Systematic Review

Teachers' Agency in Technology for Education in Pre- and Post-COVID-19 Periods: A Systematic Literature Review

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Abstract: Technology has become an indispensable element in education that challenges conventional teaching. The pandemic significantly forced a paradigm shift in education from traditional methods to digital platforms. Emerging technology expanded the teacher's role faster than predicted, and technology has become a significant criterion in defining 21st-century teachers. Teachers had to upgrade education and act as change agents in creating and managing technology-enhanced learning environments requiring teachers to be digitally literate. Considering teachers as significant stakeholders, this paper investigates how literature contributes to the knowledge of their perceptions of digital literacy in education by systematically investigating 59 research articles searched in EBSCO discovery services, covering commonly included 80 different databases in the default search. The review focuses on how teachers use technology, their challenges, and what teachers expect from successful technology integration. Results revealed a contradiction between expectations for technology integration into education before the pandemic and the experience after the lockdown. Even though teachers are confident using basic technology, many have observed a disconnect between technology and pedagogy that emphasises digital literacy's need. Teachers struggle with technology integration due to lack of knowledge, accessibility, cost, disconnection, infrastructure, time, workload, and technology anxiety Therefore, teachers expect institutions to play a significant role in integrating technology by assisting them in mitigating challenges that require defining the institutional role of a technology-integrated learning environment.

Keywords: technology integration; teachers' digital literacy; challenges; expectations; technology use

1. Introduction

The rapid technological change is leading towards tremendous changes in human life in every aspect, widening the opportunities available in the community [1]. The development of Information and Communication Technology (ICT) created massive pressure in education through its integration into teaching and learning, especially in the higher education arena [2]. Modern technology paves a path for developing various methods and channels in education. However, compared to the other industrial sectors, technology integration in education progressed at a low pace until the global COVID-19 pandemic [3]. Because of the sudden lockdowns and isolation brought on by COVID-19, technology could replace traditional face-to-face instruction with virtual platforms [4,5]. While universities typically provide Information and Communication Technology hardware facilities, teachers are responsible for handling technology in terms of searching, learning, understanding, designing, using, and, most importantly, bridging students with technology [4,6]. Therefore, in modern days, technology has gradually become one of the indispensable elements in the essential qualifications list in the digital age [7,8]. Higher education in the digital era demands changes in teaching practices that require considerable digital competencies for all the stakeholders [9].

The rapid change in technology adds everyday challenges to the education process. Being one of the significant stakeholders in the process, teachers must bear a greater responsibility in handling technological dynamism, and it is crucial for teachers to possess resilience when adapting to technological advancements [10,11]. The level of technology integration within education delivery depends on the teachers' active involvement in technology. Hence, their digital literacy will encourage teachers' activeness in technology [12].

Digital literacy refers to a range of abilities of a person, such as searching, evaluating, creating, and sharing digital content through digital technology [13], and represents the person's ability to apply technology critically [14,15]. Technological adaptation in education forces teachers to establish themselves in a digital environment, and this establishment will be impossible without a solid knowledge of technological functions, limitations, and benefits [12]. A digitised society demands digitally literate and competent teachers, which substantially influences the quality of technology integration in teaching and learning [16]. Therefore, digital literacy has become a contemporary topic in higher education, which has a more significant impact on the performance of teachers and students [12,17]. Previous research provides evidence for teaching and learning quality improvement and how digital transformation, technological advancements, and teacher literacy shape modern education. However, the literature also points out the gaps in digital literacy and its impact on advancing technology [18].

Further, teachers are claiming their low digital literacy levels that are limiting their progress with technology [4]. This mismatch between the knowledge about current demands for teachers in line with the rapid digitalisation of education and the reality of teachers' competence urges the exploration of questions about the impacts of digitalisation pertaining to teachers and their agency in technology. Hence, this paper devices a systematic literature study to answer the following questions to understand the current landscape of teachers' agency in technology for higher education.

- How do teachers use digital tools and technology?
- What challenges do teachers encounter in the process of competence development?
- What are teachers' expectations for the agency in technology enhancement in teaching?

Answering the above questions will be a revelation in the higher education research domain, highlighting the attention of higher educational stakeholders towards the fundamental prerequisite in promoting a technology-enhanced educational environment. In addition, this paper facilitates the reader to comparatively understand the teachers' position in technology during the pre- and post-COVID periods, indicating teachers' experience with technology and the areas to be further addressed.

The rest of the paper is organised as follows. Section 2 describes the methodology used for systematic literature review and the search protocols for academic articles. Section 3 summarises the results illustrating the content analysis process of selected articles. The outcome of the literature analysis is described in Section 4, and finally, the concluding remarks and possible future work to be performed as a follow-up are discussed.

2. Methods

This paper systematically reviews research papers published before and after the COVID pandemic to understand the teachers' involvement in technology-enhanced teaching. This systematic literature review aims to derive conclusions about teachers' current knowledge, skills, and perception regarding technology by reviewing related literature. The search process is based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework [19,20], encompassing four main steps of identifying records, screening, assessing eligibility, and inclusion. Articles were searched in EBSCO Discovery Services, and all the common databases included in the default search were considered at the initial stage. At the identification stage, four different protocols covering the required knowledge domain were used as described subsequently.

Furthermore, this systematic literature review focuses only on higher education or university context to understand how technology is used. Therefore, the search is limited to

"university teachers" and "university, college or higher education institute". The following four search protocols are used for curating the publication corpus for the analysis.

- Protocol 1—"Digital literacy" AND "University teachers" AND "University or college or higher education".
- Protocol 2—"Technological literacy" AND "University teachers" AND "University or college or higher education".
- Protocol 3—"Teachers' agency in technology" AND "University teachers" AND "University or college or higher education".
- Protocol 4—"Use of digital tools" AND "University teachers" AND "University or college or higher education".

