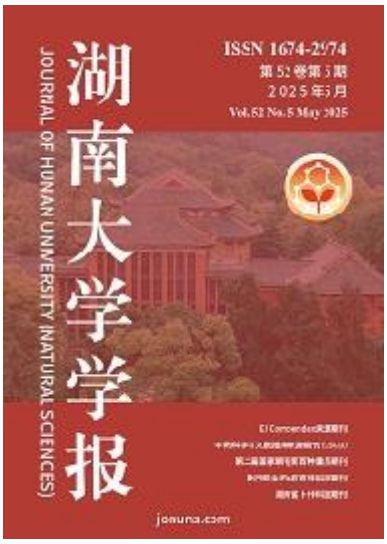

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The Impact of Community Engagement on 21st-Century Competency Development among Pre- and In-Service Teachers: A Mixed-Methods Study

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Abstract: Despite policy mandates to embed "Four Cs" competencies—communication, collaboration, critical thinking, and creative thinking—throughout teacher education, empirical evidence on how community-engagement initiatives foster these skills remains limited, particularly in Gulf contexts. Guided by sociocultural learning theory and Kolb's experiential-learning model, this sequential explanatory mixed-methods study evaluates the extent to which structured community-engagement projects cultivate 21st-century skills among pre-service and in-service science teachers in Abu Dhabi, United Arab Emirates (UAE). In the quantitative phase, 160 pre-service and 85 in-service teachers completed an adapted 21st-century-skills inventory (Cronbach's α = 0.85). Descriptive statistics and independent-samples *t*-tests revealed that in-service teachers scored significantly higher on all four competencies, with the largest differences observed for critical thinking ($t(243) = 4.72$, $p < .001$, $d = 0.60$) and collaboration ($t(243) = 3.41$, $p = .001$, $d = 0.43$), suggesting a cumulative advantage of field experience. To elucidate these patterns, the qualitative phase employed semi-structured interviews with 20 purposively selected participants representing high and low survey quartiles. Thematic analysis indicated that authentic problem-solving with community stakeholders, iterative feedback cycles, and cross-disciplinary project teams were the principal mechanisms through which engagement activities enhanced the Four Cs. Participants also identified structural constraints—restricted instructional time, insufficient funding, and limited school–community partnerships—that moderated these gains. Taken together, the findings demonstrate that well-scaffolded community-engagement modules can accelerate the acquisition of transferable 21st-century competencies, particularly for novice teachers. The study recommends embedding sustained, resource-supported community collaborations into both initial teacher education and continuing professional development frameworks across the UAE and comparable settings.

Keywords: 21st-century skills; community engagement; pre-service teachers; in-service teachers; mixed-methods research; UAE.

社区参与对职前与在职教师 21 世纪能力发展的影响：一项混合方法研究

摘要：
尽管政策层面要求在教师教育中全面融入"4C"核心能力——沟通、协作、批判性思维和创造性思维——关于社区参与计划如何促进这些能力形成的实证证据仍然有限，尤其是在海湾地区。基于社会文化学习理论和 Kolb 体验学习模型，本研究采用顺序解释型混合方法，评估在阿联酋阿布扎比职前与在职理科教师通过结构化社区参与项目培养 21 世纪技能的效果。
在量化阶段，对 160 名职前教师和 85 名在职教师使用修订版 21 世纪技能量表进行测查（Cronbach's α = 0.85）。描述性统计与独立样本 t 检验表明，在职教师在四项能力上均显著优于职前教师，其中批判性思维（$t(243) = 4.72$, $p < .001$, $d = 0.60$）和协作（$t(243) = 3.41$, $p = .001$, $d = 0.43$）的差异最大，提示现场经验的累积优势。
质性阶段通过目的性抽样，选取问卷得分高低四分位的 20 名教师，开展半结构化访谈。主题分析显示，与社区利益相关者共同解决真实问题、迭代式反馈循环以及跨学科项目团队是社区参与活动提升 4C 能力的主要机制。受访者还指出，教学时间受限、经费不足与校社合作匮乏等结构性因素会削弱这些收益。
综合来看，研究结果表明，良好支撑的社区参与模块能够加速可迁移 21 世纪能力的获得，尤其对新手教师意义重大。建议在教师职前培养和在职专业发展框架中嵌入长期、资源充足的社区协作项目，并推广至阿联酋及类似背景地

关键词： 21 世纪技能；社区参与；职前教师；在职教师；混合方法研究；阿联酋

1. Introduction

Unlike disciplines taught in traditional schools, such as science, language, history, and mathematics, 21st-century skills do not compete. Instead, teachers should acquire content-specific skills and knowledge [1, 2]. Rather than rote memorization, learning 21st-century skills emphasizes readiness to apply knowledge to various contexts. Everybody needs 21st-century coping skills, and nobody will develop them on their own. It is a time of rapid technological advancement and a changing job market [3,2, 40]. Consequently, preparing students with resilient skills to navigate an increasingly complex world is essential. In particular, there is increasing interest in tapping into the potential of community engagement to enhance the 4Cs (i.e., critical thinking, Creativity, Cross-cultural Communication, and Collaboration) among pre- and in-service teachers.

When analyzing community participation and its effect on 21st-century skills, cultural change is an important issue to consider [4]. Cultural change refers to a changing society's values, attitudes, beliefs, and actions [5, 6]. Cultural change is required to promote a shift in the catering of education [7, 8, 9]. For example, traditional teaching methods tend to prioritize mastery of academic knowledge. Hence, community engagement is the key to this change. As discussed in [10] and [11], there may not be ample opportunities for people to engage in volunteer work or service in some

societies if individuals are deprived of these types of experiences and opportunities, which could help them to cultivate the specific skills they need to acquire as part of their 21st-century employability. Public cultural changes remove these barriers and create a welcoming environment to interact with each other by enhancing social cohesion in triggering physical activity and the development of 21-century skills [7, 12, 13,14].

Schools and universities can stimulate participatory community culture by embedding service-learning and community-based research into the curriculum. Community members must make concerted efforts because cultural transformations may take time [7]. It includes challenging existing beliefs and attitudes about community engagement and the benefits of 21st-century skills. Cultural change includes the provision of support and resources to help individuals engage in these activities. Yeşilçinar and Aykan [15] contend that contemporary education systems are under mounting pressure to equip learners with the "Four Cs" of the 21st century—collaboration, communication, critical thinking, and creativity. Their argument implies a parallel imperative for teacher-preparation programmes, which must cultivate these same competencies in both pre-service and in-service teachers so that they, in turn, can embed them in classroom practice. Building on this premise, Valtonen et al. [1] argue that teacher education should explicitly prioritise the dual agenda of (a) developing teachers' own 21st-century skill set and (b) enhancing their pedagogical capacity to foster these skills in pupils. Sustained scaffolding—through mentorship, practicum experiences, and reflective feedback—has been shown to bolster pre-service teachers' self-efficacy in implementing 21st-century pedagogies. Against this backdrop, the present study examines whether—and how—structured community-engagement projects serve as a viable mechanism for strengthening teachers' Four-Cs repertoire. Specifically, it investigates teachers' perceptions of the salience and enactment of 21st-century skills within the curriculum, thereby addressing a critical gap in the literature on experiential, community-anchored approaches to teacher development.

Developing 21st-century skills is a crucial educational component because of technological advancements and the dynamic modern environment in practically every industry [16, 17]. The 4Cs have been identified as critical to an individual's success in their personal and professional lives. To effectively prepare students for the problems of the 21st century, pre-service teachers, future teachers, and in-service science teachers must possess these competencies. The 4Cs are considered advantageous, but pre-service teachers still do not have many opportunities in their teacher education programs to grow and improve these skills compared to in-service teachers [44]. Community engagement is an important strategy to address this gap. However, the impact of this strategy has received inconsistent scholarly attention. This study aims to better understand this occurrence and determine the overall effects of community engagement as a substitute strategy for educating pre-service and in-service science teachers on the 4Cs.

