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Developing a TPACK-based Course to Promote the Pre-service Preschool Teachers' Instructional Design Competence

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Abstract

This study integrates the TPACK framework into a Preschool Language Education course to examine its effects on pre-service preschool teachers' instructional design competence (IDC). The research aims to explore effective methods for IDC development and analyze its growth characteristics.

Using an R&D methodology, this study employed an experimental design with an experimental group and a control group. Data were collected from 41 pre-service preschool teachers at Putian University, Fujian Province, China, through cluster sampling. The experimental group (n=21) participated in a 13-week TPACK-based course, while the control group (n=20) received traditional instruction. The IDC Scale and Lesson Plan Scoring Rubric were used for data collection. Data analysis included independent and paired t-tests, as well as assessments of lesson plan scores and grade distributions.

Key findings indicate that (1) the TPACK-based course encompasses course objectives, content, learning organization, and assessment, with all participants achieving satisfactory or higher lesson plan scores and a 95% satisfaction rate; (2) the course significantly enhances pre-service preschool teachers' IDC; and (3) at the early stage of professional development, IDC growth exhibits characteristics of simplification, linearity, and dogmatism.

Keywords: TPACK, pre-service preschool teachers, instructional design competence, early childhood education, course development

1. Introduction

Instructional design competence (IDC) is a fundamental skill for teachers, playing a crucial role in professional expertise and educational quality (Tuinamuana, 2011). Over the past two decades, professional development frameworks and standards worldwide, including in China (Liu & Liu, 2016; MOE, 2011), have emphasized IDC as an essential component of teacher preparation.

IDC is a core skill for teachers to effectively design, organize, and implement curricula. Instructional design principles have been applied in secondary and primary teaching practices till it was introduced into Mainland China in the 1980s, while little literature was found in early education. Teachers' IDC is especially critical in early childhood education, directly affecting the quality of children's learning and educational outcomes. In Chinese educational context, preschool teachers' IDC was initially overlooked, with preschool teachers as a caregiver role. However, with the release of the Kindergarten Education Guidelines and Guidelines for Learning and Development of Children Aged 3-6, a shift to an educator emphasis made instructional design competence a key indicator of teachers' professional quality.

Existing research indicates that there are still significant gaps in Chinese preschool teachers' IDC (Zheng, 2020). Some teachers rely mainly on traditional experience in their actual teaching, lacking systematic instructional design thinking and methods. In terms of using information technology, many teachers show weaknesses and struggle to effectively incorporate modern educational tools into curriculum design. As the future backbone of the preschool teaching workforce, the development of pre-service preschool teachers' IDC is essential for equipping them with the competencies needed for their professional careers.

Given these challenges, this research aims to construct a TPACK-based course to improve the pre-service preschool teachers' IDC. This study will contribute to the field by offering a feasible approach to cultivating

pre-service preschool teachers' IDC, namely through the integration of the TPACK framework in course design. This approach not only supports teachers' professional growth but also provides empirical evidence for promoting information-based teaching in preschool education. Future research could explore the applicability of this course in other subject areas and how to sustain the development of instructional design competence in actual teaching practice.

2. Literature Review

2.1 Curriculum Development

To develop a curriculum, people often have to follow certain procedures or models, among which the most basic approach is to divide the curriculum development into several links, that is, to determine the curriculum objectives, select the course content, organize the learning content, implement and evaluate the course. There are some basic modes of operation in curriculum development, mainly including the Objective Model, Process mode，and Situational mode. The Objective Model highlights the establishment of curriculum objectives as the foundational starting point for course development.

Components of curriculum development include the determination of the course objectives, selection of the curriculum content, organization of the curriculum content, implementation, and evaluation of the curriculum. Theoretically speaking, Tyler's Rationale serves as a foundational model for these steps. In this process, establishing curriculum objectives serves as the foundational step in curriculum development. It guides the selection and organization of knowledge, skills, and other student experiences as part of the course content, which is then structured according to specific principles. Next, the curriculum is implemented, transforming the curriculum plan into tangible learning outcomes. Finally, the curriculum is evaluated, primarily focusing on assessing student learning and the effectiveness of its implementation.

2.2 TPACK Framework

TPACK is an influential foundation theory for teaching with technology integration research. It evolved from Shulman's PCK model (1986, 1987), which is suggested to be the term for evaluation of teachers' teaching expertise (Shulman, 1986). From a teachers' knowledge perspective, Mishra and Koehler (2006) extended the PCK model by incorporating technological pedagogical knowledge. TPACK is the necessary knowledge for teachers to use technology for effective teaching. Here, the concept of effective contains three meanings: one is that the teacher should know the operation process of technology (what), but explain the reason for choosing a certain technology (why), and the third is how to use technology (how) in teaching. TPACK The frame structure consists of 7 elements, which are divided into 3 independent elements and 4 composite elements. As illustrated in Figure 1.