Further, to refine the identification and to receive results related to in-service teachers' experience, the search excluded the "systematic literature review or meta-analysis", "pre-service teachers or teacher candidates or student teachers", and "school education". In addition, the study excluded all the other sources except academic journals and articles published before 2016 and included peer-reviewed, English language academic journal articles published within the time span of 2016 to 2022. The inclusion and exclusion criteria used in selecting relevant publications for answering the research questions are presented in Figure 1, according to the PRISMA guidelines.
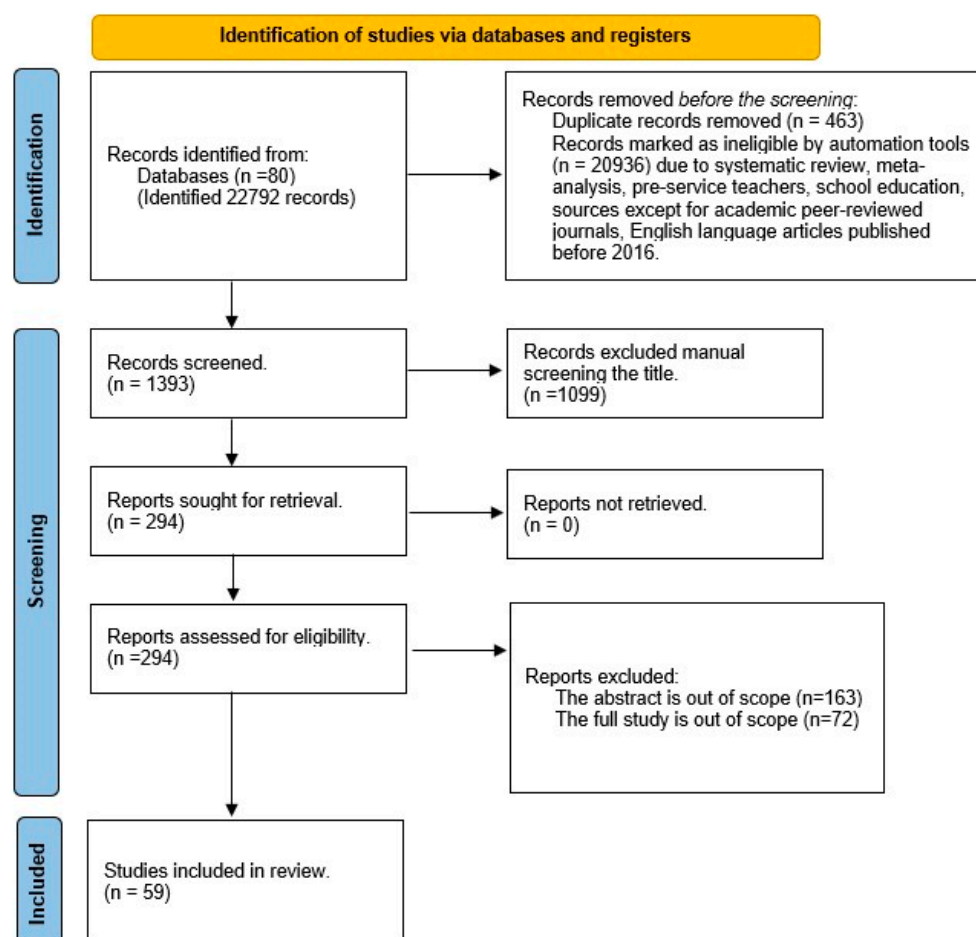

Figure 1. PRISMA flow chart adapted from [20].

Table 1 illustrates the number of articles retrieved by each protocol, and the exclusion and inclusion criteria is presented in Figure 1.

Table 1. Number of articles extracted for the study.

Protocol	No. of Studies Finalised for the Review
01	06
02	32
03	04
04	17
Total	59

Table 1 depicts fifty-nine (59) articles were selected for in-depth analysis to understand their main focuses and findings regarding teachers' knowledge, skills, and perception in using technology for education. PRISMA guidelines promote systematic, rigorous, and unbiased flow in the search process. Therefore, explicit criteria was used in reviewing findings by comparing and evaluating so as to arrive at conclusions about the current knowledge [21]. In the analysis, the findings were categorised based on two aspects: (1) the period in which the research was conducted (pre- or post-COVID) and (2) themes derived in line with the three research questions (teachers' use of technology, challenges, and their expectations). Selected papers were thoroughly discovered to capture the teachers' behaviour towards technology use to answer the study's questions. Concerning each main theme, sub-themes were identified, and each theme's frequency of occurrence was discovered in the selected research article. In addition, at the final stage of analysis, a comparison of themes is performed by considering the pre- and post-COVID periods.

3. Results

The findings section consists of two main segments. The first segment summarises the background details of the extracted research studies in terms of conduct period and methodology. The second segment deeply elaborates on the study's focus, highlighting teachers' use of digital tools, challenges, and expectations for successful technological integration.

3.1. Temporal Summary of Selected Publications

This study considers articles published before and after the pandemic and compares if there are differences in the levels of teachers' agency in digital tools. Hence, one feature extracted was whether the study was conducted before or after the COVID. A total of 32 articles from the 59 extracted studies represent the pre-COVID era, 25 papers were conducted after the global COVID period, and 2 articles have not mentioned their conduct period. The interest in technology in teaching may differ for different subjects. Articles are categorised into pre-classified subject areas to check for selection (publication) bias towards specific subject areas. Overall, 11 (19%) research studies were conducted analysing English language teachers that evidenced significant importance towards technology use in the study of English language. Furthermore, 37% (22 articles) of the papers have not restricted their analysis to a specific academic discipline and have a multidisciplinary focus.

The review includes studies from disciplines such as teacher education, social and legal sciences, physiotherapy education, natural health, nursing, mathematics, humanities and science, business administration and law, and agriculture and natural resources. However, 16 articles out of 59 (27%) have not explicitly mentioned which academic area their participants represent. The questionnaire is the most common tool used in data collection, and 58% of the selected research articles collected data related to teachers' technology integration using questionnaires. In addition, 22% of the articles have used interviews and 20% have used mixed methods in data collection.

3.2. Summary of Selected Publications towards Teachers' Behaviour and Perception of Technology
3.2.1. Teachers' Use of Digital Tools and Technology

Technology use is recognised under different aspects in the literature. Not all the literature in the SLR article corpus mentioned demographic factors associated with the use

of technology (Table 2), but primarily age, gender, or experiences, as described in Table 2, are mostly discussed.

Table 2. Demographic profile of teachers.

Demographic	Literature			
	%	Pre-COVID	%	Post-COVID
Gender	7	[22–25]	3	[26,27]
Age	3	[28,29]	5	[30–32]
Experience	7	[22,23,33,34]	7	[32,35–37]
Academic discipline	5	[24,34,38]	3	[39,40]
Academic rank	2	[34]	-	-

The key factors contributing to individuals' digital literacy is another essential aspect that describes the teacher's role in technology-enhanced teaching and learning and elaborates on the teachers' confidence, preference, awareness, motivation, and frequency of use in Table 3.

Table 3. Teachers' proficiency and perception towards technology.

Factor	Literature			
	%	Pre-COVID	%	Post-COVID
Confidence	8	[22,29,41–43]	2	[44]
Preference	8	[22,23,29,41,45]	5	[31,35,40]
Motivation to use technology	5	[45–47]	5	[35,39,48]
Awareness	17	[24,29,38,45,47,49–53]	3	[40,54]
Proficiency/competency/capability	24	[15,23–25,34,38,45,49–52,55–57]	15	[30,31,36,37,39,58–61]
Attitude	12	[22,34,38,43,49,50,53]	8	[31,36,48,60,62]
Frequency of use of technology	12	[24,25,28,29,51,52,63]	3	[64,65]

Teachers have experienced and perceived different benefits in line with the use of digital tools and technologies presented in Table 4 below, discussing fourteen different aspects discussed in the previous research studies.

Table 4. Teachers perceived uses of technology.

Benefit	Literature			
	%	Pre-COVID	%	Post-COVID
Improvements in teaching	7	[22,38,41,50]	-	-
Improvements in students' engagement	7	[15,53,66,67]	5	[26,31,48]
Improvements in learning environments	2	[66]	2	[68]
Enhancing research productivity	2	[15]	-	-
Improvements in learning	7	[22,57,59,67]	7	[26,32,54,68]
Enabling educational innovation	3	[25,67]	3	[26,69]
Improvements in the assessment process	5	[15,57,70]	3	[26,31]
Enabling strong communication	8	[22,25,57,67,70]	5	[37,54,69]
Open space to organise teaching	2	[38,71]	3	[32,48]
Facilitate educational continuation	-	-	3	[58,60]
Recording facility for later reference	-	-	2	[72]
Allow flexibility in the teaching and learning process	-	-	3	[60,69]
Provide more opportunities in the teaching and learning process	-	-	2	[69]
Ease courses' management	2	[67]	2	[40]

3.2.2. Challenges Faced by Teachers When Utilising Digital Tools and Technology

When integrating digital tools and technology into the teaching and learning process, teachers have faced various challenges mentioned in Table 5.