2. Significance of the Study

A study of this nature is significant because of its potential to advance the field of teacher education by providing insights into the impact of community engagement on how prospective and in-service science teachers gain 4Cs. The results of this study can inform higher education institutions about the importance of community engagement in developing the 4Cs. It can also guide them in incorporating community engagement into their curriculum. In addition, this study could be significant to community organizations because it can educate them on the value of working with pre-service and in-service science teachers to address social issues within the community. Therefore, this study attempts to answer the following questions:

- How does participation in community engagement activities influence the development of the 4Cs (critical thinking, creative thinking, collaboration, and communication) among pre-service and in-service science teachers?
- Are there any significant differences between pre-service and in-service science teachers regarding the impact of community engagement on the development of the 4Cs?
- What are the main barriers that pre-service and in-service science teachers face when participating in community engagement activities?

3. Literature Review

3.1. Community Engagement and 21st-Century Skills

Community engagement is a relatively multifaceted concept that involves various activities and approaches to building and strengthening relationships between individuals and communities. The evaluation of community engagement in this context entails analyzing a range of outcomes, including modifications to attitudes, beliefs, and behaviors [7]. Community engagement can help foster civic duties, which is one of its main advantages. In this context, it offers people opportunities to volunteer work and encourages students to actively participate in community development [7]. As previously mentioned, community involvement fosters growth of the 4Cs. For instance, encouraging teamwork and collaboration between teachers and community members can help to remove social barriers and develop a deeper feeling of mutual respect and trust among community members. This may contribute to the development of encouraging and welcoming

communities.

According to [18], 21st-century skills are familiar and have been taught in schools for years. However, with the demands of the evolving economy, different educational institutions are now integrating these skills into their strategic plans to equip students with higher education, careers, and life. Although 21st-century skills have been essential elements throughout human history, the methods of teaching and developing them in K–12 schools have advanced significantly. For instance, the Common Core State Standards (CCSS) now includes 21st-century skills [18]. 21st-century skills refer to a wide range of knowledge, working habits, and behaviors crucial for individual success in today's world. Generally, most educational institutions define their 21st-century skills based on what appears significant to their communities. Although this concept is widely applied in education, it lacks a consistent definition, which may lead to confusion and conflicting elucidations. However, the most commonly used categories of 21st-century skills include critical thinking, creative thinking, collaboration, and communication [19]. These are also commonly referred to as the 4Cs, based on the Partnership for 21st-Century Skills, and are essential for students to succeed in school and later in their careers.

Critical thinking effectively analyzes, assesses, and renders reasoned judgments. In other words, critical thinking makes decisions based on knowledge and communication while employing sufficient contemplation and reasoning [20]. To determine whether information or communication is important in a certain setting, one must think critically and judge it skillfully. Thus, it involves key competencies such as problem-solving, decision-making, and analysis. Individuals with critical thinking skills can solve complex problems and make informed decisions. According to [21], critical thinking enables an individual to assess the credibility and reliability of information and considers multiple perspectives to make sound and independent judgments[17]. Another 21st-century skill is creativity, which is the capacity to generate and use fresh original ideas in various circumstances. Creative thinking is the production of new practical concepts for new goods, services, or procedures that have the potential to be helpful. Since the 21stcentury poses new challenges as more opportunities emerge, creative thinking has become more relevant as more opportunities emerge [20]. A person possessing this skill can think creatively and address issues from different perspectives. Individuals need to be risk-taking, open to new concepts, and willing to adopt various approaches to develop this skill. As a 21st-century skill, collaboration is collaborating with others and working together towards a shared goal [17, 16]. Generally, work in the twenty-first century is becoming increasingly knowledge-based and specialized. Because individuals do not have all the necessary information and abilities, collaboration among workers is necessary to complete complicated jobs. In this era, people depend on others to accomplish tasks. As a result, collaboration skills are necessary to help individuals leverage team members' strengths and work towards a common goal [17, 16]. An individual with this skill can successfully work with a diverse team and is open-minded. Communication skills refer to the ability to clearly and effectively express ideas, thoughts, and information clearly and effectively [19].

Community engagement encompasses activities that enhance community cohesion, foster civic responsibility, and promote volunteerism, particularly among students. This process facilitates the dismantling of social barriers, cultivating respect and trust and contributing to a more inclusive environment. In education, there is a focus on 21st-century skills such as critical thinking, creativity, collaboration, and communication (the 4Cs) to prepare students for modern challenges. However, there is no set definition for these skills, leading to confusion and different meanings. While these skills have been around for a long time, the ways they are taught has changed significantly. Educational institutions often tailor their definitions of these skills to align them with the needs of their local community.

3.2. Advantages of Participation in Community Engagement

For teachers, the community, and society, participating in community engagement offers several advantages. The opportunity it gives pre-service teachers to build 21st-century abilities is a major benefit of this engagement. In addition, engaging in community participation can foster personal growth and development [22, 23]. In this setting, people can broaden their perspective, acquire new knowledge, and develop new skills. Therefore, it is important to strengthen social relationships. As people work together to create a sense of belonging, participation in community involvement helps deepen relationships [23, 43]. This involvement also links future teachers with the fundamental requirements of the community [22]. They investigated the community needs to assist students or people in a specific community. Furthermore, participation in community engagement provides a fantastic opportunity to learn more from others. As they are already familiar with issues and opportunities in different communities, Pre-service teachers who engage in community services can provide services effectively.

3.3. Challenging Participation in Community Engagement

According to [22], limitations in time and budget are significant barriers to community engagement. In

general, pre-service teachers may find it time consuming to participate in community engagement initiatives. In addition, they require many resources, including materials, equipment, and transportation. It may be difficult for pre-service teachers to participate in community interactions if they lack sufficient time and resources. Furthermore, participating in community engagement is quite demanding, and pre-service teachers may feel mentally and physically worn out afterward [22, 24]. This situation may result in burnout and weariness, which may reduce the benefits of exercise. It is important to note that some groups may exhibit opposition if there has not been cultural change. Additionally, certain community involvement initiatives in which pre-service teachers are interested in taking part in may involve questioning attitudes and existing beliefs, resulting in resistance or hostility from those who do not want to change [22, 23].

4. Methodology

4.1 Research Design and Paradigm

The study followed a mixed-method sequential descriptive design (Figure 1), starting with quantitative data collection and using the qualitative phase to provide deeper insights into the main findings. The decision to use this approach was made because of its potential to explore how social engagement influences the development of 21st century skills in pre-service and in-service teachers (i.e., the four skills).

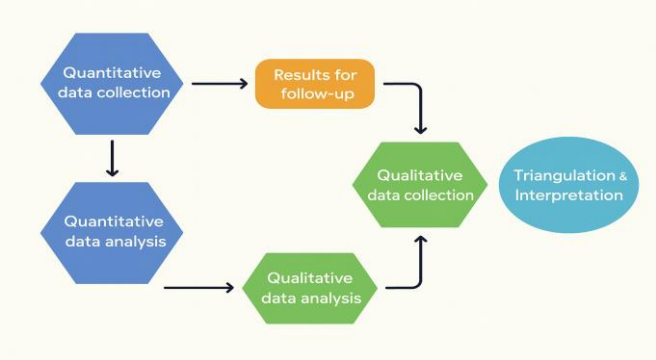

Figure 1. Study Design

This study is based on a pragmatic model that allows for the flexible use of quantitative and qualitative methods to answer research questions that provide doable actions to guide smooth implementation [25].

