An Empirical Investigation of Taiwanese Teachers' Technological Pedagogical Content Knowledge in an Initiative to Adopt Digitization during Covid-19 Pandemic

DAHUI DONG, MENG-LIN CHEN
Department of Translation and Interpretation Studies
Chang Jung Christian University
No.1, Changda Rd., Gueiren District, Tainan City 711301
TAIWAN (ROC)

Abstract: - The COVID-19 pandemic presents a new opportunity to accelerate the integration of digital and information technology with the concept of technology teaching content knowledge (TPACK) in education. The Ministry of Education of Taiwan has introduced the digitization of humanities and social sciences (H&SS) courses since 2017, and 189 projects in three categories have been chosen and subsidized by 2022. This study coded and categorized the curriculum content of these projects in accordance with the TPACK framework and used data mining techniques to investigate the TPACK of teachers involved in the implementation of these subsidized digital H&SS courses. By counting technical knowledge (TK), content-knowledge (CK), and technology-content-pedagogy knowledge (TCPK) in digital H&SS courses, we show that before the pandemic, humanities courses emphasized digital technology content with pedagogy (TCP), pedagogy (P), and technology with content (TC), while during the pandemic they focused more on content (C). Social sciences courses shifted from stressing technological pedagogy (TP) and C before the pandemic to increased emphasis on TC during the pandemic. Overall, teachers prioritized P, TCP, and TC across disciplines. Additional findings include differences in TPACK focus between fields, thorough TPACK descriptions in social sciences courses, and emphasis on technology (T) in scientific methods courses both before and during the pandemic. Analysis of P, TC, and TCP topics revealed gaps in skills and technology-specific pedagogy, thus shedding light on the strategies for developing digital teaching competencies of university teachers and how to develop them. The study also provides recommendations for future implementation of digital H&SS programs.

Key-Words: - TPACK, Digital Humanities, Content Analysis, Data Mining, Covid-19, Online learning, Remote teaching, Educational technology

Received: July 25, 2022. Revised: June 8, 2023. Accepted: July 9, 2023. Published: August 11, 2023.

1 Introduction

Informatization and digitization in Taiwan are being translated into practice in a wide variety of ways with its impact being experienced by all spheres and levels of society including higher education, [1]. But unlike traditional technologies, the majority of digital technologies were not developed with education in mind. For instance, software like digital office and online communication, which are now more common in educational institutions, were initially designed for commercial use and are characterized by the convenience of use, instability, and opaque functionality. As a result, it can be challenging to apply commercial software applications in educational situations, and teachers frequently need to rethink when, how, and why to use them, [2].

In addition, the past three years or so have witnessed the large-scale implementation of Emergency Remote Teaching (ERT) in many countries because of Covid-19. However, implementing ERT has met a number of difficulties. In, [3], the authors found that online teaching requires the use of a strong instructional design and some preparation time and that in any format or situation (including online, distance, and hybrid), teachers are frequently unprepared to develop pedagogies that optimize the use of technology and thus require substantial assistance. Similarly in, [4], the authors discovered that due to a lack of technological resources and preparation time, many teachers reported having trouble accessing, maintaining, and analyzing materials for distant students during ERT. Scholars contend that in an era of tremendous development in hardware coverage, the primary cause for this problem is not hardware, but rather the necessity to successfully integrate digital technology with everyday teaching and learning in schools, and that instructors play a crucial role in this process, [5], [6]. It has been found that many teachers, particularly those in the H&SS fields, lack theoretical frameworks to guide them in this area, and the majority of training for teachers in digital technology skills has neglected the "redesign" ability to effectively integrate technology in authentic teaching and learning contexts, [7], [8], [9]. Although some studies on the implementation of ERT during the Covid-19 call for educational institutions to think about how to improve the relevance, applicability, and responsiveness of the curriculum to ensure the ability to continue to provide education in future disasters, epidemics, and crises, [10], [11], [12], few have looked at the development or adaption of teachers' TPACK in response to the pandemic.

This empirical study makes important contributions to the field of digital humanities. It provides much-needed evidence on how teachers are integrating technology in digital humanities courses, specifically their TPACK (technological pedagogical content knowledge), based on an analysis of a substantial dataset of 189-course syllabi across disciplines in Taiwan. The comparative analysis of TPACK focus before and during the COVID-19 pandemic offers timely insights into how digital humanities teaching is evolving and adapting in response to remote instruction. This study calls attention to gaps in digital pedagogy that need to be addressed through continuous teacher training and support in developing TPACK. It also expands the literature on technology integration in digital humanities, which has predominantly focused on STEM disciplines until now. By investigating TPACK theory and framework in the context of digital humanities, this study's findings have important implications for instructional design, teacher education, and advancing digital pedagogy in the field.

2 Literature Review

2.1 TPACK Theory

Based on Shulman's PCK concept, [13], in, [14], the authors proposed the Technological Pedagogical Content Knowledge (TPACK) framework, which consists of seven elements: Technology Knowledge (hereafter TK), Pedagogical Knowledge (PK), Content Knowledge (CK), Technological Pedagogical Content Knowledge (TPK), and Technological Content. In, [14], the authors note that if teachers are to use technology effectively for teaching and learning, they must have a clear understanding of where, how, and why information technology is integrated, and they must have a deep understanding of the relationship between IT technology, the subject content being taught, and the pedagogy. Later, in, [15], the author refined this framework using conceptual analysis, arguing that TPACK is the knowledge of the interaction between technology, pedagogy, and subject content in the context of instructional strategies and subject matter representations and that it requires teachers to know how to use emerging technologies to align subject matter activities with subject matter representations. Based on their own empirical research, [16], also explicitly critique from an epistemological standpoint the integrative view of TPACK (overlay view), which assumes that the growth of a certain type of knowledge base (technical knowledge, pedagogical knowledge, or content knowledge) occurs spontaneously; according to, [16], the authors view TPACK as a distinct form of knowledge that is derived from other knowledge bases and can be developed.

2.2 TPACK Studies in the Humanities and Social Sciences

The TPACK framework provides a theoretical foundation for research on the IT integration competencies of instructors. Since 2005, a great number of related studies in the field of educational technology have been published. Some studies have focused on the overall effectiveness of teachers' instructional programs as well as the development and changes in teachers' TPACK, as well as topics such as the measurement of instructors' TPACK levels and measurement instruments, [17], [18]. Numerous studies have used the TPACK theoretical framework as a guide to investigate why IT and topic integration should be undertaken in actual subject teaching in order to raise teachers' understanding of IT and curriculum integration in practice, [3], [4], [19], [20], [21], [22]. Through a follow-up study of 13 pre-service high school mathematics teachers who participated in teacher training activities, and were guided by the TPACK theoretical framework, according to, [22], the authors found that pre-service mathematics teachers could effectively apply interactive whiteboards in teaching mathematics courses and improve their TPACK knowledge.