Table 5. Challenges in technology integration.

Challenge	Literature			
	%	Pre-COVID	%	Post-COVID
Issues in time management	8	[41,50–52,66]	10	[36,39,40,48,61,73]
Differences in discipline	8	[28,49,57,70,74]	3	[37,40]
Lack of infrastructure/resources	15	[29,38,49–51,53,57,66,67]	15	[30–32,35,39,54,59,65,73]
Need of special expertise/knowledge and skills	7	[15,24,50,51]	12	[36,39,45,48,60,68,69]
Easy distraction	2	[66]	3	[39,65]
Issues in ensuring academic integrity	3	[57,66]	3	[36,40]
Harmful use/security issues	5	[47,66,74]	2	[35]
The rapid change in the technology	5	[25,55,71]	-	-
Expensiveness	2	[29]	3	[36,64]
Organisational culture	2	[52]	2	[48]
Preparations and workload	7	[51,52,71,74]	7	[35,54,61,73]
Inability to support critical thinking skills	-	-	3	[26,32]
Disconnection between students and teachers	3	[46,67]	8	[40,48,61,65,73]
Limited access to facilities	3	[24,38]	5	[31,60,65]
Difficulty in managing classrooms	2	[46]	3	[40,48]
Absence of individual attention	3	[46,70]	2	[40]
Lack of institutional support	10	[24,45,49,50,52,66]	5	[59,60,75]
Complexity	2	[49]	2	[31]
Negative attitudes	-	-	3	[31,48]

Research conducted by Rudhumbu [75] does not explicitly mention the research period, yet discusses the lack of infrastructure and rapid change in technology and cost, which limit the teacher's active use of technology.

3.2.3. Expectations of Teachers for Technology-Enhanced Teaching and Learning

Table 6 illustrates the research studies highlighting teachers' expectations towards implementing technology-enhanced teaching in education.

Table 6. Expectations of teachers from technology-enhanced teaching and learning.

Teachers' Expectations	Literature			
	%	Pre-COVID	%	Post-COVID
Peer support and collaboration	3	[29,41]	3	[39,69]
Training	20	[15,33,34,38,41,42,46,49,55,57,66,76]	20	[26,30–32,36,39,44,54,64,65,68,69]
Institutional support	10	[33,38,47,50,55,74]	7	[26,32,69,73]
Policy involvement	5	[38,50,57]	3	[31,59]
Monitoring/supervision	3	[15,55]	-	-
Infrastructure	7	[15,28,51,53]	7	[31,64,69,72]
Accessibility	3	[53,55]	2	[64]
Technical support	5	[29,53,71]	-	-
Introducing new technology	-	-	3	[64,68]
Cultural changes	-	-	8	[32,39,65,69,73]

Even though the pre- and post-COVID period is not mentioned in the study of Hbaci et al. [77], they emphasise the need for formal training and changes required in the curriculum, broadening the scope of technological change integration.

3.2.4. Comparative Summary of the Results

Table 7 presents a summary of points highlighted concerning the three research questions in the study comparing both pre- and post-COVID periods.

Table 7. Summary of the findings.

Focus	Dimensions		Pre-COVID	Post-COVID
Nature of technology use	Gender		No considerable change	
	Age		No considerable change	
	Competence level		Perceived high	Accepted low
	Awareness		High	Understood that simple awareness is not sufficient
	Attitudes and motivation		Positive attitude + high motivation	Positive attitude + high motivation
	Perception about the usefulness	Improvements and innovations	Accepted	Not specifically discussed
		Efficient content management	Accepted	Accepted
		Improve learning	Accepted	Accepted
		Smooth Communication	Accepted	Not happy
		Flexible nature	Not specifically discussed	Accepted
	Different tools and intensity of use	Types of tools	Basic Tools	Basic tools + intensified video conferencing + collaborative tools + assessment tools
		Intensity of use	No considerable change	
		Selection	It is a choice	Mandatory
Challenges	Lack of knowledge, skills, and expertise		Not much noted	Severely experienced
	Restrictions on the common application		Discussed the need	Suffered from unavailability
	Student connection issues	Communication	Used as an additional platform	The only methodNot effective
		Classroom management and control	Manageable	Not effective
		Student engagement	Used as an additional means of engagement	Very low engagement
	Cost of technology		Restrict the accessibility	Restrict the accessibility + intensified due to the home location
	Infrastructure and resources issues		Lack of resources	Lack of resources + intensified due to location
	Security issues		Less concerned	Highly concerned
	Workload and time constraints		Less concerned	Highly concerned
	Institutional involvement issues		Experienced	Highly experienced
Expectations	Institutional support		Required the support	The institution is provided the spotlight and requires a strong support
	Connecting training, pedagogy, and academic discipline		Less concerned	Highly concerned

4. Discussion

The outcome of the SLR resulted in three main aspects directed at understanding the teacher's profile, behaviour, and experience regarding educational transformation. The focus is on how teachers utilise digital tools and technology, their challenges in technology integration, and their expectations for better technology-enhanced teaching and learning during the pre- and post-COVID era.

4.1. Teachers' Use of Technology and Their Profiles

4.1.1. Demographical Concerns

Representing the aspects of demography, gender, age, experience, academic position, individual differences, background, and the discipline to which the teacher is attached to are frequently discussed regarding teachers' technological use. Gender is occasionally viewed as a conditioning factor towards teachers' involvement in technology integra-

tion [23,25–28] The gender-based digital divide is unresolved in technology integration, and researchers have presented contradictory ideas [78]. Male lecturers are shown to be more knowledgeable and confident about acquiring and exploring technology; thus, males mostly prefer self-learning [23,25,27,28]. Conversely, females are more interested in using technology, consuming more time to familiarise themselves with technology and prefer learning from somebody rather than self-learning and exploring [26,27]. Alanazy [22] argues that gender is not decisive for teachers' competency, intensity, and motivation in using technology. In both pre- and post-COVID periods, it cannot precisely comment on which gender is more competent in using technology, as the competency, frequency of use, knowledge, and motivation of using technology is differently presented in various research contexts. No study presented a significant impact of gender on technology integration, whereas research highlights gender to illustrate different behavioural patterns in line with gender differences. However, it is emphasised that both males and females prefer to use technology and embed it in their teaching practices. Therefore, no considerable change was noticed in the use of technology with respect to gender (CF Table 7).

Research studies emphasise different dimensions of age in relation to the level of technology adoption during the pre- and post-COVID period. Highlighting the implication of age on technology integration, studies of Marín-Díaz et al., Jorge-Vázquez et al., and Kampookaew [28,30,31] suggested high digital proficiency and technical familiarity in young academics. Conversely, Tulia Ricardo-Barreto et al. [29] observed the enthusiasm of senior academics towards technology integration. However, the relationship between teachers' age and their willingness and ability towards technology adoption encompasses a complex interplay between various factors that extend beyond the simple segregation of digital natives and immigrants [79]. While age has been associated with varying levels of technological proficiency, this perspective oversimplifies reality, as technological competency depends on many factors beyond just age. Transformative events such as the COVID pandemic have demonstrated that technology adoption hinges more on necessity and available resources than age alone.