4.2 Population and Sample

Pre-service and in-service teachers participated in this study. They are all enrolled in graduate programs from different institutions in Abu Dhabi, United Arab Emirates (UAE). Al-Ain University was employed to provide access to participants' records to facilitate the sampling process. The participants represented a diverse sample from different year levels and specializations were included to ensure a wide representation of their experiences with community engagement activities. During the quantitative phase, a random sample of 160 pre-service teachers (65 biology, 55 chemistry, 25 physics, and 15 general science) and 85 in-service teachers (20 biology, 35 chemistry, 15 physics, and 15 general science) was selected to complete a structured survey designed to assess the development of the 4Cs through community engagement activities (Table1). Although the survey was structured, this method maintained the integrity of randomization by ensuring that each participant had an equal chance of being selected. Systematic random sampling minimizes selection bias while ensuring a clear and organized approach to participant selection, which enhances the generalizability of the results [26].

Table 1. Distribution of the Teachers' Sample According to Specialist

	Pre-service		In-service	
Subject	N	Percentage (%)	N	Percentage (%)
Biology	65	26.5	20	8.2
Chemistry	55	22.4	35	14.3
Physics	25	10.3	15	6.1
General Science	15	6.1	15	6.1
Total sample	160	65.3	85	34.7

In the qualitative phase, a purposive sampling technique was employed as the second step after completing the survey. Twenty participants were selected from the survey respondents based on their responses to items that reflected trends or diverse experiences in community engagement. This method allowed for in-depth and further elaboration of specific experiences and provided rich qualitative data to complement the quantitative findings. However, only interview participants with these distinguished answers were invited, based on their willingness to engage in further research, which reduced the target audience. The final sample size across both phases provided ample breadth for statistical analysis and the interviews added a rich contextual understanding.

4.3 Survey Instrument

The survey used in this study for the quantitative phase was adapted from well-established instruments designed to measure the development of 21st-century skills, particularly the 4Cs. The survey consisted of Likert-scale questions aimed at assessing the extent to which participants believed that community engagement contributed to their relevant set of skills: growth in critical thinking, creative thinking, collaboration, and communication. The survey was distributed electronically to 160 pre-service teachers and 85 in-service teachers through a secure online platform that did not require any identifiers of their personal

information. Theparticipants were given two weeks to complete the survey, and a reminder was sent to increase the sample size after the initial invitation. In alignment with ethical guidelines, when human subjects were involved in data collection, all participants provided signed or electronically signed informed consent before participation. The researchers were introduced in the invitation letter, including the study objectives, voluntary nature of their participation, and right to withdraw at any time without any negative consequences or possible risks. Anonymity and confidentiality were strictly maintained with no single option to mention any personal information that could reveal identities. Additionally, the survey featured open-ended questions to capture initial qualitative insights that may enable researchers to determine significant responses that could later be expanded upon during the interview phase. To ensure clarity and reliability, the survey was pilot-tested with a small group of pre-service teachers (n = 10).

4.4 Interview Protocol

Following an analysis of the survey data, semi-structured interviews were conducted to obtain richer and more valuable data about how pre-service and in-service teachers perceived the impact of community engagement on the development of the 4Cs. Twenty pre-service and in-service teachers were selected for in-depth interviews based on their significant responses to the open-ended questions. Each participant received a consent form detailing the purpose, procedures, and ethical safeguards of the study, including confidentiality and the voluntary nature of their involvement, which had no rewards or gifts that may influence their answers, except thanking them verbally. Interviews were scheduled based on participant availability and conducted over a two-week period. Each interview lasted between 30 and 45 minutes, with participants given the option to engage either face-to-face or online depending on their preference and availability. All interviews were audio-recorded with participants' consent and transcribed verbatim for analysis.

4.5 Data Analysis

Quantitative data from the survey were analyzed using descriptive and inferential statistics using SPSS software. Descriptive statistics, such as means (M) and standard deviations (SD), were calculated to provide a summary of the participants' perceptions of their 4Cs development through community engagement. An independent sample t-test was used to determine whether there were any statistically significant differences between the two groups. All analyses were performed using SPSS software. Cronbach's alpha was calculated to assess the reliability of the survey, resulting in a high internal consistency ($\alpha = 0.85$).

The interview transcripts were analyzed using thematic analysis based on the six-phase approach of[27]. A standardization exercise was conducted between the researchers involved in this analysis, which was chosen because it allows for a flexible and structured way of identifying, analyzing, and reporting patterns (themes) within the data [28, 29]. The standardization process began with familiarization, where the transcripts were read and critically reviewed to capture a comprehensive understanding of the data and identify initial ideas. Each chosen idea, according to this process, is labeled by a code. The codes generated were meaningful, as they captured the essential aspects of participants' experiences related to the development of the 4Cs. In the following step, the data were systematically coded inductively and deductively, which was the final part of the standardization process, as this ensured that the themes were data-driven and aligned with the research objectives [27, 30]. The codes were then grouped into broader themes representing how pre-service teachers perceived the impact of community engagement on professional skill development. Researchers have refined and reviewed the themes to conduct cross-referencing with existing research to maintain a consistent and coherent list of themes [27, 31]. One important step was considered to ensure the trustworthiness of the analysis: member checking was conducted wherein the study participants were invited to review the accuracy of their transcripts and provide feedback (if any) on the identified themes. Additionally, peer debriefing was employed to validate the findings and enhance the overall credibility [29]. Finally, the qualitative findings were triangulated with quantitative data, contributing to a richer collective understanding of how community engagement contributed to the developing of the 4Cs among pre-service teachers.

To ensure the validity of the survey, the quantitative instrument, content validation, was performed by a panel of experts in teacher education and community engagement, who reviewed the survey items to confirm that they adequately captured the dimensions of the 4Cs. Reliability was further confirmed using Cronbach's alpha, which demonstrated a high level of internal consistency for the survey items. In the qualitative phase, trustworthiness is maintained through various methods, including prolonged engagement with the data, member checking, and peer debriefing. These steps ensured the credibility and accuracy of the qualitative findings, while also providing a coherent integration of the results from both the quantitative and qualitative phases.

5. Findings

5.1 How does community engagement affect teachers' 4Cs?

5.1.1 Quantitative results

First, the fourth domain of teachers' 21st-century skills was separately calculated for the mean, standard deviation, and Cronbach's alpha (see Table 2). The highest score of the domain of the survey was communication skills for the pre-service (M = 3.77, SD = 1.05) and in-service teachers (M = 4.46, SD = 0.98). For both groups, the most frequently cited online learning communication was "I am confident in my ability to communicate with clarity and impact" followed by communication, critical thinking, and creative thinking, which had the second lowest mean scores for 21st-century skills perceived by pre- and in-service science teachers. All 21st-century skill domains had lower mean scores for pre-service teachers than for in-service teachers: critical thinking (M = 3.41, M = 4.03), creative thinking (M = 3.55, M = 4.14), collaboration (M = 3.71, M = 4.33), and communication (M = 3.77, M = 4.46). Cronbach's alpha ranged from 0.81–0.91, which is considered "good."