Moreover, some researchers have investigated the developmental status of TPACK from the standpoint of TPACK when teachers employ information technology or digital technology in their actual teaching, [2], [23], [24], [25], [26], [27], [28]. In, [2], the authors, for instance, selected pre-service teachers for their study and asked them to complete three elementary school teaching tasks related to technology applications. They then pre-tested and post-tested the pre-service teachers who participated in the tasks using an open-ended questionnaire to determine changes in their TPACK knowledge levels. Their research revealed that these preservice teachers' use of teaching methods based on content-knowledge (CK) and general pedagogical knowledge (PK) grew dramatically, however teaching methods linked to general technical knowledge (TK) remained unchanged. According to, [29], [30], the authors conducted several case studies on the creation of TPACK in a professional development program for teachers learning to utilize spreadsheets in the classroom. In, [31], [32], [33], the authors reported that more case studies are ongoing to the present day.

Many H&SS TPACK studies have concentrated on teacher education and pre-service education, [31], [34], [35], [36]. Recent research has identified gaps in technical knowledge and digital literacy among humanities and social science teachers, including limited coding, data, and computational skills compared to those in technical fields, [37], [38], [39], [40]. In response to digital technology integration, it was determined that the traditional TPACK framework requires a complementary technology solution due to the limited time typically allocated to traditional teacher education programs and one-time ICT training sessions. Since traditional face-to-face learning experiences are found to be insufficient to provide sustained TPACK development for teachers or pre-service teachers, according to, [41], the authors constructed e-TPCK, a framework used by teacher educators and instructors for continual TPACK improvement in e-learning contexts. In, [23], the authors reported interesting research among the very few language-specific TPACK investigations. It looks at a case where an English as a Foreign Language (EFL) instructor used Telegram Bot in the classroom and demonstrates how the teacher's TK, PK, and CK were successfully transformed into a TPACK model using a homemade teaching software application. Although these studies offer new insights into the TPACK knowledge base of instructors teaching H&SS courses, they are all small-scale case studies, the results of which have not yet been sufficiently tested. This study evaluates the TPACK levels of teachers implementing digital technologies in a wide collection of courses; the findings will provide fresh insights for enhancing the TPACK levels of digital H&SS teachers.

According to, [42], the authors suggest that it may be more helpful to explore successful pedagogical approaches using accessible digital tools to inform teachers' search for effective ways to gain the knowledge and skills essential to making pedagogical judgments for technology-enhanced teaching and learning. In this study, we have employed a content analysis methodology to examine in depth the descriptions of curriculum design provided by instructors of successful digital H&SS courses in Taiwan with special attention paid to the practice before and during the Covid-19 pandemic. In, [43], [44], [45], the authors reported that other studies utilizing observations, surveys, and analysis of course materials have revealed the need to improve teacher digital literacy in emerging tech areas like programming, working with data, and computational tools. This study has addressed the following questions: What TPACK knowledge sets do Taiwanese teachers display in their instructional design process for digital H&SS courses, are there differences between the sets before and during the Covid-19 era, and do these knowledge sets vary by course type? The responses to these two questions can provide insights and recommendations for enhancing the TPACK level of teachers to create better digital H&SS courses as well as to ensure the ability to continue to provide education in future disasters, epidemics, and crises. This large-scale empirical analysis of 189 digital humanities courses helps fill the gap in understanding TPACK and technology integration specifically in the context of digital humanities instruction, extending the small-scale case studies that currently dominate the literature.

2.3 A Summary of the Digital Humanities Program in Taiwan

Taiwan has limited resources for the development of humanities and social sciences. In 2017, the Ministry of Education commissioned a national university, National Chengchi University, to set up the Digital Humanities and Social Sciences Teaching Resource Center, [46], to implement a MOE Talent Cultivation Project for digital humanities and social sciences. The Center serves as a resource provider to assist Taiwanese universities in developing their own distinctive digital humanities curricula and forming a community of educators. In the previous five years, more than 600 scholars and specialists have designed and stored a total of 189 digital humanities courses, in which at least 600 teachers and 12,000 students have participated. Because higher education in Taiwan faced Covid-19 in the latter 3 years of this project, as did higher education worldwide, these curricula provided us with a very good window to study the development of TPACK among teachers before and during the Covid-19 epidemic. The program is separated into five sub-projects: "Program Overview," "International Symposium (WEDHIA)," "Workshops and Presentations," "Big Data Student Competition," and "Special Course Interviews," and published on a single platform, [47]. Since this national project's information is in Chinese, it has received little international attention; therefore, one of the purposes of this study is to increase the visibility of these digitalized H&SS courses and provide the TPACK research community with useful information about their pedagogy.

In summary, the literature reveals several gaps and issues to be addressed. Prior TPACK research is predominantly based on small-scale qualitative studies, lacking large-scale empirical evidence. The context is largely limited to STEM classrooms, with minimal focus on digital humanities. And studies comparing TPACK focus before and after the adoption of remote teaching are scarce. This study aims to address these gaps by providing a robust quantitative analysis of TPACK knowledge and integration in digital humanities courses, analyzing a dataset of 189-course syllabi in the Taiwanese context before and during the Covid-19 pandemic.

3 Research Methods

The goal of this study was to determine what instructional design considerations instructors of digital H&SS courses prioritize. We analyzed the curriculum design of TCDH-funded programs using content analysis to establish which digital technology aspects were utilized in the curriculum development and how they were implemented. Currently, researchers employ two primary types of evaluation methodologies: quantitative methods such as self-assessment and qualitative methods such as classroom observation, interviews, and discourse analysis, [48]. In, [49], the authors employed a simple self-assessment scale to document the changes and development of instructors' TPACK during the implementation of the teacher education curriculum. In another study, according to, [8], the authors recorded instructors' talks in educational programs and categorized discourse statistics according to the TPACK framework, thereby demonstrating the process of teachers' TPACK level improvement. Since this study was conducted on a collection of digital humanities courses, which required the analysis of a vast amount of textual information, a content analysis approach of data mining was adopted.

3.1 Dataset

Our empirical research was focused on the TCDH resource center's funded digital H&SS courses. These courses spanned three categories: the humanities, the social sciences, and the natural sciences and methodologies. Between 2017 and 2021, the TCDH resource center funded 189 such courses. The courses were chosen by a team of specialists from the center and, as a result, represented reasonably advanced implementations of digital H&SS courses in Taiwan. We analyzed all 189-course syllabi to understand the TPACK characteristics of the instructors of these courses.

3.2 Instruments

In, [15], the study proposes that content analysis is a technique for drawing conclusions by carefully and objectively analyzing the distinctive characteristics of information. Typically, the textual content is unstructured, making it both time-consuming and challenging to extract significant information. However, tools such as QDA Miner and Wordstat are created expressly for analyzing textual information and permit the rigorous investigation of vast quantities of textual data. As the collected texts were in traditional Chinese, this study first used the CKIP word disambiguation system, [50], for word disambiguation. Then, we coded the course descriptions of these grant projects using QDA Miner. As shown in Table 1, we constructed the coding rules based on the TPACK idea outlined by, [14], with reference to research on TPACK concept refinement, [15]. Two researchers coded the data back-to-back into 7 categories: T, P, C, TP, TC, PC, and TPCN. When there was disagreement, the final coding results were determined by reaching a consensus.