Experience plays a vital role in technology integration beyond age, and academic rank (seniority) also can be aligned with experience. The relationship between experience towards technology integration has been discussed in pre- and post-COVID context, and no correlation is recognised between years of experience as a traditional teacher and being digitally competent [34]. Damsa et al. [35] stated that most teachers did not have experience using digital tools, although they had worked as conventional classroom teachers for many years before the COVID lockdown. However, during the transition due to the global pandemic, teachers faced difficulties embedding technology into education at a distance, although they adapted quickly [80]. More senior educators might oppose technology initially due to their connection to traditional methods, thus exhibiting adaptability and openness to innovation. However, teachers with prior experience using digital tools and technology tend to continue or increase their technology integration [22,23,37]. Irrespective of age, all the teachers had to rely on technological options to continue education; therefore, no considerable significance is given to age in using technology during the COVID period. Therefore, experience should be defined in line with technology over the age or experience of being a teacher in the conventional educational setting. Hence, it is imperative to ensure the accessibility of required technology to empower teachers, facilitating their professional development and expertise.

4.1.2. Teacher's Competency and Confidence in Using Technology

Technology integration can be successful through teachers' level of proficiency, confidence, and capability [15]. Before the pandemic, different perspectives are presented in line with teachers' digital competency. Several studies point out teachers' high or above-average technical proficiency [15,25,34,38,50,52,55], and some reported a medium or low proficiency in handling technology in teaching [23,24,33,45,49,56]. Penjor et al. and Moakofhi [51,57] confirmed that academics can manage technology with the required basic

skills. Technology having vast applications, the proficiency level is expected to differ along with the functions performed, which restricts the conclusions on the overall competence in technology [15,25,50]. However, the pre-COVID context findings favour high digital competence, primarily emphasising the use of basic technological devices and features.

Research studies conducted during the post-COVID era present contradictory findings compared to the pre-COVID context. Accordingly, the levels of competence in technology were not sufficient for implementing education at a distance, and it was found that teachers had difficulty in moving and establishing themselves on digital platforms due to a lack of prior exposure [30,31,36,37,39,58–61]. Various difficulties in adapting to technology during the early stages of the transition were observed. However, teachers had to hold on to technology, which became the only teaching mode during the lockdown due to the severe spread of COVID worldwide [37,39]. Research studies have concluded about the proficiency based on teachers' self-evaluated data that indicates teachers have rated themselves as highly competent before COVID. However, post-COVID studies illustrates a contrasting reality about teachers' proficiency, suggesting that teachers have come to acknowledge their limited ability to effectively manage technology integration, particularly in the context of advanced technological features and devices that extend beyond the commonly used basic tools.

One of the critical aspects highlighted in the comparison is the scope underlying the teachers' technological proficiency. Before COVID, teachers rated themselves as highly competent in technology that uncovered basic technical skills such as PowerPoint, email, and LMS [52]. Further, during the pre-COVID context, technology was an option for teachers and those who tended to integrate technological features into their teaching executed integration as they desired. Alternatively, conventional type of teachers were free to continue with the conventional classroom delivery with minimal use of basic technology. However, after COVID, teachers could not sustain only with these basic skills utilised primarily in delivery and were expected to cover a range of activities with technology such as content development, engagement, assessment, and feedback [59]. COVID has widened the technology application's scope, leading to a demand for knowledge about unique features in technology [81]. Due to the expansion in the scope of technology application, high-rated perception of technology before COVID was accepted to be low in studies conducted after COVID.

Publications before the COVID pandemic emphasise teachers' confidence in using technology, whereas only one paper in the post-COVID addresses this aspect. Teachers have demonstrated a high confidence level in technology integration in pre-COVID times [22,29,41–43], and after COVID, Antonietti et al. [44] presented an opposite finding, mentioning teachers' lack of confidence in using technology. These mixed conclusions indicate that teachers perceived their technology competence as higher than that in reality. In contrast to the pre-COVID era, the post-COVID era compelled teachers to provide education through technology, accentuating the challenges associated with adapting to this transformation. Confidence towards technology has a significant impact on the level of technological integration in education [82]. Therefore, it is important to strengthen the teachers' confidence for a successful technological integration.

4.1.3. Teachers' Awareness of Technology

Teachers' understanding of the potential of technology towards education is discussed under digital awareness; accordingly, teachers are required to maintain strong technological awareness [83,84]. Awareness shapes their use of technology [85,86] and helps teachers to improve [54]. Awareness supports in creating teachers' beliefs and beliefs about technology influence how teachers use technology in teaching [87]. The findings of Ayten [54] emphasised that highly aware teachers have a greater tendency towards integrating technology in teaching than less aware teachers. Teachers' digital awareness is commonly discussed in pre-COVID context and reports high technological awareness of fundamental technological devices and tools.

Moreover, these studies indicate that while teachers may possess an awareness of the technological tools, they may not necessarily possess a comprehensive understanding of how to integrate technology into the teaching and learning processes proficiently [24,29,39,45,47,49–53]. The extracted post-COVID research studies mentioned the aspect of awareness from a different perspective and argued for a broader role than merely elaborating on the level of awareness. Ayten [54] showed a positive relationship between awareness and teachers' technological competency, confirming that highly technologically competent teachers are proven to be aware of the strength of technology and its use.

Furthermore, Thumvichit [40] stated that basic technology aids in continuing education during the COVID lockdown, yet online education demanded more educational technologies for teaching and learning. Fundamental technologies prove inadequate in accommodating the expanding scope and enhanced online functionalities. Therefore, simply being aware is insufficient for teachers to claim that they are digitally literate and ready for technologically integrated transformation, as digital literacy covers a broad spectrum that discusses teachers' ability to utilise technology effectively. Further, the studies of Nugroho et al. and Mutiaraningrum and Nugroho [85,88] also confirmed the need for meaningful awareness that can extend up to effective use of technology, creating innovative learning environments [85,88]. According to Tam [89], an accidental shift in teachers' behaviours is observed in response to alterations in the educational environment. However, it is contended that these unintentional adjustments do not effectively contribute to the successful optimization of educational outcomes, as they do not react with proper knowledge and purpose. Therefore, understanding the process is further emphasised than merely knowing and unintentional adaption. While teachers exhibit awareness of the technical tools, a critical concern emerges from their lack of awareness regarding the effective integration of pedagogy and technology. Technological Pedagogical Content Knowledge (TPACK) by Mishra and Koehler [90] is a widely used framework demonstrating the interplay between content, pedagogy, and technology. As expected in the framework, teachers are expected to link technology in pedagogy and subject content, considering ICT as a pedagogical instrument [68,90,91]. So and Kim [92] and Vooget et al. [93] presented the teachers' inability to connect pedagogy, content, and technology, though teachers show competencies in respective aspects independently. However, these interconnections should be discussed in a broader spectrum than simply pointing out the awareness of the tool. Awareness should be expanded by discussing how the available digital tools can be integrated into the pedagogy, which should be adequately addressed for successful integration [52].

4.1.4. Teacher's Attitudes and Motivation towards Technology Enhancement

Teachers' attitude towards technology directly impacts its use and successful integration [94]. Further, it is claimed that digital literacy is significantly influenced by the teacher's attitude over other contextual factors such as education level, gender, and experience [95]. Teachers, in general, possess a positive attitude towards technology-enhanced teaching [22,36,38,48,50,53,62]. In contrast, the findings of Jwaifell et al. [34] and Makina and Madiope [49], before the pandemic, justify that teachers may not necessarily have a positive attitude towards technology due to teachers' robust connection to conventional teaching strategies. However, the study by Kampookaew [31] after COVID found a negative attitude toward technology integration, specifically during the early stage of COVID, and Sederevičiūtė-Pačiauskienė [96] presented the impact of sudden shock of transition towards creating negative attitudes, which were regarding ease of training, leadership, and care. Gradually, these negative attitudes became positive once the teachers became familiar with the technology. However, negative experiences may lead towards negative attitudes, which is a significant challenge for a teacher to operate in a technology-aided environment [31,48]. Conversely, though teachers faced many negative experiences during the early stage of COVID due to the sudden transition, teachers have demonstrated a positive attitude, strong desire and motivation towards technology integration after COVID, as technology became the only mean for education [22,23,29,31,35,39,41,46–48].