Table 2. Descriptive Statistics of the 21 Century Skills in the Two Groups

Domains of teachers' 21st-century skills	Preservice teachers		Inservice teachers	
	Mean	SD	Mean	SD
Critical Thinking α (0.81)	3.41	1.01	4.03	0.94
I critically evaluate information and arguments before making decisions	3.34	1.02	4.43	0.66
I actively seek out different perspectives and consider alternative viewpoints	3.46	0.86	4.12	0.89
I am confident in my ability to analyze complex problems and find effective solutions	3.43	1.16	4.11	1.04
I am open to changing my opinions when presented with new evidence	3.56	0.98	3.89	1.19
I apply logical reasoning to solve problems and make informed judgments	3.35	1.42	3.65	0.77
I am able to break down complex issues into manageable components for analysis	3.34	0.64	4	1.08
Creative Thinking α (0.83)	3.55	1.03	4.14	0.98
I am comfortable taking risks and trying new approaches to solve problems	2.98	1.26	3.58	0.65
I enjoy brainstorming ideas and generating innovative solutions	3.1	0.93	4.44	1.01
I embrace ambiguity and view it as an opportunity for creative thinking	4.01	1.31	3.83	0.76
I enjoy experimenting with different methods and approaches to enhance creativity	3.88	1.11	4.32	1.4
I value originality and encourage innovative thinking in myself and others	3.79	0.87	4.22	0.87
I actively seek feedback and input from others to improve my creative thinking skills	3.55	0.69	4.47	1.19
Collaboration α (0.91)	3.71	1.00	4.33	0.93
I effectively communicate and listen to others' perspectives during group work	4.01	0.85	4.65	0.75
I actively seek opportunities to collaborate with my peers and colleagues	4.22	1.12	4.42	1
I am able to work cooperatively towards common goals with others	3.43	1.32	4.87	1.04
I value teamwork and recognize the importance of collective achievements	3.11	0.87	4.29	0.56
I actively contribute to group discussions and encourage participation from others	4.11	1.13	4.51	0.82
I enjoy sharing responsibilities and working collaboratively on projects	3.32	0.99	3.64	1.17
I appreciate the strengths and expertise of my teammates and leverage them for effective collaboration	3.74	0.73	3.9	1.19
Communication α (0.86)	3.77	1.05	4.46	0.98
I can express my ideas clearly and concisely in both written and oral forms	4.21	0.89	4.55	0,77
I actively listen to others and provide constructive feedback during conversations	3.68	1.31	4.73	0.91
I effectively use non-verbal cues to enhance my communication	3.87	1.02	4.48	0.64
I am comfortable engaging in public speaking and presenting information to audiences	3.34	0.93	4.05	1.18

5.1.2 Qualitative results

The teachers expressed that community engagement significantly contributed to the development of their 21st-century skills, particularly in critical thinking, collaboration, communication, and creativity. Many participants highlighted that working directly with diverse communities allowed them to apply theoretical knowledge to real-life situations, fostering a deeper understanding of social issues and helping them refine their problem-solving and critical thinking skills. For example, one participant stated: "*When I worked on a community project addressing environmental awareness, I had to think critically about how to adapt complex scientific concepts to be understandable for different audiences. It challenged me to be more analytical and reflective about my approach*."

5.2 Differences between pre-service and in-service teachers' 4Cs development and community participation

5.2.1 Quantitative results

A series of t-tests were conducted to determine the differences between pre-and in-service teachers' respondents (Table 3). The results indicated that there was a statistically significant difference at the p 0< .005 level in critical thinking scores for the four groups of science teachers (biology, chemistry, physics, and general science). In addition, there was a statistically significant difference (p <.05) in creative thinking scores and collaboration, p 0< .05. However, there were no significant differences in the communication scores among the four groups of teachers.

Table 3. An Independent-Samples t-Test of 21 Century skills of the Two Groups

21 Century skills		Groups	N	Mean	SD	t	df	Sig.
Critical thinking	Biology	Preservice	65	3.13	0.92	0.197	83	0.000
		In-service	20	3.64	0.67			
	Chemistry	Preservice	55	3.36	1.21	12.640	88	0.000
		In-service	35	4.24	0.88			
	Physics	Preservice	25	3.69	1.2	15.981	38	0.032
		In-service	15	4.12	0.86			
	General Science	Preservice	15	3.65	1.28	22.146	28	0.041
		In-service	15	4.65	0.9			
Creative thinking	Biology	Preservice	65	2.81	1.02	18.332	83	0.012
		In-service	20	3.82	0.95			
	Chemistry	Preservice	55	3.42	0.89	17.631	88	0.044
		In-service	35	4.04	1.05			
	Physics	Preservice	25	3.66	0.83	14.418	38	0.000
		In-service	15	3.99	1.01			
	General Science	Preservice	15	3.63	1.04	23.290	28	0.000
		In-service	15	4.45	1.01			
Collaboration	Biology	Preservice	65	3.61	1.12	19.671	83	0.019
		In-service	20	4.25	1.11			
	Chemistry	Preservice	55	3.43	0.96	14.693	88	0.029
		In-service	35	4.08	0.85			
	Physics	Preservice	25	4.17	1.17	0.563	38	0.000
		In-service	15	4.69	0.96			
	General Science	Preservice	15	3.63	0.84	6.973	28	0.000
		In-service	15	4.41	0.89			
Communication	Biology	Preservice	65	4.1	0.98	0.658	83	0.443
		In-service	20	4.4	1.02			
	Chemistry	Preservice	55	3.99	1.04	11.145	88	0.086
		In-service	35	4.18	1.13			
	Physics	Preservice	25	4.13	0.78	18.931	38	0.121
		In-service	15	4.53	0.89			
	General Science	Preservice	15	4.17	1.03	8.415	28	0.313
		In-service	15	4.34	1.12			

5.2.1 Qualitative results

The participants described community engagement as a driving force for enhancing teamwork abilities. By collaborating with community members, including local community individuals who deliver services to their schools and other pre-service teachers, they were exposed to a multitude of viewpoints that promoted open-mindedness and taught them how to handle conflicts productively, which did not significantly delay their usual duties. In-service teachers also highlighted the value of interacting with individuals from diverse cultural and social backgrounds, including connecting with expert colleagues from other institutions, which helped improve their teamwork skills and ability to collaborate in professional settings, for example, co-creating solutions for similar and common issues they face related, for example, to assessment, curricula, and field visits. One participant noted: "*I learned a lot about collaboration by working with people from various backgrounds. Everyone has different ideas, but we have to come together to achieve a shared goal. It taught me to listen and be flexible*."

The pre-service teachers, considering that some of them are being trained and placed in schools, reported that their communication skills improved through interactions with community members of varying ages, different positions of professions, cultures, and educational backgrounds, such as exposure to MOE training positions and civil defense individuals who visit schools to train the staff on evaluation plans. They needed to adjust their language using the right terminology for a better presentation of their professional discussion. One teacher commented: "*In our community project, we had to present our ideas to local leaders and parents, which required us to break down complex terms into simpler language. This helped me become a better communicator both verbally and non-verbally.*" Another in-service teacher emphasized the importance of active listening: "*I became a better listener. When you're working with community members, you realize that their input is just as important as yours.*" Additionally, community engagement fosters creativity, as teachers often need to develop innovative solutions to address community challenges and issues related to their professional roles. Many pre-service teachers observed that working in these environments required them to think creatively about developing effective and practical solutions to at least cope with the expert professional they are working with them. One participant reflected: "*We had to find creative ways to engage younger children in science experiments with limited resources. This experience pushed me to think of alternative teaching methods and make learning fun and interactive*." The opportunity to experiment with new ideas in real-world contexts helped in-service teachers develop their creative thinking skills, which they believed would be beneficial for their future teaching careers.