Table 1. Coding Rules

Codes	Coding Description	Examples
C	Only H&SS knowledge is involved in the discourse content.	There are three ways to mine data.
P	The discourse content relates only to general pedagogical knowledge.	Let students understand the application of Python.
T	The course content description only involves digital information technology knowledge.	We will use PPT, and ...
TC	The course content description involves the connection and interaction between information technology (T) and subject knowledge (C).	We use sketch boards to draw an image.
TP	The course content description involves the connection and interaction between information technology (T) and pedagogical knowledge (P).	We added images to the introduction session to get students' attention.
CP	The course content description involves the connection and interaction between mathematical subject knowledge (C) and pedagogical knowledge (P).	We can use it in life.
TCP	The course content description involves the connection and interaction of subject knowledge (C), information technology knowledge (T), and pedagogical knowledge (P).	We can use drawing software in Mona Lisa

Table 2 shows the total number of codes and their percentages in all codes following our coding process, as well as the frequency and percentage with which each code appears in the course descriptions of all 189 courses.

Table 2. Summary of Codes

Code	**Count**	**% Codes**	**Cases**	**% Cases**
C	25	2.9%	22	11.6%
P	424	49.4%	158	83.6%
T	18	2.1%	15	7.9%
CP	16	1.9%	15	7.9%
TC	122	14.2%	99	52.4%
TP	20	2.3%	16	8.5%
TCP	233	27.2%	160	84.7%

All coded data were loaded into the application Wordstat, a content analysis tool, to develop subjects based on each code, i.e. C, P, T, CP, TC, TP, and TCP. Wordstat was used to examine the frequency of the words and phrases to produce meaningful subjects based on word co-occurrence analysis. The core computational logic runs like identifying the words that appear in the same article or sentence and then treating them as having the same topic. The greater the topic's normalized PMI value, the greater the co-occurrence of the word group in the topic. For instance, when "population" and "aging" appear frequently in the same sentence, it highlights the significance of population aging in that topic. The authors then went through a manual examination of thousands of words and phrases in the topics to ensure that words and phrases funneled into each topic were truly representative. Any question as to the use of a word or phrase was resolved by looking at that specific word in context. This process resulted in topics for each code that were believed to have fully captured the corresponding topic issue in concern.

4 Results

Figure 1 depicts the proportion of the seven TPACK descriptions that occurred in each of the three types of courses, with P and TCP accounting for approximately one-third of the total internal volume across all three categories. The proportions of the remaining four groups, C, T, CP, and TP, range from 1% to 6.8% of the total internal volume, respectively. This indicates that when discussing these courses, teachers of the three kinds of courses highlighted pedagogy (P) and integration of digital technology pedagogy (TCP) the most, followed by how to integrate digital technology with course content (TC). However, teachers provided less detail regarding the interaction between T, TP, C, and CP.

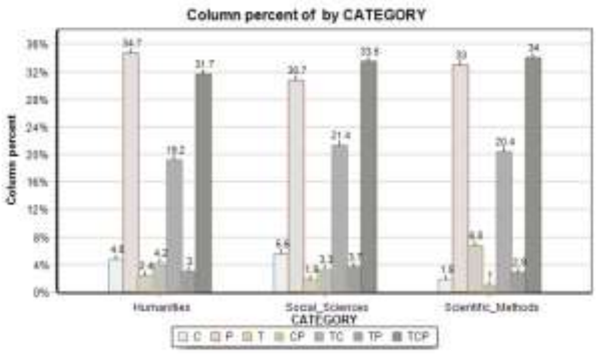

Fig. 1: TPACK by Field

Since teachers emphasized both P and TCP across the course categories, we conducted a series of chi-square tests of independence to investigate the relationships between the TPACK codes and course categories.

Table 3. P and TCP usage

Code	Chi-Square	p-value
P	19.18	0.000
C	2.95	0.229
T	4.75	0.093
CP	2.68	0.262
TC	0.88	0.645
TP	0.97	0.616
TPC	43.01	0.000

Our results indicate significant differences in the distribution of Pedagogical knowledge (P) and Technological, Pedagogical, and Content Knowledge (TPC) across the course categories (Table 3). Specifically, the chi-square statistic for the P code was 19.18, with a corresponding p-value of 0.00. For the TPC code, the chi-square statistic was 43.01, and the p-value was 0.00. Given these small p-values, we reject the null hypothesis of no association between the P and TPC codes and the course categories, suggesting a significant relationship.

However, for the remaining TPACK codes—C, T, CP, TC, and TP—the p-values were all greater than 0.05. This indicates a lack of evidence to suggest a significant association between these TPACK codes and the course categories.

Fig. 2: Crosstabulation Results

Figure 2 displays the results of the cross-tabulations of the various codes and the three categories of courses. The correspondence analysis shows that, among all the subsidized courses, the social science courses provide the most thorough descriptions of four of the seven TPACK components. The emphasis of the humanities courses and science methods courses was limited, to pedagogy and technologies respectively.

We divided these courses into two parts, pre-epidemic and mid-epidemic, using 2019 as the dividing line, as shown in Table 4. Then, we cross-tablulate the description of TPACK with course categories in these two parts of the courses separately, and the results are shown in Figure 3 and Figure 4.

Table 4. Number of courses subsidized before and during the Covid-19 pandemic

	Pre-Pandemic			During Pandemic		
	Humanities	Social_ Sciences	Scientific_ Methods	Humanities	Social_ Sciences	Scientific_ Methods
C	4	11	1	4	4	1
P	62	56	32	105	122	47
T	2	3	5	2	3	3
CP	3	1	0	4	7	1
TC	19	22	13	20	35	13
TP	5	8	2	1	3	1
TCP	22	15	10	62	91	33

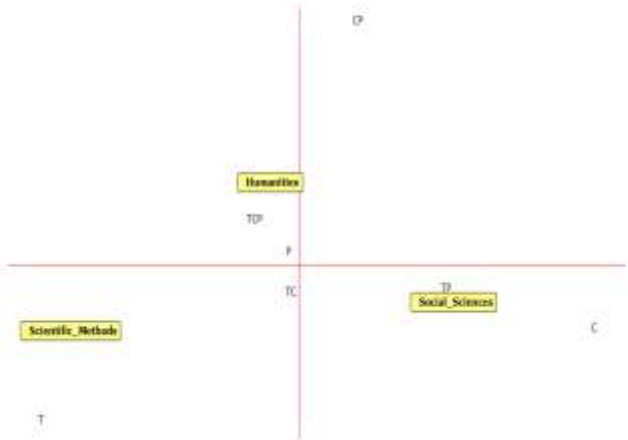

Fig. 3: Crosstabulation results before the Covid-19

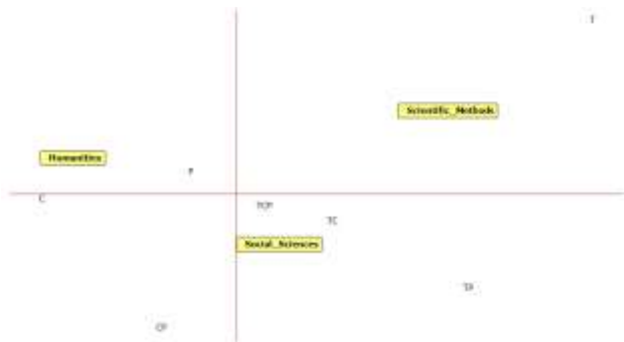

Fig. 4: Crosstabulation results during the Covid-19

Comparing Figure 3 and Figure 4, we can see that the descriptions of TPACK by teachers of humanities courses before the epidemic mainly emphasized TCP, P, and TC; while during the epidemic, their descriptions mainly focused on C. The descriptions of TPACK by teachers of social sciences courses before the epidemic emphasized more on TP and C before the epidemic; during the