Although the chosen literature presents diverse findings concerning technological competencies, a commonality exists in terms of their preferences and motivations for learning and adopting technology, regardless of contextual variations. According to Technology Acceptance Model (TAM), the attitude influences the behavioural intention to use technology [97]. Therefore, having a positive attitude towards technology indicates maintaining motivation among teachers to use technology. Hence, a mechanism is required to sustain the motivation and positive attitude towards technology by providing adequate digital literacy.

4.1.5. Teacher's Perception of the Usefulness of Technology

The decision of a user to accept the technology is primarily driven by how knowledgeable they are about the usefulness of the technical aspects [98]. Further, as per TAM, perceived usefulness plays a significant role in influencing the actual use of technology [97]. Extracted research studies have presented a range of benefits perceived and experienced by the teachers during both the pre- and post-COVID era.

Improvements and innovations: The studies of Alanazy [22], Cote and Milline [41], and Hafifah and Sulistyo Mishra [50] during the pre-COVID period highlighted the ability of technology to improve teaching practice. Surprisingly, none of the selected studies conducted during the post-COVID era has specifically commented on the improvement in teaching practices through technology integration. Sudden transition and lack of affordability prevented teachers from exploring technology [85,99]. In particular, during the early stage of COVID, quickly improvised teaching methods imposed pressure on non-expertise teachers, and they experienced negativities due to lack of infrastructure [100]. In line with the findings of Pathiranage and Karunarathne [4], teachers emphasised various drawbacks of online teaching over conventional teaching, possibly a fact that restricts teachers from commenting about the improvement of teaching with technology after COVID.

Conversely, findings of Tena et al. [25] and Shah et al. [67] during the pre-COVID season and Cored Bandrés et al. [26] and Ødegaard et al. [69] during post-COVID period emphasised that technology enables innovations in education. Although teachers discuss the innovative use of technology during the pre- and post-COVID period, there is no extensive attention given to topics such as gamification, augmented reality (AR), artificial intelligence (AI), simulation, etc. It indicates the limitation of teachers within the scope of basic tools. Teachers generally rely on LMS, spreadsheets, forums, podcasts, PowerPoint, emails, etc. Teachers continuously comment on the ability of technology to make education innovative [25,26,67,69], yet significant involvement is not observed in integrating recent technologies in educational settings. Technology allows many teaching innovations but cannot be successfully integrated without teachers' active involvement as change agents [101]. However, according to Huda et al. [102], teachers' competency plays a significant role in embedding innovative teaching strategies, and Soto et al. [103] presented the need for teachers to update themselves as a primary need for competence in integrating technology innovations. These arguments validate the need for teachers to be digitally literate.

Efficient content management: Technology allows teachers to organise their teaching with more features in a broad space and develop more organised content [32,38]. Kraglund-Gauthier and Moseley [71] view Learning Management System (LMS) as an excellent organising tool that enables teachers to organise the content in an understandable format. Even though LMS is a heavily used administrative tool, Tena et al. [25] observed that the utilisation of LMS to its full potential is yet to achieved, and teachers are relying only on basic functions and avoiding complex functionalities in LMS. Teachers who participated in the study of Moakofhi et al. [57] emphasised the convenience of receiving and storing technology-aided assessments, while Goradia [70] and Kampookaew [31] acknowledged the efficiency of handling technology-aided assessments. Further, technology facilitates excellent student progress monitoring methods, which provide an updated picture of the student's performance [15]. Therefore, teachers accept that the assessments via technological platform help to improve the entire process compared to the physical assessment

operations [26]. Regardless of the pre- and post-COVID context, technology is consistently regarded as a viable platform for course administration, enhancing process productivity and efficiency while reducing time constraints. However, a notable issue persists in the underutilization of technology. The use of technology should be promoted with all required infrastructure, policies, and culture, whereas the absence of these factors limits the use of technology to its full potential [104]. In addition, teachers shoulder a significant share of responsibility for the underutilization of technology, given that the practical implementation of technology predominantly occurs at the teacher level. Consequently, it is necessary for teachers to acquire adequate digital literacy to employ technology to its full potential.

Ability to improve learning: Considering the learning viewpoint, irrespective of the pandemic, teachers are optimistic about the technology's ability to improve students learning via various digital tools, allowing students to explore new knowledge outside the classroom by broadening the learning space and collaborations [22,26,32,54,57,59,67,68]. Integrating new tools and open space for wider collaborations improves the learning environment [66,68]. Studies by Sadaf and Gezer, Yazon et al. [15], Shah et al. [67], and Goradia [70] show that technology and student engagement are positively correlated, highlighting that technology is laying a platform for students, such as discussion forums in LMS, to post their issues. Studies after COVID have proved the same outcome regarding student engagement and technology [26,31,48]. Teachers tend to favour conventional delivery when comparing traditional teaching methods with technology-assisted approaches, primarily due to concerns regarding limitations in students' progress. Despite the potential for students to access the broader world through technology, teachers express dissatisfaction with how students utilize these resources, as they have not observed significant advancements. In contrast, the findings of David et al. [4,105] observed that even amidst many challenges, both teachers and students are enjoying technology-integrated learning and witness learning improvement. It is widely acknowledged that to enhance students learning through technology, the teacher must possess sufficient digital literacy for better instructional design. This proficiency is essential to effectively guide students toward their self-improvement by exploring technology.

Smooth communication: Communication is an essential function easily activated via technology, and most teachers recognise familiarity and interest towards technology-aided communication. They accept that technology enables smooth communication between the student and the teachers, and these communication tools can be primarily embedded when designing learning activities [22,25,38,57,70]. Technology-aided communication is considered as a suitable online counterpart of face-to-face communication [38]. Research studies conducted after COVID presented a different opinion regarding communication tools. Teachers were not happy about the level of communication via technology, and most of the teachers have shown their unfamiliarity with using these communication tools [37,69]. In particular, during pre-COVID period, teachers meet students frequently, and communication via technology has become an extra avenue for both parties to continue discussions outside the classroom [105–107].

Teachers broadly define communication, including the non-verbal cues enabled through face-to-face delivery, which are lacking in remote communication [4,107]. Further, teachers get exhausted in remote communication, "Zoom Fatigue" due to the constant interaction with the screen [108], and students' low response requires teachers to continually force students to answer, which creates a negative and tiring experience for teachers [105]. Based on these drawbacks, teachers have not shown a positive acceptance towards technology-aided communication after the COVID context; conversely, before COVID, teachers accepted technology for communication. However, it is essential for teachers to be literate about different communication tools and their features to optimise the benefits of technology-aided communication [109], as technology can expand the boundaries of interactions.