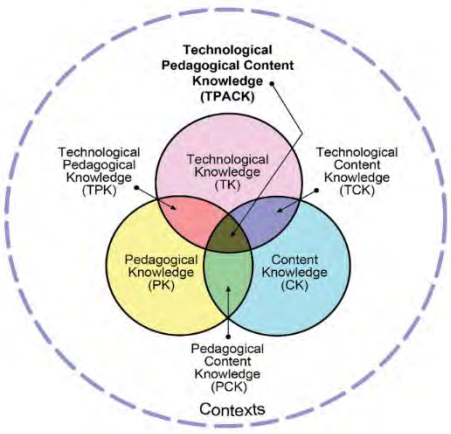

Figure 1. The TPACK framework

Source: http://tpack.org/

2.4 Research on IDC

2.4.1 Definition of IDC

Instructional design competence is defined as a multidimensional concept. Psychologically speaking, it is viewed as an individual psychological trait demonstrated in the process of completing a specific activity, serving as the

essential psychological condition for achieving such tasks（McClelland, 1973). In the context of human resources, competence is viewed as an integration of knowledge, skills, and attitudes within specific roles or work environments (Spencer & Spencer, 1993). In this study, instructional design competence is defined as the essential knowledge, skills, and attitudes that pre-service preschool teachers must acquire to effectively engage in instructional design tasks. To achieve this, teachers must have a solid grasp of preschool language education, educational technology, and pedagogical knowledge. Additionally, they should develop key skills, including objective setting, analysis of children's learning, instructional design analysis, selection of teaching strategies, media, and information technology, as well as evaluation and reflection. Finally, they need to cultivate a positive attitude toward understanding the significance and effectiveness of self-directed instructional design.

2.4.2 Measurements of IDC

Researchers have designed different evaluation methods for IDC development domestic and international, encompassing methods of self-assessment questionnaires based on theoretical frameworks, behavioral analysis, situational simulation, and outcome assessment.

Specific to the instructional design competence, the measurement could be conducted through the explicit behavior of teachers in the instructional practice context, include Ibstpi® instructional design ability set, self-reported IDC Scale, SLPAI (Science Lesson Plan Analysis Instrument), CTDES (Chemistry Teaching Design Evaluation Scale), literature coding method and the method of behavioral event interview. Researchers (Zhang, 2019; Wang, 2022) constructed a rural teacher teaching design ability inspection model by using the literature coding method and the method of behavioral event interview.

In this research, mixed methods were adopted to measure the pre-service teachers' instructional design competence. Highlighted for its convenience, quickness, comprehensiveness, and long-turn tracking, self-assessment and instructional design products will be combined to assess the IDC. We combined a self-reported IDC Scale and lesson plan scoring method of the instructional design products to evaluate the pre-service preschool teachers' IDC.

2.4.3 Development Strategies

The existing research has summarized several strategies for teachers' instructional design competence. Teachers can enhance their instructional design competence by participating in professional training programs that offer both theoretical knowledge and practical skills. Garet et al. (2001) emphasized that the effectiveness of professional development depends on the relevance of the training content and its applicability in teaching. Additionally, Desimone (2009) argued that training programs tailored to real teaching contexts, coupled with ongoing support, can significantly improve teachers' instructional design competence.

2.4.4 TPACK and Teachers' IDC

The TPACK framework serves as a systematic tool for enhancing teachers' instructional design competence by emphasizing the seamless integration of technology, pedagogy, and content knowledge. Through TPACK-oriented training and practice, teachers can deepen their understanding of technology's role in instructional design and continuously refine their skills through reflection and assessment. However, within the Chinese context, the application of the TPACK framework in preschool education remains in its infancy. Research exploring how this framework can effectively enhance the instructional design competence of preschool teachers particularly pre-service preschool teachers is scarce. Few studies have focused on developing and improving the instructional design competence of this group, leaving a significant gap in the literature.

Preschool Language Education is one of the five core professional courses in the preschool education program. It aims to help pre-service preschool teachers understand the principles and methods of language education for early children while mastering the design and organization of five common types of language education activities: conversation activities, narrative activities, listening and speaking games, early reading activities, and literary activities.

Based on existing research, this study integrated the TPACK framework into the Preschool Language Education course to explore the development of pre-service preschool teachers' IDC. Due to class time constraints, the teaching experiment focuses on three types of activities: conversation, narrative, and literary activities. Accordingly, the research questions are as follows:

RQ1: What are the components of a TPACK-based course designed to promote pre-service preschool teachers' IDC?

RQ2: What is the effect of the TPACK-based course on enhancing pre-service preschool teachers' IDC?

RQ3: What are the characteristics of pre-service preschool teachers' IDC growth?

3. Method

3.1 Research Design

This study employed a Research and Development (R&D) approach to implement a TPACK-based curriculum aimed at enhancing the instructional design competence of pre-service preschool teachers. The growth of teachers was assessed through pre- and post-testing. An experimental group and a control group were established to compare the differences between the two and evaluate the effectiveness of the TPACK course. The experimental group participated in the TPACK course developed for this study, while the control group engaged in a traditional course that covered only preschool language content. The main differences between the two lay in their course content and implementation. The TPACK course included instructional design case analysis and reflection based on the TPACK framework, while the traditional course focused solely on preschool language education. Although traditional courses also addressed design theory and practice, it didn't integrate TPACK theory or involve TPACK-based analysis and reflection. By utilizing the TPACK framework, pre-service preschool teachers gained a deeper understanding of the principles and applications of instructional design, thereby improving their instructional design practices. The study anticipates that pre-service teachers in the TPACK course will demonstrate stronger instructional design competence compared to their peers in traditional courses, which will be validated through pre- and post-assessments. Additionally, the study will analyze instructional design products to explore the developmental characteristics of pre-service teachers' instructional design competence. The study design is illustrated in Figure 2.