epidemic, the description of TC was increased. The descriptions of TPACK by teachers of scientific methods courses basically did not change much, and before and during the epidemic, their courses always focused more on the technical aspects of T.
Based on the preceding steps, we then focused mainly on the 3 TPACK elements P, TC, and TCP, as they were most thoroughly described as shown in Figure 1. We investigated these 3 TPACK elements, identified common subjects inside each element, and then evaluated how these themes were described within each course category.

4.1 Pedagogy

Table 5 reveals that the majority of the 189 digital humanities and social sciences courses mention five pedagogical techniques. The keywords essentially depict the instructional approaches employed by teachers. Classroom Material, for instance, represents a more traditional form of teaching in which the teacher provides course materials and uses a guided approach in the classroom to enhance students' understanding of the humanities context. Cultivation Community means that teachers often take students into the community to develop their observational skills and assign them to read in order to deepen their understanding of the community. Brainstorm refers to the use of brainstorming to stimulate students' creativity and strengthen their thinking, including soliciting input from a panel of brainstorming experts, proposing topics, and guiding questions to stimulate creativity, with students elaborating on their ideas and the teacher organizing all ideas and encouraging discussion. Typically, the Problem-Solving method entails helping students define the problem, rewrite it, and assume responsibility for it; the teacher presents objective facts rather than personal viewpoints, allowing students to analyze them, investigate the root cause of the problem, and generate corresponding solutions through various brainstorming techniques. The instructor will also assist the students in analyzing the pros and cons of the potential solutions and selecting the best one. The instructor also examines and coordinates with the student the future steps to be taken to tackle the problem, as well as monitors the progress on a regular basis.

Table 5. Topics in Pedagogy

Topic	Keywords
Classroom Material	Classroom; Materials; Planning; Teaching; Analysis; Explaining;
Cultivation community	Cultivation; Community; Observation; Teaching; Reading;
Expert Invitation	Expert; Invitation; Research; Lecture; Professor; Achievement;
Brainstorm	agitation; brain power; industry division;
Problem Solving	problem; solution; caring; professional; orientation;

As we can see from Figure 5, the humanities course curricula are most frequently described as utilizing the Cultivation Community approach, followed by Brainstorming and Classroom Materials; the social sciences curricula are most frequently described as Problem Solving, followed by Brainstorming, Expert Invitation, and Classroom Materials. This demonstrates that in the process of digitizing H&SS courses, the classroom teaching tradition is maintained, but community and industrial elements are incorporated in place of the traditional emphasis on comprehension and memorization. In contrast to the conventional emphasis on comprehension and memorization, digital H&SS courses place a greater emphasis on analytical reasoning. These instructional strategies are seldom discussed in scientific methods curricula.

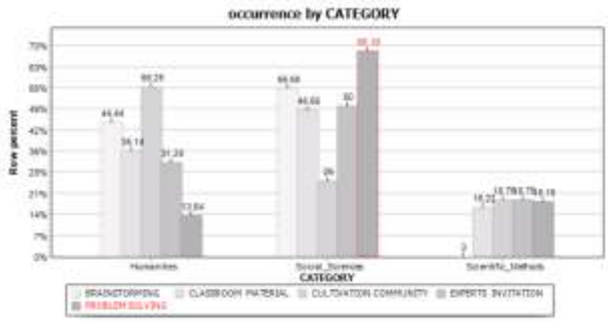

Fig. 5: Pedagogy Knowledge by Field

4.2 Technology and Content Pedagogy Knowledge

As shown in Table 6, this TPACK component is comprised of the following seven themes: Social Politics and Economics, Local, Robotics Fintech, Cross-Cultural, Enterprise, Automatic Artificial Intelligence, and Program Interactive Creation. It pertains to the pedagogy of digital information technology and material from the humanities and social sciences. These topics provide examples of typical digital and humanistic social themes that are more applicable and practical in the digital humanities curriculum being promoted by the Ministry of Education of Taiwan. Social Politics and Economics, for example, is self-explanatory, indicating that a large number of courses describe digital content in politics and economics. The keywords under each topic include verbs and nouns, with the verbs pertaining primarily to pedagogy and the nouns to pedagogical purposes, tools, etc. As part of the teaching process, the verbs under the topic Cross-Culture may indicate that the instructor leads students on learning tours, assigns them practical tasks, and teaches them about the culture.

Table 6. Topics in Technology and Content Pedagogy

Topic	Keywords
Social politics economics	Parliament; deepening; information technology; links; awareness; Practice; politics; In-depth; Community; Focus; Advanced; Theory; language; System; Actual; public opinion; utilization; elections; Data Science; Society; Experience; R; public opinion; Collection; Lead; elections; skills; Understanding; training; Research; Surveys; Projects; Information; literacy; Explore; studio; Advanced; Empirical; Theory; political science; Use; politics; management; Tools; architecture;
Local	Region; Literature; Logic; shooting; Transmission; digitalization; Context; Text; place; Schemes; stories; Strengthening; Problem solving; In-depth; Imagery; depth; Search; Development; Diversity; Humanities; issues; Establish; Think; knowledge; platform; Modules; unity; AR; Films; tourism; on the ground; sightseeing; modeling; Guided tours; ..app; collocation; interaction; Groups; production; Resources; formation; Teachers; Reporting; Culture; digital tools; platform; Games; Literature and history; Thoughts; works; Rendering;
Robotics fintech	Robots; fintech; Finance; Thoughts; Mode; Commercial; Import; innovation; Action; Thinking; Empirical; ..ai; Creativity; Development; Teaching; ..app; Explore; Social; Cases; Think; Smart; Encourage; technology; interface; Practitioners; Impact; Including; development; field; Understand;
Cross-culture	cross-cultural; VR; Virtual; Impact; Communication; era; Reality; Common; Space; Guided tours; participation; Understand; Teaching; Industry; digital humanities; Lead;
Enterprise	Enterprise; teachers; Industry; cooperation; Practitioners; Guidance; Special topics; Share; Case-by-case cases; Display; Huge amount of data; Information; links; grouping; discussion; Industry-university; Binding; Teaching; Practice; Results; advertising; brand; facebook; Consumers; promotion; Website; Media; Open; marketing; Operations; Activities; Community; Data; Instantaneous; Industry-university; Reporting; End of period
Automatic artificial intelligence	Automatic; artificial intelligence; Music; python; Specialists; programming language; Scholars; machine learning; AI; Principle; auxiliary; Introduction; Published; software; System; writing; Robots; geographic information;
Program interactive creation	Procedures; interaction; works; Design; training; Entities; units; picture books; Orientation; Journey; Operations; self-directed learning; form; Thinking; Creation; Games; Aesthetics; Theme; structure; Integration; Field; cross-cutting; skills; cross-domain;

Figure 6 demonstrates that all seven themes were present in all three-course types. The social sciences courses are the most comprehensive, with Cross-Culture being the least common topic at 38% and the rest exceeding 40%. The majority of descriptions for humanities courses focused on local topics, indicating that many digital H&SS courses favor the Local theme. Automatic Artificial Intelligence was the most frequently mentioned topic for digital courses in science methods, indicating a preference for integrating AI automation into the digitization process.