5.3 Teachers' community engagement challenges

Despite the positive outcomes, participants also noted several barriers to engaging in community activities. Time constraints, limited access to resources, and a lack of institutional support were the most frequently cited obstacles. Some pre-service teachers expressed difficulty balancing their academic commitments with community engagement projects. One participant stated: "*It was challenging to allocate time between classes and personal commitments to participate fully in community projects. It would be beneficial if educational institutions provided more structured opportunities that align with our schedules*." Moreover, some participants indicated that lack of prior exposure to community engagement created a sense of uncertainty, many of whom were initially unfamiliar with how to become involved, and we experienced some hesitation. Additional guidance and mentorship from our university would be beneficial.

Furthermore, many in-service teacher shave offered various suggestions to overcome barriers to community engagement. They advocated for more institutional support, including mentorship programs and clear guidance on how to integrate community engagement into teaching practices. Some also suggested that schools provide additional time and resources to participate in community projects. For example, an in-service participant stated that "*If universities had formal partnerships with community organizations, it would make it easier for us to get involved and help bridge the*

gap between theory and practice." Additionally, creating structured programs in which community engagement is a mandatory part of the curriculum was proposed as a way to ensure that more pre-service teachers have opportunities to develop their 4Cs through hands-on experience.

6. Discussion

The quantitative findings highlighted the differences between pre- and in-service science teachers and how community engagement affects and is associated with teachers' 21st-century skills (critical thinking, creativity, communication, and collaboration). In-service teachers consistently scored higher across all domains, particularly in communication and collaboration, likely because of their practical experience, professional exposure, and familiarity with the right terms, at least in the teaching experience. These findings align with those of [32] and [33], which emphasize the importance of real-world applications in skill development, as these real-world applications require the co-creation of solutions to address issues, such as climate change and conservation efforts, which also require clear and precise communication between community members.

In terms of critical thinking, in-service teachers significantly outperformed pre-service teachers, particularly chemistry teachers. This suggests that in-service teachers benefit from more frequent opportunities to apply critical thinking in real-world contexts, which helps sharpen these skills. This aligns with the studies on teacher development by [34] and [35]. Similarly, in-service teachers scored higher on creative thinking with their practical experience fostering innovation and adaptability, as noted in [36]. Collaboration scores were also higher for in-service teachers, reinforcing the idea that professional environments, such as schools, provide better opportunities for teamwork and collaboration than academic settings [37, 38]. Although in-service teachers had higher communication scores, these differences were not always significant. However, their greater exposure to diverse audiences in professional settings, such as parents and students, may give them a slight advantage in communication [39].

More precisely, the qualitative findings confirmed the significant role of community engagement in developing teachers' 21st-century skills [41], particularly critical thinking skills [42], collaboration, communication, and creativity. All teachers in the study highlighted that working with communities allowed them to apply theoretical knowledge in real-life situations, such as making daily decisions in their daily life situations, selecting water brand bottles that have a lower sodium ratio used to purify the water, thus improving their problem-solving and critical thinking skills using inquiry skills [41-44]. One participant noted that adapting complex scientific concepts for multicultural students required deep reflection, aligning with research on the importance of practical skills development experiences [33]. Collaboration with diverse groups was essential in fostering teamwork and open-mindedness, as teachers had to navigate different perspectives and work toward shared goals. This finding supports the finding that professional collaboration strengthens adaptability and teamwork [37]. Teachers also reported improvements in communication skills, as they needed to adjust their language and presentation styles for various audiences. This aligns with [39], who emphasized the role of diverse audiences in enhancing communication. Community engagement also promotes creativity, as teachers must develop innovative solutions to real-world challenges [36]. However, time constraints, limited resources, and institutional support barriers suggest the need for more structured support for these activities [38].

7. Implications and Recommendations

The findings indicate that in-service teachers demonstrate higher proficiency in 21st-century skills (critical thinking, creativity, communication, and collaboration) than pre-service teachers, largely because of the real-world experiences they accumulate over time. This underscores the importance of practical hands-on learning opportunities for pre-service teachers, which can better prepare them for future professional demands. Community engagement plays a vital role in developing these skills by offering teachers real-life scenarios in which to apply their theoretical knowledge. However, challenges such as limited resources, time constraints, and lack of institutional support hinder the full development of these skills, particularly for pre-service teachers.

This study offers several recommendations for future research. First, teacher education programs should integrate hands-on community-based projects to bridge the gap between theoretical knowledge and practical application. This would allow pre-service teachers to develop critical thinking skills and creativity in real-world contexts. In addition, schools and teacher-training institutions should provide more resources and formal support for community engagement activities. This may include allocating time within curricula, offering financial resources, and incentivizing participation in such projects to maximize skill development. Finally, both in-service and pre-service teachers should be provided with continuous professional development opportunities that focus on enhancing 21st-century skills, with an emphasis on collaboration and communication strategies for diverse audiences.

8. Conclusion

Embedding community engagement within the professional remit of both pre-service and in-service science teachers in the United Arab Emirates (UAE) is

pivotal for cultivating the constellation of 21st-century competencies—critical thinking, creativity, communication, and collaboration—that undergird a robust professional identity and, ultimately, enhance pupil attainment. The consistently higher performance of in-service teachers relative to their pre-service counterparts can be ascribed to their sustained exposure to authentic classroom contexts and to the prescriptive demands of the UAE science curriculum, which require educators to design learning experiences that enable students to transfer scientific knowledge to the resolution of everyday challenges.

Structured participation in community-based projects bridges theory and practice, enabling teachers to operationalise pedagogical constructs in situ and to internalise reflective, evidence-informed approaches. These findings reaffirm the imperative of systematically embedding authentic, context-relevant community experiences across the continuum of teacher preparation and professional development. To close the observed skills gap, pre-service programmes and in-service qualifications should incorporate scaffolded, institutionally supported placements that facilitate meaningful collaboration with community stakeholders while attenuating pervasive barriers such as limited time, insufficient resources, and inconsistent administrative backing.

Declarations

Author Contributions

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All authors have read and approved the final manuscript.

Data Availability Statement

Data are available from the corresponding author upon reasonable request; public access is restricted to protect participant confidentiality.

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The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of Al Ain University (protocol GP-321-2024, 6 March 2024).

Informed Consent Statement

Written informed consent was obtained from all participants.

Conflicts of Interest

The authors declare no conflicts of interest. All ethical standards—including those regarding plagiarism, informed consent, data integrity, duplicate publication, and redundancy—were rigorously observed.

References

[1] Valtonen, T.; Hoang, N.; Sointu, E.; Näykki, P.; Virtanen, A.; Pöysä-Tarhonen, J.; Häkkinen, P.; Järvelä, S.; Mäkitalo, K.; Kukkonen, J. How Pre-service Teachers Perceive Their 21st-Century Skills and Dispositions: A Longitudinal Perspective. *Computers in Human Behavior,* 2021, *116*, 106643. https://doi.org/10.1016/j.chb.2020.106643.

[2] Khaleel Alarbi; Mohanad Halaweh; Tairab, H.; Najeh Rajeh Alsalhi; Annamalai, N.; Aldarmaki, F. Making a Revolution in Physics Learning in High Schools with ChatGPT: A Case Study in UAE. *Eurasia Journal of Mathematics Science and Technology Education* 2024, *20*(9) em2499–em2499. https://doi.org/10.29333/ejmste/14983.

[3] Lamb, R.; Etopio, E. A. Virtual Reality: A Tool for Pre-service Science Teachers to Put Theory into Practice. *Journal of Science Education and Technology* 2020, *29*(4) 573–585. https://doi.org/10.1007/s10956-020-09837-5.

[4]Liesa-Orús, M.; Latorre-Cosculluela, C.; Vázquez-Toledo, S.; Sierra-Sánchez, V. The Technological Challenge Facing Higher Education Professors: Perceptions of ICT Tools for Developing 21st Century Skills. *Sustainability*2020, *12*(13) 5339. https://doi.org/10.3390/su12135339.