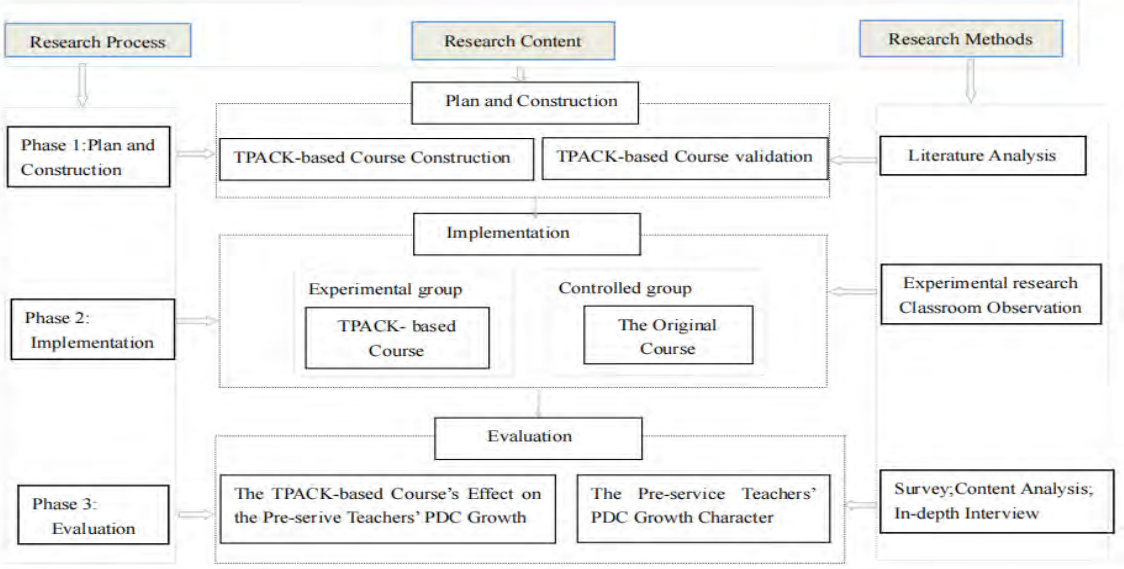

Figure 2. Research design

3.2 Participants

To implement the TPACK framework course, we recruited a total of 41 pre-service preschool teachers from the 2022 cohort majoring in preschool education at Putian University using cluster sampling. Among them, 21 participants were assigned to the experimental group, while 20 were designated as the control group, selected through random sampling. These participants had just completed the foundational courses in preschool education and had not yet taken any instructional design courses, nor did they possess any prior experience in instructional design.

3.3 Measurement

This study utilized three measurement methods to achieve its research objectives. First, the validity of the constructed TPACK-based course was assessed using the Item Objective Congruence (IOC) method to evaluate its quality. Second, the IDC scale was employed to measure the instructional design competence of pre-service preschool teachers, investigating the curriculum's impact on their development. Finally, the Lesson Plan Scoring Rubric was applied to evaluate the growth of instructional design competence, providing insights into the developmental characteristics of pre-service teachers' instructional design competence.

3.3.1 IOC

IOC is a commonly used index to evaluate the validity of items in tests or questionnaires. It is primarily used to measure the congruence between items and target content, and it is widely applied in educational measurement and questionnaire design.

In this study, IOC was used to measure the congruence between the TPACK-based course and the pre-service preschool teachers' IDC development. A total of 5 experts in the relevant field were invited to rate the relevance of the 4 items to the course. The rating criteria are:

1: Highly relevant to the objective

0: Uncertain or cannot judge

-1: Not relevant to the objective

The calculation formula is:

$$IOC = \frac{Number\ of\ "1"\ ratings - Number\ of\ "-1"\ ratings}{\text{Total number of exeprts}}$$

The total IOC was the average score of the IOC of course objective, course content, learning organization, and course assessment.

3.3.2 IDC Scale

The Instructional Design Competence (IDC) Scale for pre-service preschool teachers was developed by adapting the IDC scale originally designed for physics teachers (Guan, 2023). In this adaptation, subject-specific knowledge related to physics was replaced with domain knowledge pertinent to early childhood language, making the IDC measurement suitable for pre-service preschool teachers. The IDC scale encompasses three dimensions: instructional design knowledge, instructional design skills, and instructional design attitude. It consists of 36 items, with 10 items focusing on instructional design knowledge, 20 items measuring instructional design skills, and 6 items assessing instructional design attitude. A five-point Likert scale is used to rate the IDC, where respondents indicate their level of agreement with each statement. The scores for each question are summed and divided by the total number of respondents to determine the overall tendency for that question. The scores for all questions are then summed and divided by the number of questions to calculate an overall average score for each dimension, which reflects the pre-service preschool teachers' IDC level. A higher score indicates a better level of IDC.

In this study, the overall Cronbach's Alpha coefficient of the scale was 0.984. The Cronbach's Alpha values for the dimensions of instructional design knowledge, instructional design skills, and instructional design attitude were 0.968, 0.982, and 0.857, respectively, indicating that the scale demonstrates high internal consistency.

3.3.3 Lesson Plan Scoring Rubric

A scoring rubric for activity design plans will be developed by experts to assess design outcomes. This rubric was created by two specialists based on the definitions of instructional design competence and activity design plans. It includes six components: Activity Title Making (ATM), Objective Making (OM), Content Analyzing (CA), Learner Analyzing (LA), Strategies, Resource, and Media Selection (SRMS), and Teaching Events Arrangement (TEA). Each component will contain several subcategories, with each subcategory featuring multiple indicators corresponding to different score levels. The scoring for each component is as follows: ATM = 8, OM = 12, CA = 8, LA = 8, SRMS = 12, and TEA = 52, resulting in a total score of 100 for an activity design plan.

To ensure the validity of the scoring rubric, ten draft activity design plans were pilot-tested by two preschool language educators, and their feedback was used to refine the performance levels and definitions of each criterion until the rubric reached an acceptable standard. To ensure reliability in scoring, we invited two raters with ten years of experience in preschool language education to evaluate the pre-service preschool teachers' activity design plans. They engaged in thorough discussions about the plans and reached a consensus on the assessments. The inter-rater reliability was calculated using Spearman's rank correlation coefficient, yielding a value of 0.964, which is significant at the 0.01 level.

