborate on lesson planning, share resources, and discuss their experiences with technology integration. This time fosters a collaborative culture where teachers can learn from one another and experiment with new strategies.

Leadership Support: School leaders play a critical role in promoting technology integration and professional development. By providing resources, setting clear expectations, and offering encouragement, school leaders can create an environment where technology is seen as an essential tool for improving teaching and learning.

Technical Support: Effective technology integration requires adequate technical support to troubleshoot problems and maintain devices. Schools must have dedicated IT staff to ensure that digital tools and platforms are functioning properly and that teachers can access the support they need.

A strong school-based support system creates a foundation for sustained professional growth and ensures that technology integration is not a one-time initiative but an ongoing process.(As shown in figure 2)

Figure 2. Classroom Setting with Teachers and Students Using Technology

6. Conclusion

In the real world, all kinds of information are distributed in everyone's mind and in the cognitive retention of various artifacts. People will collect all kinds of information in the environment and form conclusions through inquiry and critical thinking to solve problems. Therefore, distributed cognition emphasizes interactive behavior, realizes distributed learning through communication and interaction, emphasizes the use of information and communication technology to support distributed cognitive activities, and attaches importance to the role of artifacts in cognition. This study provides important enlightenment for the design of learning environment.

References

[1] Price T. Cognition, Interaction, and Creativity in Songwriting Sessions: Advancing a Distributed Dual-Process Framework[J].Social Psychology Quarterly,2025,88(1):1-21.

[2] Zha L ,Zhang H ,Wang N , et al.Distributed Cognitive Positioning System Based on Nearest Neighbor Association and Multi-Point Filter Initiation for UAVs Using DTMB and INS[J]. Drones, 2025,9(2):130.

[3] Gupta S M ,Srivastava A ,Kumar K .RORA: Reinforcement learning based optimal distributed resource allocation strategies in vehicular cognitive radio networks for 6G[J].Vehicular Communications, 2025,521.

[4] Gibaut W ,Gudwin R .Building a Cognitive Twin using a distributed cognitive system and an evolution strategy[J].Cognitive Systems Research,2025,1326.

[5] Zhang Y H .Psychological Analysis and Career Decision-Making of College Students Based on Cognitive Algorithms on Distributed Platforms[J].International Journal of High Speed Electronics and Systems,2025,(prepublish)

[6] Hegde C ,Kiarashi Y ,Levey I A , et al.Feasibility of assessing cognitive impairment via distributed camera network and privacy-preserving edge computing.[J]. Alzheimer's & dementia (Amsterdam, Netherlands),2025,17(1):e70085.

[7] Tribble E .Distributed cognition, Shakespeare’s theatre, and the dogma of harmony[J]. Topoi, 2024,(prepublish):1-7.

[8] Chen Y ,Chen L .Promoting Shared Metacognition in Online Learning: The Practices of Distributed Teaching Presence and the Relationships to Cognitive Presence[J].Education Sciences, 2024,15(1):4-5.

[9] Colin R T ,Ikink I ,Holroyd B C .Distributed Representations for Cognitive Control in Frontal Medial Cortex.[J].Journal of cognitive neuroscience,2024,21-28.