Flexible nature: Ødegaard et al. [69] showed that technology can open more online learning opportunities for students. The flexible nature of the technology allows students

to learn freely without time and space restrictions, which is another benefit perceived by the teacher [60,69]; recorded lectures are an excellent example of flexibility [72]. The flexible nature of technology brings further opportunities for educators and institutes to continue their education even after the COVID period [58,60]. Technology-aided teaching enables asynchronous learning, and according to Hodges et al. [110], asynchronous learning is more flexible and provides space for self-organizing and reflection. Thus, a specific instructional design is required to derive self-oriented learning through technology. The issue connects to educators' digital competency and literacy within the context of instructional design, which involves the integration of content, technology, and pedagogy.

4.1.6. Different Tools and Intensity of Use

Many technology tools are tailored for different purposes [79]. It is claimed that digital tools enhance the quality of education by mediating learning, engagement, and communication and allowing anytime access [11]. Therefore, it is essential to be aware of the tools and technologies teachers use regularly. Interestingly, there was no significant difference in the types of tools used by the teachers in pre- and post-COVID times. Teachers have mainly utilised tools and technology in planning, teaching, sharing, storing, and communicating [25,29,36,38,67]. In pre- and post-COVID periods, teachers used technological hardware such as computers, projectors, etc. Among computer programmes, PowerPoint is the most famous tool in delivery [36,40,52,63,64]. PowerPoint is considered as a computer-aided instruction supporting teaching [111]. PowerPoint is easy to use and has many technological features. Its user-friendliness promoted the tool among teachers and students [112]. Conversely, PowerPoint has been identified as a reason for poor attendance, high deviations during the delivery, and declining students' attention towards self-learning that negatively influences the students' performances and interactions [113,114]. This observation underlines that ordinary application of tools like PowerPoint can yield negative consequences, leading to a decline in the quality of education. These negativities highlight teachers' crucial role in competently managing tools with an effective instructional design.

Teaching plans were frequently developed via surfing websites, and YouTube is another common tool used in teaching through audio–visual aids [24,38,54,63,70]. Student management is performed through LMS [25,31,40,52]. LMS has become a prevalent technological platform that enables speed sharing and effective communication between students and teachers [97]. Before COVID, Tena [25] presented that LMS had not been used to its full potential. The functions of LMS are compensated by the solid physical connection between the teacher and the student in the conventional classroom teaching environment [4,115]. Even though teachers comment on using institutional LMS to share, publish, and collect materials easily [116], teachers practically utilise face-to-face connection for these functions. Therefore, LMS was considered an optional teaching–learning platform before the COVID period (CF Table 2).

Conversely, LMS became a mandatory tool in education after the COVID period. LMS facilitates education continuation even amidst the disconnection between teachers and students, being an excellent platform that bridges the teachers and students in distance education [117]. Even though the priority of the LMS has changed after COVID, no considerable research work demonstrates the use of LMS to its full potential. A comparative study conducted by Zharova [118] emphasised a lack of understanding about the benefits of LMS before the massive transformation due to COVID, yet an increasing tendency is noticed towards the use of LMS over other channels by both teachers and students after COVID. However, in line with Tena [25], the findings of Bahar and Guoyan [115,116] also noticed underutilisation of LMS and stated the need for exploring features of LMS for effective teaching and learning process. Hence, LMS being a commonly used collaborative educational tool, its pedagogical use is limited, while the instrumental and functional use is utilised. This limitation requires attention for becoming literate about the effective use of the tool.

Student–teacher communication is primarily carried out via emails and messaging apps such as WhatsApp [24,29,38]. Unlike the pre-COVID period, video-conferencing tools such as Zoom and MS Teams were added to the communication portfolio during the COVID period as a replacement for face-to-face discussions in the physical classroom. These conferencing tools were also used before the pandemic, yet they became increasingly popular after the education shift. After the pandemic, collaborative tools such as Padlet, shared screens, Kahoot, and Canvas have increased, targeting more student engagement [31,36,40,64]. However, it is observed that those collaborative tools have not become famous among academics and are less frequently used in teaching. Teachers have articulated concerns regarding the accessibility of these tools attributed to associated costs. Further, teachers possess less experience in using and aligning emerging tools like Padlet, collaborative screens, and gaming apps into the pedagogy that demands further guidelines, training, and infrastructure for the execution.

Online evaluation was a widely discussed aspect during the post-COVID period. Academics have encountered many issues related to academic integrity. Studies by Tulia Ricardo-Barreto et al. [29] emphasise that inadequate focus on ethical care of intellectual property and plagiarism tools made online evaluations difficult. During the pre-COVID period, teachers occasionally used technological applications in communication, classroom collaborations and assessments. The presentation tool PowerPoint has been popular for handling teaching material. When the teacher and the student are in the same vicinity, the classroom is under the teacher's supervision. However, in remote teaching after COVID pandemic, physical activities were replaced by various technological tools targeting student engagement. According to Antón-Sancho and Sánchez-Calvo [64], the pandemic led towards an increment in technology integration and an increasing tendency to use technology.

Further, educators discuss, research, and develop many new educational technologies, and teachers generally prefer to use basic and familiar tools rather than complex and new technological options. However, no evidence exists in the studied literature about the significant use of innovative educational technology, specifically focusing on pedagogical requirements; instead, it shows continuous use of commonly known tools. Discussions elaborated on the teacher's awareness of the availability of multiple technologies. Nevertheless, teachers have restricted themselves mainly to freely available common tools prescribed by the institutes [35]. Furthermore, it is noted that teachers primarily utilize technological tools within the scope of their institutions, as the institute sponsors those tools. Despite educational institutions' provisions and sponsorships of technological resources, teachers often exhibit underutilization, highlighting significant gaps in digital literacy. However, there is a lack of self-initiative among teachers to discover and utilize innovative educational technologies at their level. Thus, it is evident that mere availability and awareness alone do not inspire teachers to proactively engage with technology.

4.2. Challenges Encountered by Teachers in Technology Integration

4.2.1. Lack of Knowledge, Skills, and Expertise

The literature shows that technology integration in education is challenging for teachers. Teachers perceive lack of knowledge, skills, and expertise as a more significant obstacle to their involvement in technology [15,24,36,39,50,51,60,69]. Even though studies by Mishra [50], Yazon et al. [15], and Dhakal [24] identified high digital competence among teachers in handling technology, teachers have perceived technological knowledge acquisition as challenging due to its dynamism [39]. The existing technical knowledge and skills can become obsolete due to the dynamism of technology, and teachers lack adequate knowledge if they do not update their skills accordingly [25,55,71], which further emphasises the need for continuous professional development [41,52,119].

In certain instances, teachers perceive technology as a barrier to moving forward and do not possess the required skills to handle the complexity of the technology [31,49]. Teachers should play a pivotal role as change agents in technological transformation, a

role that can be effectively executed with comprehensive knowledge. Specifically, teachers investigated in post-COVID research highlighted deficiencies in technological knowledge, skills, and expertise, thereby restricting them from defining themselves as technologically competent. Comparatively, teachers utilised in pre-COVID research rated as highly competent yet urged for more knowledge Findings of Mirete et al. and Pettersson [120,121] emphasised the importance of knowledge, skills, and expertise in exploring digital tools and integrating them in the pedagogy than its simple application in contextual needs. During the establishment of TPACK, Koehler and Mishra [122] discuss the importance of aligning content and pedagogical and technological knowledge for effective teaching with digital tools. According to Koehler and Mishra [122], greater convergence of the three concepts of content, pedagogy, and technology enables a comprehensive understanding of complex interactions among the three that fosters effective technology integration. Therefore, the lack of the required digital skills among teachers is a significant challenge for teachers to be confident and competent in their regular teaching and learning activities.