3.4 Data Collections

3.4.1 Data of IOC

The researcher provided the constructed TPACK course objectives, content, learning organization, and

evaluation materials to five experts. The experts were instructed to assess the effectiveness of the course in enhancing the teaching design abilities of pre-service early childhood teachers. Following the scoring criteria, they rated each item as relevant, uncertain, or irrelevant. The researcher compiled the scores provided by the five experts and calculated the ratings using the specified formula.

3.4.2 Data of IDC

The questionnaire method was used to investigate the pre-service preschool teachers' IDC by IDC scale. The researcher released the IDC questionnaire in the Wenjuan Xing online, and the participants were requested to fill it out before and after the course implementation both from the experimental group and control group.

3.4.3 Data of Lesson Plan

During the 3 cycles of iterative design practice, the pre-service preschool teachers' lesson plans were also collected by the researcher for further analysis. Each round of teaching practice consisted of an initial instructional design plan and a revised version. After each session on instructional design concepts, each group developed an original plan based on the knowledge acquired. Following feedback from instructors and peers, the groups refined their plans to produce revised instructional designs. The educator then assessed both the original and revised plans using the instructional design scoring rubric. Six compositions of the course plan were scored according to the framework, and the total score was accumulated. The scoring of the lesson plans was computed according to the Lesson plan Scoring Rubric.

3.5 Data Analysis

From a quantitative research perspective, the IDC data were analyzed by independent T-test of the control group and experimental group, paired sampling test of the experimental pre-test and post-test. So the mean, standard deviation, independent T, and paired sampling T were analyzed finally, to evaluate the effect of a TPACK-based course on the pre-service teachers' IDC development.

The scoring of lesson plans was analyzed by average score, and the number of ranking levels (poor, fair, good, very good, and excellent) according to the points. Points below 60 were classified as poor, 60-70 as fair, 70-80 as good, 80-90 as very good, and above 90 as excellent. The number of good and above grades was counted.

4. Results

4.1 Developing of TPACK-based Course

4.1.1 Draft of TPACK-based Course

Based on the existing literature, to improve the pre-service preschool teachers' IDC, the research employed a TPACK framework for a preschool language education course and emphasized a full analysis of the design components and iterative design practice during the course. The TPACK-based course includes the course objective, course content, learning organization, and course assessment.

Course objective To master the principles and the basic concepts of Preschool Language Education and scientifically design and implement preschool language education activities.

Course content The course content includes two modules of basic theoretical learning of preschool children's language education and design practice. The basic theory of preschool language education includes the basic concept of Preschool Language Education, language education activities, content, method and TPACK application in teaching design, and design practice of learning includes three specific types of language instructional design and guidance, namely Conversation activities, Narrative activities, Literary activities design, and guidance. The details of TPACK-based course content is shown in Table 1.

Table 1. TPACK-based course contents and objectives

Unit	Course content	Objective
1	The essence of language and children's language learning	To understand the basic concepts of language education for preschool children
2	The objective, content, principle, and method of preschool children's language education	To understand the basic concepts of preschool language activity design
3	TPACK theory introduction	To understand the TPACK theoretical framework, relationship with teacher professional growth, and application in instructional design
4	Design principles of the conversation activity	To learn the conversation activity design concepts
4.1	Practise of Conversation activity design	To design the Conversation activity *I Have Grown Up or I Came to Kindergarten*
4.2	Micro-teaching of conversation activity design	To Implement the conversation activity *I Have Grown Up Or I Came to Kindergarten*
5	Narrative activity design principles	To learn the narrative activity design concepts
5.1	Practice of narrative activity design	To design the narrative activity *Two Cats Fight for a Fish*
5.2	Micro-teaching of narrative activity	To Implement the narrative activity *Two Cats Fight for a Fish*
6	Literature activity design principles	To learn the literature activity
6.1	Practice of literature activity design	To design the literature activity A *Monkey Sells a Ring; Falling Leaves; The Barber's Adventure*
6.2	Micro-teaching of literature activity	To Implement the literature activity A *Monkey Sells a Ring or Falling Leaves or The Barber's Adventure*

Learning management The learning organization is divided into two parts, the theoretical learning part(1-3 units) and the practical part(4-6 units). Theoretical learning is taught by online learning and teacher educators, and the learning result is assessed through a quiz. The practical part includes the design practice of three types of language activities. The conversation activities, the narrative activities and the literary activities will be selected for iterative design.

Theoretical teaching In this part, pre-service preschool teachers should master the discipline of preschool children's language education, and understand the concept, goal, content, and methods of preschool children's education, they are demanded to master the theoretical knowledge of language education for preschool children. Educators will upload the learning content (course syllabus, teaching video, and quiz) to the Chaoxing Platform in advance, and the educator will release the learning content and learning task before class. The pre-service preschool teachers are demanded to preview the content. The educator will conduct the classroom teaching and use an online quiz to evaluate the learning effects.

Practical training In the instructional design for the experimental group, we adhered to the core elements of the TPACK framework: teaching content, pedagogical methods, and teaching technology. The process involved analyzing specific types of teaching video cases and instructional design components, emphasizing feedback and revision. The instructional design practice was completed through three iterative cycles. The practical training followed a structured design process, including Design principles instruction, TPACK analysis of teaching videos, TPACK analysis of activity design , activity design, feedback and revision, micro-teaching, feedback, further revision, and reflection. This cycle was repeated iterative, as illustrated in Figure 3.