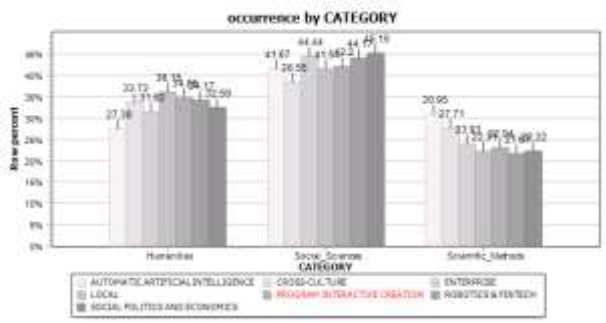

Fig. 6: Technology and Content Pedagogy Knowledge by Field

4.3 Technology and Content Knowledge

The content descriptions in this section of the course deal with the connections and interactions between digital information technology and subject knowledge, and there are seven themes (as shown in Table 6). As can be seen from Figure 7, the description of the TC content is similar to that of TCP, with almost half of the courses in sociology, followed by courses in humanities and courses in scientific methods.

This TPACK component focuses on the relationships and interactions between digital information technology and subject matter, and it contains seven themes (Table 7). As shown in Figure 7, the description of TC content is comparable to that of TCP, with over half of the courses in social sciences courses, followed by humanities and scientific methods courses.

Table 7. Topics in Technology and Content

Topic	Keywords
Politics economy media	Politics; Software; Nowadays; Era; Community; Combine; Media; Theory; Life; Information; Phenomenon; Immediate; Policy; Decision-making; Media; Value; Community; Society; Information; Analyse;
Humanistic literacy	Humanities; Field; Innovation; Knowledge; Society; Attainment; Multivariant; Mode; Culture; on the ground; Specialized; on the ground; Multivariant; Theory;
Industrial integration	Enterprise; Study; System; Marketing; Exploitation; Found; Analyse; Industry; Products; Operations; Target; Marketing; Serve; Exploitation; big data;
Ecosystem	Environment; Significance; Space; Life; Technology; Develop; Process; System; Society; History;
Cross-disciplinary	Cooperate; Ability; Attainment; cross-cutting; Process; Educate; Digit;
Traditional resources	Tradition; Resource; Technology; digital tools; Digit; Apply; Interaction; Develop;
Big data AI tools	Data; Artificial intelligence; Foundation; big data; Information;

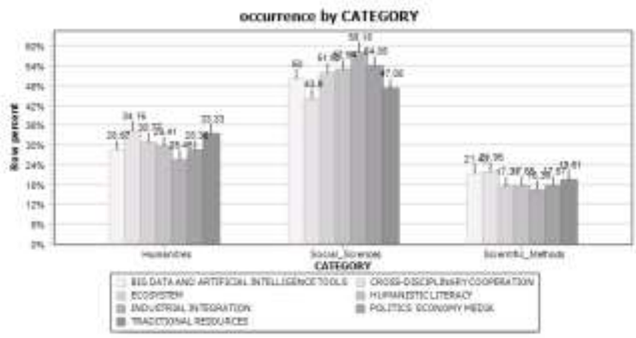

Fig. 7: Technology and Content Knowledge by Fields

Nearly half of all TC descriptions were from social sciences classes (Figure 7). In addition, the descriptions of the seven subjects varied significantly within each group, with the humanities courses comprising approximately 30%, the social sciences courses 50%, and the science methods courses comprising approximately 20%. These cross-group comparisons of TCs demonstrate that both faculty and program reviewers favor and emphasize TCs in course descriptions for digital H&SS courses.

To assess the association between the TC and TPC codes, we conducted a Chi-Square Test for Independence with Spearman Rank Correlation (Table 8). The results of the chi-square test for independence indicate a significant association between the presence or absence of the TC and TPC codes ($p < 0.001$). This suggests that the occurrence of these codes in the course categories is not independent. Furthermore, the Spearman rank correlation coefficient between the frequencies of TC and TPC codes is 1.00 ($p < 0.001$), indicating a perfect positive association. These findings provide evidence of a significant and strong positive association between the TC and TPC codes across course categories, indicating that as instructor focus on technology-content (TC) links increased, integration of technology-pedagogy-content (TPC) also rose proportionally.

Table 8. Association between the TC and TPC

Test	Statistic	p-value
Chi-Square Test for Independence	51.43	0.000
Spearman Rank Correlation	1.00	0.000

5 Discussion and Implication

The results of this study suggest that teachers of all three types of courses emphasized pedagogy (P) and the integration of digital technology pedagogy (TCP) and technology and content (TC) more than digital technology content (T), digital information technology pedagogy (TP), and subject content (C). Despite the fact that the compound element TC contains both T and C, which may partially explain why there is too little T, C, and TP content, the lack of T and TP reflects the fact that these digitization courses are primarily "applied" in nature, i.e. using a particular digital information technology instead of teaching the technology. This outcome is expected given that these courses are structured as 18-week units and that it is challenging for students from humanities and social sciences backgrounds to really learn digital technology in that time.

Additionally, the results of this study suggest that because the teachers also come from backgrounds in the humanities and social sciences, they might not be able to impart professional and technical knowledge to the students. Therefore, only a limited number of technologies at the application level may be thought of as being integrated into the curriculum during curriculum design. In line with this, previous studies have found that teachers in the humanities and social sciences often lack extensive formal training in new digital technologies, [37], [38], [40]. For example, they may have limited skills in coding, [45], working with large datasets, [37], [43], or computational analysis, [39], [44], compared to those in technical fields like computer science and engineering. This gap in technical knowledge can make it challenging for humanities and social science teachers to provide effective instruction on emerging technologies themselves, as reflected by the focus on application-level tools rather than deeper technology skills in the observed courses. Building digital literacy and technical pedagogical knowledge will require targeted professional development and training programs tailored to humanities and social science teachers' needs. Compared to previous small-scale TPACK studies, [23], [36], this large-scale quantitative analysis of 189 digital humanities course syllabi also provides new insights regarding technology integration practices, such as the finding that integrative knowledge like TCP and TC were emphasized substantially more than discrete technical skills like TK and TP. Our methodology enabled the investigation of nuanced differences in TPACK application across humanities, social sciences, and scientific methods courses on a scale not achievable through smaller qualitative studies. These insights advance understanding of critical knowledge gaps as well as current integration practices in digital humanities education.