4.2.2. Restrictions on Common Application

The difference in the teacher's academic discipline can be a significant obstacle for academics since specific disciplines require different tools for subject-specific activities. The findings of Mercader and Gairín [123] has identified academic discipline as an influential factor in technology integration. Review results of Lai and Bower [123] confirm that most of the research on technology application in education focuses on science disciplines such as mathematics, physics, biology, chemistry, or engineering. Further technology application in language-related teaching is also common, and the least attention is given to social sciences such as business, economics, humanities, etc. [123]. Before the pandemic, there were discussions on using specific software for various academic disciplines. Alternatively, in post-COVID era, teachers started integrating common technology regardless of the academic field. However, such a practice may have led to issues in practical works (demonstrations) and limitations for student interaction and engagement [4]. These issues have driven teachers to trace back to the principles and understand the need for a potent blend of pedagogy and technology rather than being experts in handling technical devices [49,70]. The differences in the teaching and learning activities of different disciplines are a significant challenge limiting teachers' acceptance of technology in education [24,49,57,70,74].

4.2.3. Challenges in Students' Online Connectivity

Moakofhi et al. [57] showed a high preference among teachers for face-to-face communication over online communication since the teachers found difficulties in monitoring the student's active engagement in online classes. The feeling of disconnection between the student and the teacher has become a significant challenge for teachers, and most of the teachers expressed their concerns that they are clueless about what students do in online classes [46,65]. The situation worsened during COVID times due to students' disappearance or being silent listeners throughout the lesson. The teachers had to make extra effort to make them talk and interact [40]. Although the discussion forum is a popular means of communication, teachers do not achieve teaching satisfaction without active interaction with students [4]. Shah et al. [67] found that teachers perceive students as information seekers; therefore, teachers are responsible only for passing the subject knowledge via presentation slides or similar means.

Online delivery fails to stimulate student motivation for class engagement, as teachers tend to transpose the same content and instructional design employed in physical classrooms onto the online platform. These outcomes urge a teacher to be equipped with a proper design that motivates students to be active. Furthermore, Goradia [70] emphasises the necessity of introducing new educational technologies to enhance student engagement beyond what is already known to teachers. Easy distraction due to less monitoring and lack of individual, personalised attention given to students has disrupted their activeness in the classroom [39,40,46,65,66,70]. In addition, low engagement is partly due to a lack of

control and flexibility in joining online [46]. The COVID outbreak degraded the situation, and the absence of face-to-face delivery made teachers completely blindfolded about the class; teachers could not see how students reacted, resulting in difficulties in organising class activities [40,48]. The absence of direct connection with students has negatively impacted teachers, as they feel isolated when they speak on screens without any reaction from students [48], which makes them dissatisfied with online teaching.

Before COVID, technology was optional, and teachers were given the freedom to use technology when necessary. Students could communicate physically with the teachers, ensuring important facts were duly communicated between the two parties. Traditional teachers were unhappy about integrating ICT into teaching due to various aspects such as losing control, low engagement, ICT fear, etc. [124]. Unlike the pre-COVID context, during post-COVID, teachers and students got completely separated, and communication was only possible via technology, especially at the early stage of COVID [125]. However, students and teachers were unhappy with online communication due to disconnections and distractions during teaching and learning [126].

Cored Bandrés et al. [26] and Liesa-Orús et al. [32] confirmed that technology weakly influences the development of students' critical thinking abilities. In contrast, Saadé et al. [127] showed that students' critical thinking is nurtured outside of the class, and it is deeply supported via technology by allowing students to access worldwide information. However, Saadé et al. [127] emphasise the need for proper technological integration and course design to lead towards critical thinking. Moreover, there arises a question regarding the adequacy of the course design and assessment methods to evaluate students' critical thinking abilities effectively. The gaps in evaluating teaching and learning in the online setting directly impact academic integrity and quality. When an assessment is taking place at a distance, teachers cannot guarantee the integrity and the reliability of the work completed and suspect the possibility of cheating due to the presence of open space for students to seek external aid [36,40,57,66]. Thus, the necessity for appropriate pedagogical and technical innovations becomes evident in designing instructions and assessments while ensuring the quality outcome and fostering students' skills.

4.2.4. Cost of Using Technology and Its Features

Most innovative technological tools are commercially available at a cost with limited free access. The purchase costs of the tools discourage teachers from using them. Therefore, teachers mostly prefer freely available options or institution-supported services, as they are financially borne by the institute [29,64]. Before the pandemic, according to Hafifah and Sulistyo [38], teachers perceived that technology offered greater access to information, yet no personal involvement existed to acquire the required technology. During the post-COVID period, lack of home technology was a significant problem for teachers and students [60,65]. Though the internet paves the way for massive information and facilities, it will become unsuccessful if the teacher does not have the required permission, knowledge, and infrastructure to access them.

4.2.5. Lack of Infrastructure and Resources

Lack of internet facilities is the most significant infrastructure issue faced by teachers. The teachers have recognised the lack of internet in pre- and post-COVID periods [29,35,38,49–51,57,57,59,66]. However, insufficient computer labs and power outages have become significant challenges before the COVID outbreak [57]. The biggest concern during the post-COVID era was the unavailability of technology at home [54,73]. Further, teachers complained about the inadequate technical equipment during post-COVID, emphasising the limitation of the existing equipment for a successful and continuous online delivery [65].

4.2.6. Security Issues

Discussions about security threats associated with technology have persisted for an extended period, yet the prominence has escalated during the COVID pandemic [128,129]. Teachers are aware of the harmful consequences of technology [47]. Further, the internet allows students to misuse and access unsuitable content, such as gaming and violence [66,74]. Contrary to the harm it brings, the post-COVID research emphasises technology's security issues in terms of threats to privacy aspect [35]. Specific technological applications are activated with personal information, which can be quickly passed to unknown third parties. The same issue was seen in online data storage and communication due to hacking threats. Further, technological breakdown may result in a loss of data, which is another challenging security issue. Therefore, it is evident that the use of technology requires a significant investment in cybersecurity and policies as a precautionary measure for unethical behaviours. Hence, it is apparent that the utilization of technology demands substantial investments in cybersecurity and the formulation of policies as preventive measures against unethical conduct. In contrast to the pre-COVID era, the post-COVID period has intensified security demands due to the increased dependence on technology. Consequently, teachers expect a significant commitment from educational institutions in this regard.

4.2.7. Workload and Time Constraints

Time constraint is a common challenge for teachers. Irrespective of the COVID pandemic, teachers experienced and perceived that technology integration is time-consuming. Considerable time is required for teachers to learn and understand the use of the tool, and it discourages incorporating technology into their classroom activities [35,36,39,40,48,51,52,61,66]. In the studies before the pandemic, teachers claimed they were not interested in using technology in class due to limited time to deliver the lesson [41,50,52,66]. Thus, technology was a choice for them in the pre-COVID period [52], as the student and the teacher were physically meeting. However, teachers use technology-aided materials, assessments, and activities as supplement materials. The studies concluded the time constraint differently during the post-COVID period. According to teachers, shifting to online platforms added an extra workload [35,36,40,48,73]. The findings of Thumvichit [40], Wang [48], and Mohammad Freihat [36] specifically noted the teacher's lack of interest in exploring new technological features due to the time required in exploring and preparing.