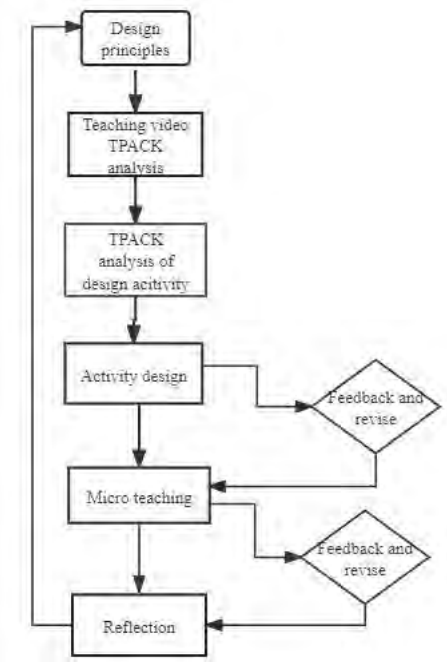

Figure 3. Practical training process of the iterative design

Course assessment The learning outcome was utilized to comprehensively assess the course. Experts were invited to evaluate instructional design products, where experts assess the components of design lesson plans, such as objectives making, content analysis, methods selection, and so on. The advantage of this approach lies in its ability to deeply analyze the process of instructional design, emphasizing the integration of theory and practice, and providing constructive feedback for enhancing teaching skills.

4.1.2 Result of the IOC Test

IOC test was adopted to ensure the quality of the construction course. Five experts from the field of curriculum development, instructional design, and education technology were requested to evaluate the appropriateness of constructing PACK-based to the pre-service preschool teachers' IDC development. Course objectives, course content, learning organization, and course assessment were scored separately in an IOC test. The details are as follows:

Table 2. Results of the IOC test

Item	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Average score
Course objective	1	1	1	1	0	0.8
Course content	1	1	0	1	1	0.8
Learning organization	1	1	1	1	1	1
Course assessment	1	1	1	1	1	1
Total average	0.9					

Generally, an IOC value of ≥ 0.5 is considered acceptable for an item to be valid. The total IOC average score of the test was 0.9 in this study, which showed that the course had a good structure and quality, suitable for promoting the preservice teachers' IDC.

4.2 The Effect of the TPACK-based Course on the Pre-service Preschool Teachers' IDC Improvement

Table 3. Descriptive Analysis of the Pre-test and Post-Test

	Experimental class(n=21)		Control class(n=20)		Independent T Test	
Indicator	$\bar{X}$	S.D.	$\bar{X}$	S.D.	T	P
Pre-test IDC	3.7950	0.51276	3.8090	3.8090	-0.099	-0.099
Post-test IDC	4.2950	.45884	3.9350	.47424	38.732**	0.018

Note:**<0.01

As Table 3 shows, the IDC mean of the pre-test of the experimental class and control class were 3.7950 and 3.8090, the T showed no significance, while the post-test of both classes were 4. 2950 and 3. 9350 separately, and a P value of 0. 018 of the independent T-test. Data shows that in the pre-test both classes were homogeneous. After the implementation of the TPACK-based course, both groups' average scores of IDC have been improved, and the difference between the two is significant. To get a further understanding of the effect of the TPACK-based course to the pre-service preschool teachers' IDC improvement, a paired T-test is conducted, and the details are shown in Table 4.

Table 4. Paired sample test of experimental class

Test	Pre-test $\bar{X}$	Post-test $\bar{X}$	$\bar{X}$	S.D.	T
Paired test	3.795	4.2950	-.50048	.44276	-5.180**

Note:**<0.01

The significance of the correlation of the pair is a prerequisite for performing paired sample tests. Table 4 shows for both groups, the correlation between the pair of both groups was significant. The paired-sample test significance for the experimental group was 0.000, which was extremely significant. It demonstrates that the TPACK-based course has a very significant result in improving the instructional design competence of pre-service preschool teachers, and the effect is better than the control one.

4.3 The Character of the Pre-service Preschool Teachers' IDC Improvement

4.3.1 A Steady Growth, Yet High Scores Remain Elusive

In the iterative design process, each group collaborated to create a design lesson plan. Pre-service preschool teachers designed five initial drafts based on their concepts after learning in class and then revised them based on feedback from teachers and peers, resulting in five revised versions. Table 5 showes the mean and grade number of each round's lesson plans.

Table 5. The Score and grade number of Each Round' Lesson Plan

		Mean	S.D.	Poor	fair	good	Very good	excellent
Round 1 n=5	Original	58.2	9.284	3	2	0	0	0
	revised	74.6	8.234	0	1	2	2	0
Round 2 n=5	Original	67.6	5.595	0	3	2	0	0
	revised	75.6	4.336	0	0	4	1	0
Round 3 n=5	Original	76.6	5.639	0	2	2	1	0
	revised	79.4	3.715	0	0	2	3	0

As shown in Table 5, in the teaching design of conversation activities, narrative activities, and literary activities, the original average scores of the instructional design products were 58.2, 67.6, and 79.4, respectively. The revised average scores were 74.6, 75.6, and 79.4, respectively. Points below 60 were classified as poor, 60-70 as fair, 70-80 as good, 80-90 as very good, and above 90 as excellent. In the first round of original designs, there were no instructional design products with a good grade, while in the second round, there were 2. By the last round of design practice, all 5 products were rated as good or above. The instructional design of pre-service preschool teachers improved with each round of teaching design. After receiving feedback from teachers and peers, the instructional designs in the second and third rounds all achieved a grade of good or above. However, both the original and the revised manuscripts received no excellent grades.

In a word, the data indicate that pre-service preschool teachers' instructional design competence shows steady growth during the course of their studies, yet high scores still remain elusive.