In this study, we found that the emphasis on TPACK by humanities teachers before and after the epidemic was very different (Table 4 and Table 5). This may be due to the fact that before the epidemic, there were many digital technologies that could be implemented in humanities classes, but after the epidemic, all classes were taught online, and many of the previously implemented digital humanities courses reverted back to the learning of humanities content. For example, the field-based pedagogy presented in Table 6 is often used in humanities courses, but after the epidemic, many social restrictions prevented field-based and field-based instruction. In contrast, social science courses prior to the epidemic mostly emphasized some applications of technology that were likely to have little requirement for in situ themselves, so after the epidemic, teachers of social science subjects made a closer integration of these original technologies with the course content, and thus the discourse of concern in TCP and TC showed an increasing trend. For example, some of the T&C topics in Table 6, such as Integrating content with Automatic Artificial Intelligence are a form often seen in social science courses. learning of AI technologies can also be done online, so what teachers had to do after the epidemic was to reinforce the online content, which may explain why in Table 4 and Table 5 the differences in the descriptions of TPACK for social studies courses in Table 3 and Table 4. These findings advance the theoretical conceptualization of TPACK by providing empirical evidence of how humanities and social science teachers are applying TPACK principles in authentic educational contexts. For instance, the prevalence of TCP and TC alignments shows teachers are able to combine technical and content knowledge, while the lack of focus on TK and TP highlights room for improving technical pedagogical skills. Building on initial frameworks by [14], [16], our analysis reveals patterns in TPACK integration particularly in digital humanities.

Regarding the efficacy of digital humanities courses, instructional design in authentic teaching situations may be more helpful in increasing digital abilities among teachers. In this study, teachers were found to consciously consider "how to teach," i.e., focus on the PC, but rarely actively consider the potential impact and constraints of digitization on teaching and learning, and the predominant methods of utilizing digital technology were "presenting" and "showing." Therefore, teachers may need additional and diverse forms of continuous guidance and assistance in TPACK development. These may include self-questioning, brainstorming, and interactive communication, [51], [52], or case studies that show different types of learning activities, [49], [53], [54]. We believe that as teachers begin to intentionally focus on TC, TP, and TPC, their interpretation of the term "integration" will become more nuanced, and digital H&SS classroom instruction will undergo a substantial transformation.

The findings of this study revealed that the main components of the TPACK descriptions for teachers in these funded programs were educational technology competencies related to P, TCP, and TC, while other TPACK statements were minimal, with no more than 15% in each category of digital humanities courses. This indicates that instructors in these programs might not be fully cognizant of how very important T, TP, C, and CP are to TPACK abilities. Taiwan’s Ministry of Education and higher education institutions should improve the development of teachers’ educational technology abilities and boost teachers' awareness of TPACK. It is crucial to offer or implement supplemental courses that can improve teachers' educational technology competencies in order to fully facilitate the positive development of their TPACK competencies. This will allow teachers to learn and master digital educational technology while comprehending digital educational technology knowledge and skills.

TPACK is a vital theoretical framework for the development of teachers' educational technology competencies, [55]. TPACK knowledge offers high reliability and utility as a predictor of instructors' proficiency in the classroom, [56]. Therefore, we recommend that educational authorities and higher education institutions evaluate and measure teachers' TPACK competencies in the process of promoting digital H&SS courses, encourage teachers to achieve a deep understanding of the relationship between TK, CK, and PK, strengthen their TPACK awareness, and enhance their TPACK in specific teaching contexts competence. Furthermore, for administrators and policymakers, the results of this study illuminate critical gaps like a lack of discrete technical skills training and technology-specific pedagogy. Our identification of these specific under-developed knowledge areas provides guidance for improving teacher preparation and curriculum design through targeted TPACK training tailored to digital humanities disciplines, [40]. Addressing these gaps can better equip teachers to effectively leverage technology in humanities and social science teaching.

6 Conclusion

This study analyzed the TPACK integration practices of teachers in digital humanities, illuminating profound shifts in technology use that mirror transformations in education. Few studies have empirically examined TPACK competencies in digital humanities, particularly before and after the adoption of remote teaching modalities.

The extensive qualitative findings underscore an urgent need for humanities and social science teachers to substantially improve their TPACK skills if they are to leverage technology meaningfully. While instructors prioritized certain knowledge facets, truly comprehensive digital literacy in teaching remains distressingly elusive. Sustained, focused professional development is an absolute imperative to sufficiently empower educators in harnessing the new tools of the trade amidst the winds of change now sweeping through higher education. Educators require greater literacy in emerging technologies to fully capitalize on pedagogical innovation opportunities.

The TPACK framework offers a valuable compass for fundamentally enhancing technology integration opportunities in digital humanities classrooms. By focusing the lens on neglected competency areas like discrete technological knowledge and synergistic overlaps between technology and content, instructors can potentially transform traditional teaching approaches to engage digitally immersed students through deliberate, purposeful digital pedagogy. Academic institutions must commit to providing continuous, targeted TPACK training apposite to digital humanities exigencies and contexts, both existing and emergent.

This analysis provides an important baseline for policymakers and administrators to significantly inform teacher training requirements and curriculum design upgrades for forthcoming digital humanities programs, whether online, face-to-face, or blended. As the pandemic continues driving remote and hybrid instruction models, substantively developing educators' TPACK capabilities is essential to building truly resilient digital humanities paradigms for the future.

7 Limitations

TPACK represents a contemporary suite of pedagogical competencies, the genesis and evolution of which are deeply intertwined with context. While the portrayals of digital H&SS courses in this study underscore teaching both within and beyond the classroom, they fall short of providing comprehensive depictions of contextualized, hands-on environments. The cultivation of TPACK capabilities cannot be detached from the specific operational context. It is crucial to consider teachers' aptitude for applying educational technology within the backdrop of the information and digital age. This involves creating a conducive teaching environment (encompassing both physical classrooms and online spaces) for educators, and offering an open, immersive context for the application of educational technology when aiding teachers in enhancing their TPACK skills.

The journey toward developing and refining teachers' digital proficiencies is a complex and protracted one. This process is shaped and limited by a multitude of factors. Beyond the seven elements outlined in the TPACK framework, it may also encompass situational components such as classroom layout, pre-existing levels of students and instructors, equipment setup, and the educational philosophy of the school, [57], [58]. In the present study, which primarily concentrated on the seven TPACK components, these contextual factors were not taken into account. Future research that incorporates these situational elements into consideration will undoubtedly yield more intriguing results.

References:

[1] M. Niess, R. N. Ronau, S. O. Driskell, O. Kosheleva, D. Pugalee, and M. W. Weinhold, "Technological pedagogical content knowledge (TPCK): Preparation of mathematics teachers for 21st century teaching and learning," in *AMTE monograph series*, vol. 5, *Inquiry into mathematics teacher education*, F. Arbaugh and P. M. Taylor, Eds., San Diego, CA: Association of Mathematics Teacher Educators, 2008, pp. 143–156.