[5] Pahl-Wostl, C.; Tàbara, D.; Bouwen, R.; Craps, M.; Dewulf, A.; Mostert, E.; Ridder, D.; Taillieu, T. The Importance of Social Learning and Culture for Sustainable Water Management. *Ecological Economics* 2008, *64*(3) 484–495. https://doi.org/10.1016/j.ecolecon.2007.08.007.

[6]Adams, R.; Martin, S.; Boom, K. University Culture and Sustainability: Designing and Implementing an Enabling Framework. *Journal of Cleaner Production* 2018, *171*, 434–445. https://doi.org/10.1016/j.jclepro.2017.10.032.

[7] Zygmunt-Fillwalk, E.; Malaby, M.; Clausen, J. *The Imperative of Contextual Cognizance: Pre-service*

Teachers and Community Engagement in the Schools and Communities Project; 2010. https://files.eric.ed.gov/fulltext/EJ896070.pdf (accessed 2025-05-10).
[8] Mochizuki, Y.; Bryan, A. Climate Change Education in the Context of Education for Sustainable Development: Rationale and Principles. *Journal of Education for Sustainable Development* 2015, *9*(1) 4–26. https://doi.org/10.1177/0973408215569109.
[9] Hughes, V.; Delva, S.; Nkimbeng, M.; Spaulding, E.; Turkson-Ocran, R.-A.; Cudjoe, J.; Ford, A.; Rushton, C.; D'Aoust, R.; Han, H.-R. Not Missing the Opportunity: Strategies to Promote Cultural Humility among Future Nursing Faculty. *Journal of Professional Nursing* 2020, *36*(1) 28–33. https://doi.org/10.1016/j.profnurs.2019.06.005.
[10] Hsu, H. C. Does Social Participation by the Elderly Reduce Mortality and Cognitive Impairment? *Aging & Mental Health* 2007, *11*(6) 699–707. https://doi.org/10.1080/13607860701366335.
[11] Agopian, T. Online Instruction during the Covid-19 Pandemic: Creating a 21st Century Community of Learners through Social Constructivism. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas* 2022, *95*(2) 1–5. https://doi.org/10.1080/00098655.2021.2014774.
[12] Giles-Corti, B.; Vernez-Moudon, A.; Reis, R.; Turrell, G.; Dannenberg, A. L.; Badland, H.; Foster, S.; Lowe, M.; Sallis, J. F.; Stevenson, M.; Owen, N. City Planning and Population Health: A Global Challenge. *The Lancet* 2016, *388*(10062) 2912–2924. https://doi.org/10.1016/s0140-6736[16] 30066-6.
[13] Mitsea, E.; Drigas, A.; Mantas, P. Soft Skills & Metacognition as Inclusion Amplifiers in the 21st Century. *International Journal of Online and Biomedical Engineering [iJOE]* 2021, *17*(04) 121. https://doi.org/10.3991/ijoe.v17i04.20567.
[14] Michalski, J. H.; Cunningham, T.; Henry, J. The Prospects and Challenges of Increased Access and Student Success. *Humboldt Journal of Social Relations* 2017, *39*, 66–89. https://doi.org/10.2307/90007872.
[15] YEŞİLÇINAR, S.; AYKAN, A. Lesson Study and 21st-Century Skills: Pre-service Teachers Reason, Produce and Share. *Participatory Educational Research* 2022, *9*(3) 315–329. https://doi.org/10.17275/per.22.68.9.3.
[16] Maruskin, J. B. 21st-Century Skills and Pre-service Teacher Education. *Informed Transitions: Libraries Supporting the High School to College Transition* 2013, 141.
[17] Bedir, H. Pre-service ELT Teachers' Beliefs and Perceptions on 21st Century Learning and Innovation Skills (4Cs) .*Dil ve Dilbilimi Çalışmaları Dergisi* 2019, *15*(1) 231–246. https://doi.org/10.17263/jlls.547718.
[18] Urbani, J.; Roshandel, S.; Michaels, R.; Truesdell, E. *Developing and Modeling 21st-Century Skills with Pre-service Teachers*; 2017. https://files.eric.ed.gov/fulltext/EJ1157317.pdf.
[19] Hoon, T. S.; Muthukrishnan, P.; Choo, K. A.; Kam, N. K. B. M. Z.; Singh, P. Pre-service teachers' motivation and adoption of 21st-century skills. *Computer-Assisted Language Learning Electronic Journal* 2022*, 23*, 205–218.
[20] Dippenaar, H.; Human-Vogel, S.; van der Linde, M. Exploring Experiences of Pre-service Teachers in Community Engagement: Let Us Work in Communities! *Educational Research for Social Change* 2015*, 4*, 55–67.
[21] van Laar, E.; van Deursen, A. J. A. M.; van Dijk, J. A. G. M.; de Haan, J. Determinants of 21st-Century Skills and 21st-Century Digital Skills for Workers: A Systematic Literature Review. *SAGE Open* 2020, *10*(1) 215824401990017. https://doi.org/10.1177/2158244019900176.
[22] Evans, M. P. Educating Pre-service Teachers for Family, School, and Community Engagement. *Teaching Education* 2013, *24*(2) 123–133. https://doi.org/10.1080/10476210.2013.786897.
[23] Chambers, D. J.; Lavery, S. Service-Learning: A Valuable Component of Pre-service Teacher Education. *Australian Journal of Teacher Education* 2012, *37*(4). https://doi.org/10.14221/ajte.2012v37n4.2.
[24] Myers, J. P.; Rivero, K. Preparing Globally Competent Pre-service Teachers: The Development of Content Knowledge, Disciplinary Skills, and Instructional Design. *Teaching and Teacher Education* 2019, *77*, 214–225. https://doi.org/10.1016/j.tate.2018.10.008.
[25] Kaushik, V.; Walsh, C. A. Pragmatism as a Research Paradigm and Its Implications for Social Work Research. *Social Sciences* 2019, *8*(9) 1–17. https://doi.org/10.3390/socsci8090255.
[26] Taherdoost, H. Sampling Methods in Research Methodology; How to Choose a Sampling Technique for Research. *International Journal of Academic Research in Management* 2016, *5*(2) 18–27. https://doi.org/10.2139/ssrn.3205035.
[27] Braun, V.; Clarke, V. Using Thematic Analysis in Psychology. *Qualitative Research in Psychology* 2006, *3*(2) 77–101. https://doi.org/10.1191/1478088706qp063oa.
[28] Dawadi, S. Thematic Analysis Approach: A Step by Step Guide for ELT Research Practitioners. *Journal of NELTA* 2020, *25*(1-2) 62–71. https://doi.org/10.3126/nelta.v25i1-2.49731.
[29] Maguire, M.; Delahunt, B. Doing a Thematic Analysis: A Practical, Step-By-Step Guide for Learning and Teaching Scholars. *All Ireland Journal of Higher Education* 2017, *9*(3). https://doi.org/10.62707/aishej.v9i3.335.
[30] Christou, P. A. How to Use Thematic Analysis in Qualitative Research. *Journal of Qualitative Research*