4.3.2 The Distinct Focal Points in Each Round

Further analysis from the instructional design products and the course plans of pre-service preschool teachers from each of the three iterative design cycles were analyzed, revealing distinct focal points in each round.

In the first round of instructional design, the primary focus was on ensuring the completeness and correctness of the instructional design format, such as whether activity names were complete and accurate. During this phase, some pre-service preschool teachers omitted certain elements, such as failing to specify the age group in the activity name, not adhering to the steps required for conversation activity design, or neglecting to use key terms associated with conversation activities in their descriptions. These issues were resolved after feedback and revisions.

In the second round of instructional design, attention shifted to the effectiveness of the instructional content and strategies, as well as the determination of teaching objectives, key points, and potential difficulties. By the end of the first two rounds, pre-service preschool teachers had grasped the basics of instructional design. Subsequently, the focus shifted to the application of technology in teaching—specifically, how to use tools like PowerPoint, videos, or audio resources to better represent instructional content and achieve more effective teaching outcomes.

In the three rounds of instructional design practice, the instructional design competence of pre-service preschool teachers has been significantly improved, but it is still difficult to get an excellent level overall, and continuous professional learning and long-term practice are still needed.

From the change of the focus of the three rounds of instructional design practice, it can be seen that the growth of the instructional design competence of pre-service preschool teachers shows the characteristics of simplicity and framework, which confirms Harder's (2006) summary of simplification, linear, dogma of instructional design competence of novice teachers.

5. Conclusion

5.1 TPACK-based Course Components

This study combined the TPACK framework with the preschool language education course and constructed the TPACK-based course, which includes four parts: course objectives, course content, learning organization, and course assessment, aiming to improve the pre-service preschool teachers' IDC. The course was evaluated by the expert IOC with a validity of 0.91, indicating that the course is suitable for improving the pre-service preschool teachers' IDC. The course includes the essence of language education, the concepts related to language education, TPACK theory, and the theoretical learning and practice of three teaching activities. The practical training emphasizes the analysis of the TPACK framework for specific types of teaching video cases and teaching design elements, focuses on feedback and modification, and completes the teaching design practice through three rounds of iterative design. The practical training follows design principles——teaching videos TPACK analysis ——TPACK analysis of design activity----activity design —— feedback and revision —— micro-teaching —— feedback and revise ——reflection. The quality of the course is evaluated by the teaching design product and the pass rate of the lesson plans. In the third round of instructional design practice, all the design products reached Good and above. In the after-class interviews, the pre-service preschool teachers' satisfaction with the TPACK-based course was 95%. The interviewees had high opinions of the repeated practice and feedback in the iterative design practice, they regarded the training as very helpful for the improvement of instructional design competence.

5.2 Effectiveness of a TPACK-based Course to Pre-service Preschool Teachers' IDC

The results indicate that pre-service preschool teachers who participated in the TPACK-based course demonstrated a significant improvement in IDC compared to those in the control group who received traditional instruction. This finding suggests that the TPACK-based course is effective in enhancing pre-service preschool teachers' IDC.

The intellectual orientation and practice-reflection orientation of teacher professional development provide a theoretical basis for TPACK to promote teacher professional development. The intellectual perspective of teachers' professional development holds the view that teachers' effective teaching must learn systematical, universal, and standardized knowledge. Accordingly, the education expert academic leading, education academic research, and dominated by teacher education institutions were highlighted. Additionally, the practice-reflection orientation of teacher professional development emphasizes that teachers constantly reflect on and improve their teaching methods and strategies in the actual teaching process, to improve the teaching quality (Department of Normal Education of the Ministry of Education, 2003). The subjects of this study are pre-service preschool teachers, who are in the early stage of teacher professional development. Their main learning approach is in the

university. They don't get too many opportunities for practical teaching. Their professional development mainly comes from the theoretical teaching and teaching practice guidance of teacher educators. Based on intellectual orientation, the TPACK framework analysis part of theoretical learning and teaching cases is designed to help pre-service preschool teachers acquire standardized knowledge such as preschool language design knowledge and educational knowledge; based on practice-reflection, design teaching practice, and reflection are designed to promote their reflection on teaching design.

Also, according to Hardré (2006) teacher' IDC development model, The IDC development from novice to expert is the common development of instructional design knowledge, instructional design skills, and metacognition, which are mutually interrelated and promote; the meta-cognition of instructional design can improve instructional design knowledge and instructional design attitude. In teaching cases (teaching video and task analysis), TPACK-based analysis is the element of teaching the meta-cognition of instructional design that can help pre-service teachers better improve teaching design knowledge and teaching design skills.

5.3 The Characters of the IDC Growth

The analysis of iterative lesson plans among pre-service teachers revealed three distinct growth stages in their instructional design competence (IDC). In the initial stage, the focus was on ensuring format correctness and structural integrity, as teachers learned to incorporate essential components of instructional design. As they transitioned to the intermediate stage their emphasis shifted to enhancing content effectiveness and refining teaching strategies, allowing them to align their objectives with student needs. Finally, in the advanced stage, they began integrating technology into their lesson plans, using digital tools like PowerPoint and interactive videos to enrich instructional outcomes. Overall, this development followed a trajectory of simplification, linearity, and adherence to templates, consistent with Hardré's (2006) observations regarding novice teachers. This progression highlights the significance of structured learning experiences in improving instructional design skills.

Fuller's (2009) Concerns-based Stages of Teacher Development, describes how the concerns of teachers during their careers change with the accumulation of time and experience. He divided teacher professional development into four stages, pre-teaching concerns, early concerns about survival, teaching situations concerns, and concerns about students. Pre-service teachers are in the pre-teaching concerns stage. They only imagine the role of students, have no practical teaching experience, and have not formed a deep understanding of teaching. They pay far more attention to the teaching content than to the children and the teaching situation.