[2] C. Graham, J. Borup, and N. B. Smith, "Using TPACK as a framework to understand teacher candidates' technology integration decisions," *Journal of Computer Assisted Learning*, vol. 28, no. 6, pp. 530–546, 2012.

[3] F. Bulusan, E. M. Codamon-Dugyon, and J. J. M. Bolintao, "Exploring the challenges of tertiary students in non-laboratory courses after the first year of emergency remote teaching," *European Journal of Educational Research*, vol. 11, no. 1, pp. 481–492, 2022.

[4] T. Trust and J. Whalen, "Emergency remote teaching with technology during the COVID-19 pandemic: using the whole teacher lens to examine educator's experiences and insights," *Educational Media International*, vol. 58, no. 2, pp. 145–160, 2021.

[5] A. R. Srivastava, "Digitalization of higher education using cloud computing: Issues and challenges faced by teachers," in *Digitalization of Higher Education Using Cloud Computing: Implications, Risk, and Challenges*, S. L. Gupta, N. Kishor, N. Mishra, S. Mathur, and U. Gupta, Eds., Boca Raton: Chapman & Hall, 2021, pp. 55–70.

[6] A. Y. C. Hou, I.-J. G. Lu, and C. Hill, "What has been the impact of covid-19 on driving digitalization, innovation and crisis management of higher education and quality assurance? - A Taiwan case study in alignment with the INQAAHE virtual review," *Higher Education Policy*, vol. 35, no. 3, pp. 568–590, 2022.

[7] P. Mishra and M. Koehler, "Educational technology by design: Results from a survey assessing its effectiveness," in *Conference Proceedings*, 2005, pp. 1511–1517.

[8] M. Koehler, P. Mishra, and K. Yahya, "Tracing the development of teacher knowledge in a design seminar: Integrating content, pedagogy and technology," *Computers & Education*, vol. 49, no. 3, pp. 740–762, 2007.

[9] C. Graham, R. Culatta, M. Pratt, and R. West, "Redesigning the teacher education technology course to emphasize integration," *Computers in the Schools*, vol. 21, 1-2, pp. 127–148, 2004.

[10] M. Cahapay, "Navigating the post-COVID-19 era of 'Next Normal' in the context of Philippine higher education," *Asia-Pacific Journal of Educational Management Research*, pp. 57–64, 2021.

[11] J. A. Pacheco, "The "new normal" in education," *Prospects*, vol. 51, 1-3, pp. 3–14, 2021.

[12] J. Xiao, "Decoding new normal in education for the post-COVID-19 world: Beyond the digital solution," *Asian Journal of Distance Education*, vol. 16, no. 1, pp. 141–155, 2021.

[13] L. S. Shulman, "Those who understand: Knowledge growth in teaching," *Educational Researcher*, vol. 15, no. 2, pp. 4–14, 1986.

[14] P. Mishra and M. Koehler, "Technological pedagogical content knowledge: A framework for teacher knowledge," *Teachers College Record*, vol. 108, no. 6, pp. 1017–1054, 2006.

[15] S. M. Cox, "A Conceptual Analysis of Technological Pedagogical Content Knowledge," Doctoral Dissertation, Brigham Young University, Prove, UT, 2008.

[16] C. Angeli and N. Valanides, "Epistemological and methodological issues for the conceptualization, development, and assessment of ICT–TPCK: Advances in technological pedagogical content knowledge (TPCK)," *Computers & Education*, vol. 52, no. 1, pp. 154–168, 2009.

[17] G. Hulya and A. Karamete, "A short review of tpack for teacher education," *Educational Research and Reviews*, vol. 10, no. 7, pp. 777–789, 2015.

[18] W. Wang, D. Schmidt-Crawford, and Y. Jin, "Preservice teachers' TPACK development: A review of literature," *Journal of Digital Learning in Teacher Education*, vol. 34, no. 4, pp. 234–258, 2018.

[19] C. S. Chai, J. H. L. Koh, and C.-C. Tsai, "A review of technological pedagogical content knowledge," *Educational Technology & Society*, vol. 16, no. 2, pp. 31–51, 2013.

[20] M. Koehler, P. Mishra, K. Kereluik, T. S. Shin, and C. Graham, “The technological pedagogical content knowledge framework,” in *Handbook of Research on Educational Communications and Technology*, J. M. Spector, M. D. Merrill, J. Elen, and M. J. Bishop, Eds., New York, NY: Springer, 2014, pp. 101–111.

[21] M. Niess, “Transforming Teachers’ Knowledge: Learning Trajectories for Advancing Teacher Education for Teaching with Technology,” in *Technological Pedagogical Content Knowledge: Exploring, Developing, and Assessing TPCK*, C. Angeli and N. Valanides, Eds., New York, NY: Springer, 2015, pp. 19–37.

[22] K. Holmes, “Planning to teach with digital tools: Introducing the interactive whiteboard to pre-service secondary mathematics teachers,” *Australasian Journal of Educational Technology*, vol. 25, no. 3, 2009.

[23] L. Huang and S. P. Lajoie, “Process analysis of teachers’ self-regulated learning patterns in technological pedagogical content knowledge development,” *Computers & Education*, vol. 166, p. 104169, 2021.

[24] J. Kriek and A. Coetzee, “Development of a technology integrated intervention in tertiary education,” *Journal of Baltic Science Education*, vol. 15, no. 6, pp. 712–724, 2016, doi: 10.33225/jbse/16.15.712.

[25] J. G. Martin, “Exploring College Instructors’ Integration of Technology into Their Curricula,” Doctoral Thesis, College of Education, Walden University, Minneapolis, MN, 2016.

[26] C. Mouza, R. Nandakumar, S. Yilmaz Ozden, and R. Karchmer-Klein, “A longitudinal examination of preservice teachers’ technological pedagogical content knowledge in the context of undergraduate teacher education,” *Action in Teacher Education*, vol. 39, no. 2, pp. 153–171, 2017.

[27] V. H. Shinas, R. Karchmer-Klein, C. Mouza, S. Yilmaz-Ozden, and J. J. Glutting, “Analyzing preservice teachers’ technological pedagogical content knowledge development in the context of a multidimensional teacher preparation program,” *Journal of Digital Learning in Teacher Education*, vol. 31, no. 2, pp. 47–55, 2015.

[28] M. Phillips, “Re-contextualising TPACK: Exploring teachers’ (non-)use of digital technologies,” *Technology, Pedagogy and Education*, vol. 25, no. 5, pp. 555–571, 2016.

[29] M. Niess, “Developing teachers’ technological pedagogical content knowledge (TPCK) with spreadsheets,” San Antonio, Texas, USA, 2008.

[30] M. Niess, K. Lee, P. Sadri, and G. Suharwoto, “Guiding inservice mathematics teachers in developing a technology pedagogical knowledge (TPCK),” Orlando, Florida, 2006.