in Tourism 2022, *3*(2) 79–95. https://doi.org/10.4337/jqrt.2023.0006.
[31] Nowell, L. S.; Norris, J. M.; White, D. E.; Moules, N. J. Thematic analysis: Striving to meet the trustworthiness criteria. *International journal of qualitative methods* 2017, *16*, 1609406917733847.
[32] Fukkink, R.; Helmerhorst, K.; Gevers Deynoot-Schaub, M.; Sluiter, R. Training Interaction Skills of Pre-service ECEC Teachers: Moving from In-Service to Pre-service Professional Development. *Early Childhood Education Journal* 2019, *47*(4) 497–507. https://doi.org/10.1007/s10643-019-00928-6.
[33] Guggemos, J.; Seufert, S. Teaching with and Teaching about Technology – Evidence for Professional Development of In-Service Teachers. *Computers in Human Behavior* 2021, *115*, 106613. https://doi.org/10.1016/j.chb.2020.106613.
[34] Cáceres, M.; Nussbaum, M.; Ortiz, J. Integrating Critical Thinking into the Classroom: A Teacher's Perspective. *Thinking Skills and Creativity* 2020, *37*, 100674. https://doi.org/10.1016/j.tsc.2020.100674.
[35] Changwong, K.; Sukkamart, A.; Sisan, B. Critical Thinking Skill Development: Analysis of a New Learning Management Model for Thai High Schools. *Journal of International Studies* 2018, *11*(2) 37–48. https://doi.org/10.14254/2071-8330.2018/11-2/3.
[36] Hammond, L. D.; Flook, L.; Cook-Harvey, C.; Barron, B.; Osher, D. Implications for Educational Practice of the Science of Learning and Development. *Applied Developmental Science* 2019, *24*(2) 97–140. https://doi.org/10.1080/10888691.2018.1537791.
[37] Gast, I.; Schildkamp, K.; van der Veen, J. T. Team-Based Professional Development Interventions in Higher Education: A Systematic Review. *Review of Educational Research* 2017, *87*(4) 736–767. https://doi.org/10.3102/0034654317704306.
[38] Love, H. B.; Cross, J. E.; Fosdick, B. K.; Tofany, E.; Dickmann, E. M. Teaching Team Science: The Key to Addressing 21st Century Global Challenges. *Small Group Research* 2022, 104649642211213. https://doi.org/10.1177/10464964221121349.
[39] D'Haem, J.; Griswold, P. Teacher Educators' and Student Teachers' Beliefs about Preparation for Working with Families Including Those from Diverse Socioeconomic and Cultural Backgrounds. *Education and Urban Society* 2016, *49*(1) 81–109. https://doi.org/10.1177/0013124516630602.
[40] Khalil, R. Y.; Tairab, H.; Qablan, A.; Khaleel Alarabi; Mansour, Y. STEM-Based Curriculum and Creative Thinking in High School Students. *Education Sciences* 2023, *13*(12), 1195–1195. https://doi.org/10.3390/educsci13121195.
[41] Ali, N.; Abu Khurma, O.; Alzouebi, K.; Jarrah, A.; Khine, M. S.; Albahti, F.; AlShannag, Q. Digital Skills and Science Achievement: Analyzing Socio-Economic Factors and Learning Views. *Educational Process International Journal* 2025, *15* (1). https://doi.org/10.22521/edupij.2025.15.120.
[42] Othman Abu Khurma; Farah El Zein. Inquiry Skills Teaching and Its Relationship with UAE Secondary School Students' Critical Thinking: Systematic Review of Science Teachers' Perspectives. *Eurasia journal of mathematics science and technology education* 2024, *20* (2), em2397–em2397. https://doi.org/10.29333/ejmste/14155.
[43] Jaberi, A.; KhadeeghaAlzouebi; Othman Abu Khurma. An Investigation into the Impact of Teachers' Emotional Intelligence on Students' Satisfaction of Their Academic Achievement. *Social sciences* 2024, *13* (5), 244–244. https://doi.org/10.3390/socsci13050244.
[44] Husband, T. *Selected Scholarship on Teaching and Learning at Illinois State University Developing 21st Century Skills in Teacher Education Through Digital Storytelling*; 2014. https://sotl.illinoisstate.edu/downloads/gauisus/HusbandVolume2.pdf?utm_source=chatgpt.com (accessed 2025-05-17).

参考文献

[1] Valtonen T. ; Hoang N. ; Sointu E. ; Näykki P. ; Virtanen A. ; Pöysä-Tarhonen J. ; Häkkinen P. ; Järvelä S. ; Mäkitalo K. ; Kukkonen J. 职前教师如何看待其 21 世纪技能与素质：纵向视角. *Computers in Human Behavior*, 2021, 116: 106643. https://doi.org/10.1016/j.chb.2020.106643
[2] Khaleel Alarbi ; Mohanad Halaweh ; Tairab H. ; Najeh Rajeh Alsalhi ; Annamalai N. ; Aldarmaki F. 借助 ChatGPT 变革高中物理学习：阿联酋案例研究 . *Eurasia Journal of Mathematics, Science and Technology Education*, 2024, 20(9): em2499. https://doi.org/10.29333/ejmste/14983
[3] Lamb R. ; Etopio E. A. 虚拟现实：帮助职前科学教师将理论付诸实践的工具. *Journal of Science Education and Technology*, 2020, 29(4): 573–585. https://doi.org/10.1007/s10956-020-09837-5
[4] Liesa-Orús M. ; Latorre-Cosculluela C. ; Vázquez-Toledo S. ; Sierra-Sánchez V. 高校教师面临的技术挑战：对 ICT 工具培养 21 世纪技能的感知. *Sustainability*, 2020, 12(13): 5339. https://doi.org/10.3390/su12135339
[5] Pahl-Wostl C. ; Tàbara D. ; Bouwen R. ; Craps M. ; Dewulf A. ; Mostert E. ; Ridder D. ; Taillieu T. 可持续水资源管理中的社会学习与文化的重要性. *Ecological Economics*, 2008, 64(3): 484–495. https://doi.org/10.1016/j.ecolecon.2007.08.007
[6] Adams R. ; Martin S. ; Boom K. 大学文化与可持续性：赋能框架的设计与实施. *Journal of Cleaner Production*, 2018, 171: 434–445. https://doi.org/10.1016/j.jclepro.2017.10.032