In the same way, teachers' IDC usually have the following characteristics in the early development stage: when they design teaching activities, they rely on guidance and templates, they often rely on curriculum standards, textbooks or guidance and templates provided by tutors, they do not have enough experience to create or adjust the instructional design independently. In the early stages, by simulating the instructional design that they have observed or learned in teacher training, they may try to replicate successful teaching strategies.

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Authors' Contributions

Xiuqiong Ren was responsible for conceptualizing and designing the study, and manuscript draft, and Jiraporn Chano contributed to the critical revision of the final version. All authors have reviewed and approved the manuscript.

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The authors declare no conflicts of interest or competing financial or personal relationships that could have influenced the work reported in this paper.

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Obtained.

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The Publication Ethics Committee of the Canadian Center of Science and Education.

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The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

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Appendix

Appendix A. The rubric criteria of the lesson plan

Theme	Definition	Skill indicators	Operational definition	score
Activity Title Making AT	The components of the activity title	Class lever	Clear write	2
			Not write	0
		Domain	Clear write	2
			Not write	0
		Activity name	Clear write	2
			Not write	0
		Activity type	Clear write	2
			Not write	0
Objective Making OM	The objective making ability encompasses the writing of appropriate, quality and concise learning objectives	Numbers of learning objectives	3 objectives	4
			1-2 objectives	3
			No objectives	0
		Number of type-specified or language-specified objective	Type-specified language objective;	6
			Only language specified objective	3
			Objective not related to language	0
		Numbers of well written learning objectives	Behavioral verb+learning content, use the right verb	2
			The objective is appropriate realization for an activity	2
		Numbers of objective dimensions	3 of dimensions of knowledge, skill and emotion or attitude	2
			1-2 dimensions	1
Content analysis CA	The teaching content analysis involves teacher's critiquing and understanding of the content, topics and components to be taught including deep understanding of ideas in the Guide.	Understanding the internal connection and logicality of content	None	0
			Recognizing the structure	1
			Analyzing the structure	2
		Eliciting the key part and difficulty point of content	Identify the key part correctly	2
			Analyzing the key part	4
			none	0
		Keeping track of request of the language guideline	Quoting and discussing	2
			Just quoting	1
			none	0
Learner analyzing LA	The learner analyzing refers to analyzing leaner interests and abilities, and identifying those dimensions of common learner characteristics that carry different implications for instruction	Describing children's thinking traits or learning interests	More exact	2
			Exact	1
			none	0
		Describing students' prior conceptions or prior learning knowledge	More exact	2
			Exact	1
			none	0
		Knowing how to evaluating student's learning difficulties	More exact	4
			Exact	2
			none	0
Strategies, Resources and medias selection SRMS	Strategies, Resources, and media selection consists of three decisions: strategies	Chose the strategies fit for the instructional content	The strategies is more helpful for children understand	3
			The strategies is helpful for children understand	2
			No strategies	0
		Resources or technology are suitable for the instructional content	The resource and media are more suitable for children understand	3
			The resource and media are suitable for children	2

			understand	
			Not applying resource and media	0
		Selected methods and media are helpful for highlighting key instructional content	methods and media suit for more key instructional Content learning	3
			methods and media are suit for key instructional Content learning	2
			methods and media don't suit for key instructional Content learning	0
		Chosen methods and media helpful to address the difficult instructional content	methods and media are more helpful for reducing the grade of difficulty	3
			methods and media are helpful for reducing the grade of difficulty	2
			methods and media are not helpful for reducing the grade of difficulty	0
Teaching events arrangement TEA	Introduction	Creative and attractive thinking	Creative thinking	4
			Just review	2
			none	0
		Closing related to topic	Highly relevant to the teaching topics, simply and clearly	4
			Lowly relevant to the teaching topics, vaguely	2
			Irrelevant to the topic	0
		Draw from children's familiar experience	Appropriate connecting	4
			General connecting	0
			none	0
	The designing stages that closely align with the instructional content	The completion degree of the instructional design	Complete outline and detailed of the design	8
			Only outline without detail	2
			Outline is not complete	0
		Stress key and difficulty instructional content	Indicating key and difficulty instructional content in detail	8
			Just indicate which is key or difficulty	4
			Not indicate	2
		Present content logically and clearly	Clear and logical	8
			Not clear or not logical	4
			Not clear nor logical	2
		Teachers questions in instructional guidance	Simply and highly relevant to the following instruction	8
			Relevant to the instruction but complicated	4
			Not relevant to the instruction	0
		Design instructional phases are distinct	Following the type-specified instructional design phases and use the specified term	8
			Following the type-specified instructional design phases and don't use the specified term	4
			Don't follow the the type-specified instructional design phases	0

Appendix B. Scores of three rounds of lesson plans

Scores of Conversation lesson plan

Group		At	OM	CA	LA	SRMS	EA	Total
Group 1	original	4	10	6	4	6	25	55
	Revised	6	10	6	8	12	40	82
Group 2	original	6	8	6	8	10	30	68
	Revised	8	10	6	8	12	38	82
Group 3	original	6	6	4	2	4	30	52
	Revised	8	6	4	2	4	38	62
Group 4	original	4	6	6	6	8	36	68
	Revised	8	6	6	6	8	40	74
Group 5	original	6	6	4	0	4	28	48
	Revised	8	8	7	4	6	40	73