[31] S. K. Howard, J. Tondeur, J. Ma, and J. Yang, “What to teach? Strategies for developing digital competency in preservice teacher training,” *Computers & Education*, vol. 165, p. 104149, 2021.

[32] C. Mouza, “Developing and assessing TPACK among pre-service teachers: A synthesis of research,” in *Handbook of Technological Pedagogical Content Knowledge (TPACK) for Educators*, M. C. Herring, M. Koehler, and P. Mishra, Eds., 2nd ed., New York: Routledge, 2016, pp. 169–190.

[33] H. Yildiz and T. Gokcek, “The development process of a mathematic teacher’s technological pedagogical content knowledge,” *European Journal of Educational Research*, vol. 7, no. 1, pp. 9–29, 2018.

[34] S. Bibi and S. H. Khan, “TPACK in action: A study of a teacher educator’s thoughts when planning to use ICT,” *Australasian Journal of Educational Technology*, vol. 33, no. 4, pp. 70–87, 2015.

[35] S. Inpeng and S. Nomnian, “The use of facebook in a TEFL program based on the TPACK framework,” *Language Education and Acquisition Research Network*, vol. 13, no. 2, pp. 369–393, 2020.

[36] P. Pondee, P. Panjaburee, and N. Srisawasdi, “Preservice science teachers’ emerging pedagogy of mobile game integration: a tale of two cohorts improvement study,” *Research and Practice in Technology Enhanced Learning*, vol. 16, no. 1, pp. 1–27, 2021.

[37] T. Abid, G. Zahid, N. Shahid, and M. Bukhari, “Online teaching experience during the Covid-19 in Pakistan: Pedagogy–technology balance and student engagement,” *Fudan Journal of the Humanities and Social Sciences*, vol. 14, no. 3, pp. 367–391, 2021.

[38] G. Abrosimova, I. Kondrateva, E. Voronina, and N. Plotnikova, “Blended learning in university education,” *Humanities & Social Sciences Reviews*, vol. 7, no. 6, pp. 6–10, 2019, doi: 10.18510/hssr.2019.762.

[39] M.-T. Kaarakainen and L. Saikkonen, “Multilevel analysis of the educational use of technology: Quantity and versatility of digital

technology usage in Finnish basic education schools," *Journal of Computer Assisted Learning*, vol. 37, no. 4, pp. 953–965, 2021.

[40] R. I. Tursunovich, "Guidelines for designing effective language teaching materials," *American Journal of Research in Humanities and Social Sciences*, vol. 7, pp. 65–70, 2022.

[41] C. Angeli, N. Valanides, A. Mavroudi, A. Christodoulou, and K. Georgiou, "Introducing e-TPCK: An adaptive e-learning technology for the development of teachers' technological pedagogical content knowledge," in *Technological Pedagogical Content Knowledge: Exploring, Developing, and Assessing TPCK*, C. Angeli and N. Valanides, Eds., New York, NY: Springer, 2015, pp. 305–318.

[42] J. L. Sickel, "The great media debate and TPACK: A multidisciplinary examination of the role of technology in teaching and learning," *Journal of Research on Technology in Education*, vol. 51, no. 2, pp. 152–165, 2019.

[43] S. Hardhienata, Y. Suchyadi, and D. Wulandari, "Strengthening technological literacy in junior high school teachers in the industrial revolution era 4.0," *Journal of Humanities and Social Studies*, vol. 5, no. 3, pp. 330–335, 2021.

[44] A. Richard, "Effectiveness of ICT integration in Nigerian educational system," *Journal of Research in Humanities and Social Science*, vol. 9, no. 4, pp. 16–30, 2021.

[45] A. van der Walt, J. Steyn, A. Trusler, and M. van Zaanen, "Challenges and opportunities of digital humanities training in South Africa: Moving beyond the Silos," in *Digital research in the arts and humanities, Digital Humanities Workshops: Lessons Learned*, L. Estill and J. Guiliano, Eds., London, UK: Routledge, 2023, pp. 55–66.

[46] TCDH, *MOE Talent Cultivation Project for Digital Humanities.* [Online]. Available: http://www.dhcreate.nccu.edu.tw/

[47] TCDH, *MOE Talent Cultivation Project for Digital Humanities.* [Online]. Available: www.dhcreate.nccu.edu.tw (accessed: Sep. 1 2022).

[48] M. C. Herring, M. Koehler, and P. Mishra, Eds., *Handbook of Technological Pedagogical Content Knowledge (TPACK) for Educators*, 2nd ed. New York: Routledge, 2016.

[49] M. Koehler and P. Mishra, "What happens when teachers design educational technology? The development of technological pedagogical content knowledge," *Journal of Educational Computing Research*, vol. 32, no. 2, pp. 131–152, 2005.

[50] CKIP Lab, *CKIPTagger*. Taipei, Taiwan: Academia Sinica, 2020. [Online]. Available: https://github.com/ckiplab/ckiptagger

[51] E. Al Khotaba, "Interaction in e-learning setting through teaching English as foreign language by native-English teachers: e-classroom discourse," *Arab World English Journal*, SI, pp. 466–478, 2022, doi: 10.24093/awej/covid2.31.

[52] W. Gao, "Designing an interactive teaching model of English language using Internet of things," *Soft Computing*, vol. 26, 20, SI, pp. 10903–10913, 2022, doi: 10.1007/s00500-022-07156-y.

[53] J. Pan, "An online teaching design of oral English against COVID-19: an "ideological-and-political-theories-education-in-all-courses" perspective," *English Language Teaching*, vol. 14, no. 9, pp. 39–47, 2021.

[54] J. Ahmad, "Effectiveness of blended approach in teaching and learning of language skills in Saudi context: a case study," *English Language Teaching*, vol. 14, no. 11, pp. 118–127, 2021.

[55] C. S. Chai, J. H. L. Koh, and C.-C. Tsai, "Facilitating preservice teachers' development of technological, pedagogical, and content knowledge (TPACK)," *Educational Technology & Society*, vol. 13, no. 4, pp. 63–73, 2010.

[56] M. Koehler and P. Mishra, "Introducing TPCK," in *Handbook of Technological Pedagogical Content Knowledge (TPCK) for Educators*, AACTE Committee on Innovation and Technology, Ed., New York, NY: Routledge, 2008, pp. 3–29.

[57] M. J. C. Swallow and M. W. Olofson, "Contextual Understandings in the TPACK Framework," *Journal of Research on Technology in Education*, vol. 49, 3-4, pp. 228–244, 2017.

[58] J. M. Rosenberg and M. J. Koehler, "Context and technological pedagogical content knowledge (TPACK): A systematic review," *Journal of Research on Technology in Education*, vol. 47, no. 3, pp. 186–210, 2015.

Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

The authors equally contributed to the present research, at all stages from the formulation of the problem to the final findings and solution.

Sources of Funding for Research Presented in a Scientific Article or Scientific Article Itself

The research is funded by The National Science Council, Taiwan (ROC) (NSC 111-2410-H-309-007)

Conflict of Interest

The authors have no conflicts of interest to declare.