Teachers generally accept that the technology integration should align with new designs, as the onsite traditional teaching plans and materials are incompatible with the technology [35,51,71]. Furthermore, Penjor et al. [51] emphasise the need to promote the connection between pedagogy and technology rather than simply embedding activities via technology. However, teachers were free to decide upon the level of technology integration prior to the pandemic. Due to the COVID, teachers have been forced to shift to digital platforms. They had to change the materials, contents, and teaching plans to make them suitable for online delivery, and these changes added extra workload, which consumed more time [35,54,61,73]. Due to a lack of familiarity, teachers had to spend considerable time practising new features [73]. Therefore, it is observed that the technology cannot be integrated with immediate notice and needs a reasonable timeframe for teachers to plan and learn. Otherwise, it will only be a replacement without successful diffusion.

4.2.8. Challenges Related to Institutional Involvement

Lack of institutional involvement in facilitating technology integrations is a common challenge teachers faced in pre- and post-COVID contexts. They have experienced insufficient facilities, infrastructure, and technical support [24,35,50,52,59,60,66,75]. The lack of policy in managing technology integration is another challenge teachers faced, and teachers expect the policy to be developed and monitored by the institution [45,75]. The benefits of having a policy can be discussed in two aspects: (1) To set targets for teachers to be digitally literate and promote technology integration in the curriculum [130] and (2) To ensure students' safety and appropriate behaviour and promote equal treatment [131].

Therefore, teachers perceive that the institution's ICT policy lacks conditions and guidelines to encourage them to grow with technology. In addition, organisation culture is regarded as a constraint in promoting technology in education [39,48,52]. The institute is responsible for creating a culture where teachers can openly discuss their competencies and needs and share knowledge. However, the institute has a significant role beyond purchasing technology and providing teacher training. The need for institutional involvement is intensified mainly in the post-COVID period.

4.3. Teachers' Expectations towards Successful Technology Integration

4.3.1. Institutional Support

Research in the pre-COVID era highlighted the need for institutional support in providing facilities such as tools, internet connection, and access to tools and training [15,28,38,47,51,53,55]. Few studies after the COVID pandemic reiterate the need to reinforce technology tools, resources, facilities, and access to those resources [31,64,72]. Institutional involvement in technical support is mainly discussed during the pre-COVID period [29,53,71]. Research studies after COVID emphasise the need for institutional focus towards exploring and introducing advancing technologies [64,68]. However, Mishra [50] and Ertem Akbaş and Çavuş [74] argued the need for cultural changes supporting more collaborations among faculty members and their professional development. Establishing a new learning culture is the central idea demanded by the teachers who participated in the studies after the COVID period [26,32,69,73]. Cote and Milliner [41], Tulia Ricardo-Barreto et al. [29], Ødegaard et al. [69], and Gong et al. [39] discussed the need for peer collaboration from the learning point of view, considering it as a facilitator for teachers to learn the use of technology. These actions were not the path taken during the quick adaption of online teaching during the pandemic. Teachers are now well aware of the importance of a collaborative culture rather than being self-centric and following individualistic best practices.

Before the COVID period, traditional teaching practices were abundant; technology integration requires more openness to the digital world and teaching practices are subject to rapid changes due to the frequent advancements in ICT. The dynamic nature of technology demands more collaborations, which create a better platform for sharing knowledge and being updated, requiring continuous development than one-time training or professional development initiatives [41,47,55,73]. Furthermore, to ensure continuous development, the institute must monitor and supervise technological integration performance [15,55]. Having related policies in place is a form of institutional support the teachers expect. They look for policies covering technology use to ensure effective use, teacher evaluation, motivation, and control of harmful effects and confirming appropriate behaviour in digital platforms [31,38,50,57,59].

4.3.2. Connecting Training, Pedagogy, and Academic Discipline

Training is a common requirement for improving teachers' digital competence. In the pre-COVID discussions, it was highlighted that teachers were mostly competent at handling technology. However, they demand formal training concerning technology integration [15,33,34,38,41,42,46,49,55,57,66,76]. Integrating technological tools across various disciplines was a significant challenge for teachers even during the pre-COVID period, emphasising the need to specify technological functions for particular subjects. Teachers demanded changes in the curriculum, creating more space to embed technical features [29]. Research studies after the COVID period presented a distinct view on training, highlighting the need to connect pedagogy and technological tools. Teachers do not demand basic training; they exclusively require training on specific technologies that can be integrated into the curriculum, supporting the pedagogy of delivering different subjects [32,39,44,64,68].

5. Conclusions

For education in the digital age, technology plays an indispensable role [7,8]. Consequently, the contemporary world is actively engaged in aligning various emerging tech-

nologies to enhance education and, as a result, improve student performance outcomes. A technologically blind teacher cannot guide their students to the light of technology. Hence, it is essential to pay greater attention to teachers regarding their technological proficiency to attain the desired outcomes in technology-integrated education.

Before the global pandemic, teachers perceived themselves as technologically competent and had massive, innovative plans for technology integration in education. However, the high demand for technology in education imposed in line with the pandemic lockdown has led teachers to experience new and escalated challenges in delivering their teaching, realising the reality is more complicated than expected. Teachers show reservations and insecurities in innovatively handling technology, and no evidence was found for corrective actions to change the teaching design format suitable for online delivery. This inability has left a question about the teachers' ability to innovate education with technology. Comparing the pre- and post-COVID period, no considerable enhancement is noticed concerning the use of technological tools in academic delivery. Despite institutions' investments in promoting technology, teachers rely on basic and common technological tools that only support minimal lecture delivery rather than accelerating students' engagement via innovative instructions and online activities [55,132,133]. Lack of skills, familiarity, infrastructure, cost, accessibility, disconnection, time restrictions, workload, and anxiety about technology are common features that limit technological integration irrespective of the COVID context. Across the period, positive attitudes and awareness of digital capabilities create a favourable environment for teachers to improve their digital and innovation skills. However, the attitude, desire, and availability of multiple tools become ineffective unless those are effectively embedded into the pedagogy.

Disconnection between the pedagogy and the technology is an obstacle highlighted during the post-COVID period compared to pre-COVID context. However, technology cannot be separated from pedagogy for successful technology-enhanced teaching [68,90,91,122]. It indicated being literate in aligning common technological options for specific academic disciplines. Irrespective of the context, no considerable acceleration of interest is observed among teachers in applying technology for discipline in social sciences, yet language teachers are significantly progressing with technological application in language teaching. During both pre- and post-COVID contexts, training for technology is a common demand made by teachers. In addition, technology is a changing aspect that demands teachers to focus on continuous development [134]. As teachers are less self-motivated to explore and update themselves, they expect significant institutional involvement in facilitating continuous professional development [4].

Further, teachers perceive that the institutions should bridge technology and teacher through policies and regulations, provide necessary infrastructure, and align the organisational culture towards technology integration to promote the institute's technology-enhanced teaching and learning environment. The comparison of the research work performed related to teachers' agency in technology during pre- and post-COVID context highlighted noticeable differences. Technology, being an optional addition during the pre-COVID period, led teachers to freely use technology without significant governance imposed on teachers' actions. However, the sudden change due to COVID has become an eye-opener for all the education stakeholders, specifically making teachers realise their actual competency and role in technological integration. Teachers discovered a range of difficulties after the COVID period in establishing their digital competence, and most importantly, teachers' inability to apply suitable technology in the appropriate context places a significant question about their digital literacy. In addition, institutional involvement is spotlighted towards upgrading and maintaining digital literacy. Therefore, future research work should be conducted to develop mechanisms and guidelines defining the institutional role in maintaining teachers' digital literacy to ensure successful technological integration in teaching and learning.

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