Scores of Narrative lesson plan

Group		At	OM	CA	LA	SRMS	EA	Total
Group 1	original	8	10	4	6	8	38	74
	Revised	8	10	4	6	8	44	78
Group 2	original	8	8	4	4	4	32	60
	Revised	8	12	6	4	6	36	72
Group 3	original	8	6	4	4	4	38	64
	Revised	8	12	4	4	4	40	72
Group 4	original	8	10	4	4	6	39	71
	Revised	8	12	6	6	8	42	82
Group 5	original	8	12	6	2	6	35	69
	Revised	8	12	6	4	6	38	74

Scores of literature lesson plan

Group		At	OM	CA	LA	SRMS	EA	Total
Group 1	original	8	12	4	4	6	35	69
	Revised	8	12	4	4	8	38	74
Group 2	original	8	12	4	4	10	40	78
	Revised	8	12	6	6	6	43	81
Group 3	original	8	10	6	6	6	40	78
	Revised	8	12	6	6	6	42	80
Group 4	original	8	8	4	4	6	38	68
	Revised	8	10	6	6	8	40	78
Group 5	original	8	10	6	6	8	42	80
	Revised	8	10	6	6	10	44	84

Appendix C. Instructional Design Competence Scale for Pre-service Preschool Teachers

Dear students:

Thank you so much for filling out the questionnaire.

The main purpose of this study is to explore the instructional design competence of pre-service preschool teachers. The survey results are only used for academic research, and will not be made public to third parties. There is no right or wrong choice, please choose or fill in according to your actual situation. Sincerely thank you for your support and cooperation!

The questionnaire includes two parts, your personal information and assessment of instructional design competence.

Personal information:

1.Your gender: male☐ female ☐
2.Your class: pre-school 221☐ pre-school 222 ☐
3.Your seat number:_____
4.The instructional design experience: yes ☐ no☐
5.The Internship experience in preschool or kindergarten: yes☐ no☐

Assessment of instructional design competence

Dimensions	Items	Scoring Rubric				
		1	2	3	4	5
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Instructional Design Attitude	**1.** I think instructional design is very important to teaching.					
	2. I realize the importance of young children's development in teaching evaluation.					
	3. I know that the ultimate goal of instructional design is to achieve the fundamental task of children's development.					
	4. I know that the ultimate goal instructional design in the field of language is the children's language development and thinking abilities.					
	5. I can always take every instructional design positively and seriously.					
	6.I am sure that I can complete every instructional design very well.					
Instructional Design Knowledge	**7.** I am familiar with the learning content, development goals and educational inspirit of the language domain stipulated in the Guide.					
	8. I have mastered enough knowledge of language domain (such as the essence of language, the principles of preschool language education, vocabulary and expression, reading and comprehension, storytelling ability, etc.).					
	9. I understand the objectives and content structure of the course in Language Education for Preschool Children.					
	10. I understand the value of this course for the development of a preschool teacher's professional ability.					
	11. I have mastered the basic knowledge of instructional design, such as the objectives and processes of teaching design, common teaching methods and teaching strategies.					
	12. I understand the commonly used organizational forms in teaching design. Such as group teaching, group teaching and individual teaching.					
	13. I understand the relevant knowledge of teaching evaluation, such as the objectives of evaluation and evaluation methods.					
	14. Understand the basic theories of teaching reflection, such as metacognitive and reflection thinking theory, thinking teaching theory, etc					
	15. I have mastered the knowledge of various educational software, such as PPT production, the use of electronic whiteboard, animation production, audio and video editing.					
	16. I have mastered the method of finding information, such as finding suitable background music or related animations or high-quality teaching activities on various preschool education public accounts or video platforms.					
Instructional Design Skill	**17.** I can clearly analyze the key goals of language areas and types of language activities.					
	18.I can clearly analyze the teaching objectives of the three dimensions in the teaching activities.					
	19. I can analyze the objectives of the teaching design according to the concept of the Guide.					
	20. I can analyze the development characteristics of children of different ages and carry out appropriate teaching design.					
	21. I can analyze the individual differences of children's development and design the material.					
	22.I can analyze the appropriate teaching design of children's learning trajectory of the knowledge point (such as the order of language development).					
	23. I can choose the appropriate introduction method, so as to arouse children's curiosity and attention to the problem.					

	24. The organization and arrangement of teaching content can match with the teaching objectives and reflect the hierarchy and internal logic.					
	25. Combining the teaching content and the characteristics of preschool education, choosing a variety of teaching methods and teaching strategies to carry out teaching design.					
	26. Be able to grasp the teaching difficulties according to children's cognitive level and teaching objectives, understand the difficulties, and know the strategies to break through the difficulties.					
	27. I can design effective problems around the key points and difficulties of teaching, which can stimulate and mobilize children's enthusiasm for learning. Teaching resources and strategies.					
	28. I can choose the appropriate course resources (such as online videos, animations or teaching cases related to teaching activities)					
	29. I can choose appropriate educational technologies (such as the use of multimedia, electronic whiteboard, video, audio) for teaching design activities to make the teaching content more effective.					
	30. I can design appropriate links and forms for teaching activities, so that the interaction between teachers and children is more effective, and it can better reflect children's subjectivity.					
	31. Be able to observe children in class whether they have learned the content and evaluate the teaching design, and give timely feedback according to different evaluation results.					
	32. Be able to accept or consult with your classmates to promote the improvement of your teaching design.					
	33. Be able to reflect on the teaching design from the appropriateness of the teaching content arrangement.					
	34. Be able to reflect on whether the teaching objectives are clear and whether the teaching activities are consistent.					
	35. I Can reflect on the teaching design from whether the teaching process is smooth and whether the logic is clear.					
	36. I Can reflect on whether the teaching design is reasonable by comparing with high-quality class examples					

The questionnaire ends there，thank you for your participation, I wish you a happy life and academic success!