[7] Zygmunt-Fillwalk E. ; Malaby M. ; Clausen J. 情境意识的必要性：职前教师与“学校与社区项目”的社区参与. 2010. https://files.eric.ed.gov/fulltext/EJ896070.pdf （访问日期：2025-05-10）
[8] Mochizuki Y. ; Bryan A. 可持续发展教育背景下的气候变化教育：理念与原则. *Journal of Education for Sustainable Development*, 2015, 9(1): 4–26. https://doi.org/10.1177/0973408215569109
[9] Hughes V. ; Delva S. ; Nkimbeng M. ; Spaulding E. ; Turkson-Ocran R.-A. ; Cudjoe J. ; Ford A. ; Rushton C. ; D’Aoust R. ; Han H.-R. 把握机遇：促进未来护理教师文化谦逊的策略. *Journal of Professional Nursing*, 2020, 36(1): 28–33. https://doi.org/10.1016/j.profnurs.2019.06.005
[10] Hsu H. C. 老年人的社会参与能否降低死亡率与认知损伤？ *Aging & Mental Health*, 2007, 11(6): 699–707. https://doi.org/10.1080/13607860701366335
[11] Agopian T. 疫情期间的在线教学：通过社会建构主义创建 21 世纪学习共同体. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, 2022, 95(2): 1–5. https://doi.org/10.1080/00098655.2021.2014774
[12] Giles-Corti B. ; Vernez-Moudon A. ; Reis R. ; Turrell G. ; Dannenberg A. L. ; Badland H. ; Foster S. ; Lowe M. ; Sallis J. F. ; Stevenson M. ; Owen N. 城市规划与人口健康：全球挑战. *The Lancet*, 2016, 388(10062): 2912–2924. https://doi.org/10.1016/S0140-6736(16)30066-6
[13] Mitsea E. ; Drigas A. ; Mantas P. 软技能与元认知：21 世纪包容性的助推器. *International Journal of Online and Biomedical Engineering (iJOE)*, 2021, 17(4): 121. https://doi.org/10.3991/ijoe.v17i04.20567
[14] Michalski J. H. ; Cunningham T. ; Henry J. 扩大入学与学生成功的前景与挑战. *Humboldt Journal of Social Relations*, 2017, 39: 66–89. https://doi.org/10.2307/90007872
[15] Yeşilçınar S. ; Aykan A. 课例研究与 21 世纪技能：职前教师的思考、产出与分享. *Participatory Educational Research*, 2022, 9(3): 315–329. https://doi.org/10.17275/per.22.68.9.3
[16] Maruskin J. B. 21 世纪技能与职前教师教育. 见：*Informed Transitions: Libraries Supporting the High School to College Transition*, 2013: 141.
[17] Bedir H. 职前英语教师对 21 世纪学习与创新技能（4Cs）的信念与认知. *Dil ve Dilbilimi Çalışmaları Dergisi*, 2019, 15(1): 231–246. https://doi.org/10.17263/jlls.547718
[18] Urbani J. ; Roshandel S. ; Michaels R. ; Truesdell E. 与职前教师共同培养并示范 21 世纪技能. 2017. https://files.eric.ed.gov/fulltext/EJ1157317.pdf
[19] Hoon T. S. ; Muthukrishnan P. ; Choo K. A. ; Kam N. K. B. M. Z. ; Singh P. 职前教师的动机与 21 世纪技能采纳. *Computer-Assisted Language Learning Electronic Journal*, 2022, 23: 205–218.
[20] Dippenaar H. ; Human-Vogel S. ; van der Linde M. 职前教师的社区参与体验：让我们在社区中工作！ *Educational Research for Social Change*, 2015, 4: 55–67.
[21] van Laar E. ; van Deursen A. J. A. M. ; van Dijk J. A. G. M. ; de Haan J. 员工 21 世纪技能与数字技能的决定因素：系统性文献综述. *SAGE Open*, 2020, 10(1): 215824401990017. https://doi.org/10.1177/2158244019900176
[22] Evans M. P. 培养职前教师的家庭、学校与社区协作能力. *Teaching Education*, 2013, 24(2): 123–133. https://doi.org/10.1080/10476210.2013.786897
[23] Chambers D. J. ; Lavery S. 服务学习：职前教师教育的宝贵组成部分. *Australian Journal of Teacher Education*, 2012, 37(4). https://doi.org/10.14221/ajte.2012v37n4.2
[24] Myers J. P. ; Rivero K. 培养全球胜任力职前教师：内容知识、学科技能与教学设计的发展. *Teaching and Teacher Education*, 2019, 77: 214–225. https://doi.org/10.1016/j.tate.2018.10.008
[25] Kaushik V. ; Walsh C. A. 实用主义研究范式及其对社会工作研究的启示. *Social Sciences*, 2019, 8(9): 1–17. https://doi.org/10.3390/socsci8090255
[26] Taherdoost H. 研究方法中的抽样方法：如何选择抽样技术. *International Journal of Academic Research in Management*, 2016, 5(2): 18–27. https://doi.org/10.2139/ssrn.3205035
[27] Braun V. ; Clarke V. 心理学中的主题分析. *Qualitative Research in Psychology*, 2006, 3(2): 77–101. https://doi.org/10.1191/1478088706qp063oa
[28] Dawadi S. 主题分析方法：ELT 研究者的分步指南. *Journal of NELTA*, 2020, 25(1-2): 62–71. https://doi.org/10.3126/nelta.v25i1-2.49731
[29] Maguire M. ; Delahunt B. 进行主题分析：面向教学科研者的实践指南. *All Ireland Journal of Higher Education*, 2017, 9(3). https://doi.org/10.62707/aishej.v9i3.335
[30] Christou P. A. 如何在定性研究中使用主题分析. *Journal of*

Qualitative Research in Tourism, 2022, 3(2): 79–95. https://doi.org/10.4337/jqrt.2023.0006
[31] Nowell L. S. ; Norris J. M. ; White D. E. ; Moules N. J. 主题分析：力求满足可信度标准. *International Journal of Qualitative Methods*, 2017, 16: 1609406917733847.
[32] Fukkink R. ; Helmerhorst K. ; Gevers Deynoot-Schaub M. ; Sluiter R. 职前幼教教师互动技能培训：从在职到职前的专业发展. *Early Childhood Education Journal*, 2019, 47(4): 497–507. https://doi.org/10.1007/s10643-019-00928-6
[33] Guggemos J. ; Seufert S. “用技术教学”与“教技术本身”——在职教师专业发展的证据. *Computers in Human Behavior*, 2021, 115: 106613. https://doi.org/10.1016/j.chb.2020.106613
[34] Cáceres M. ; Nussbaum M. ; Ortiz J. 将批判性思维融入课堂：教师视角. *Thinking Skills and Creativity*, 2020, 37: 100674. https://doi.org/10.1016/j.tsc.2020.100674
[35] Changwong K. ; Sukkamart A. ; Sisan B. 批判性思维技能发展：泰国高中新的学习管理模式分析. *Journal of International Studies*, 2018, 11(2): 37–48. https://doi.org/10.14254/2071-8330.2018/11-2/3
[36] Hammond L. D. ; Flook L. ; Cook-Harvey C. ; Barron B. ; Osher D. 学习与发展科学对教育实践的启示. *Applied Developmental Science*, 2019, 24(2): 97–140. https://doi.org/10.1080/10888691.2018.1537791
[37] Gast I. ; Schildkamp K. ; van der Veen J. T. 高等教育团队式专业发展干预：系统综述. *Review of Educational Research*, 2017, 87(4): 736–767. https://doi.org/10.3102/0034654317704306
[38] Love H. B. ; Cross J. E. ; Fosdick B. K. ; Tofany E. ; Dickmann E. M. 教授团队科学：应对 21 世纪全球挑战的关键. *Small Group Research*, 2022: 104649642211213. https://doi.org/10.1177/10464964221121349
[39] D’Haem J. ; Griswold P. 教师教育者与师范生对与不同社会经济与文化背景家庭合作准备的看法. *Education and Urban Society*, 2016, 49(1): 81–109. https://doi.org/10.1177/0013124516630602
[40] Khalil R. Y. ; Tairab H. ; Qablan A. ; Khaleel Alarabi ; Mansour Y. STEM 课程与高中生创造性思维. *Education Sciences*, 2023, 13(12): 1195. https://doi.org/10.3390/educsci13121195
[41] Ali N. ; Abu Khurma O. ; Alzouebi K. ; Jarrah A. ; Khine M. S. ; Albahti F. ; AlShannag Q. 数字技能与科学成绩：社会经济因素与学习观分析. *Educational Process International Journal*, 2025, 15(1). https://doi.org/10.22521/edupij.2025.15.120
[42] Othman Abu Khurma ; Farah El Zein. 探究技能教学与阿联酋中学生批判性思维的关系：对科学教师视角的系统综述. *Eurasia Journal of Mathematics, Science and Technology Education*, 2024, 20(2): em2397. https://doi.org/10.29333/ejmste/14155
[43] Jaberi A. ; Khadeegha Alzouebi ; Othman Abu Khurma. 教师情绪智力对学生学业满意度的影响. *Social Sciences*, 2024, 13(5): 244. https://doi.org/10.3390/socsci13050244
[44] Husband T. 伊利诺伊州立大学教学与学习研究精选：通过数字故事讲述在教师教育中培养 21 世纪技能. 2014. https://sotl.illinoisstate.edu/downloads/gauisus/HusbandVolume2.pdf （访问日期：2025-05-17）

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