Journal of Education and Development; Vol. 8, No. 2; May, 2024
ISSN 2529-7996 E-ISSN 2591-7250
Published by July Press

Survey of Teachers' Perception of Future School Learning Space

Baoping Li[1], Jieya Huang[1], Qiaochu Yang[1] & Yuhan Feng[1]

[1] Faculty of Education, Beijing Normal University, Beijing, China

Correspondence: Baoping Li, Faculty of Education, Beijing Normal University, Beijing, China. E-mail: libp@bnu.edu.cn

Received: March 15, 2024 Accepted: April 7, 2024 Online Published: May 5, 2024

doi:10.20849/jed.v8i2.1411 URL: https://doi.org/10.20849/jed.v8i2.1411

Abstract

The cultivation of students' core competencies is a worldwide issue. Transforming the learning environment to promote innovative pedagogy has become a trend. As a critical role in students' cultivation, teachers' perception of learning space has the direct effect on learning outcomes. This study aims to investigate the teachers' perception of the new learning space. A teacher's perception of future school learning space scale is developed to collect the data, which includes 8 subscales and 35 items, 355 teachers participated in the study. Result of Descriptive statistics and Independent-samples t-tests indicated that: (a) Future School Learning Space Scale is reliable and effective; (b) teachers' perception of Comfortability of learning space, Constructive Learning, Differentiation Learning are relative higher, Cloud Technology and Connectivity are both lower; (c) Teachers in different group, such as gender, teaching experience and type of school have significant difference in their perception of future learning space. Implications for Chinese future learning space design and construction have discussed.

Keywords: future learning space, teacher perception of learning space, teacher digital literacy, future school

1. Introduction

As the critical factor of education system, schools always focus on the requirements of society for students. Educational systems should empower learners with skills and competences to cope with a constantly changing world, cultivation of students' core competencies becomes a consensus in the 21st century. How to transform the previous school to facility the future education is the key task of various countries. In the context of future school, the education transformation emphasizing more on personalized and flexible education needs in the postindustrial era and on supporting teaching and learning approaches which are suitable for facilitating or enabling complex skills development, such as formative analytics, place-based learning, learning with robots (Herodotou *et al.*, 2019).

1.1 The Future School Learning Space

Learning space refers to a place and the surroundings where teaching and learning occur. The scope of learning space is always extent according the changes of learning style and technologies used in learning. At first, learning space in schools always refers to the formal learning location, like classrooms, laboratories, now the informal learning location, like libraries, outdoor sports field, museum etc. are included. As more and more emerging technologies integration into learning space, the learning space has expanded from physical forms to digital and online forms (Huang *et al.*, 2019). In this expanded learning space, the spatiotemporal concepts associated with learning activities have undergone disruptive changes. The COVID-19 has brought online learning into the limelight. It's possible that classrooms will be shared virtually with external pupils, providing learning to home students.

Learning space can accommodate learners and learning facilities, as well as meet the behavioral, physiological, and psychological needs of learning activities through the creation of a certain learning culture. The illumination, decoration colors, temperature, and layout of furniture can affect the physiological and psychological comfort. Illumination can optimize the students' emotions and enhance their level of excitement; different colors provide certain psychological implications for students; the flexibility of classroom activity channels, convenient access to equipment, and adjustable furniture can all affect the students learning experiences (Mogas-Recalde & Palau, 2021; Liu *et al.*, 2022). Wilson & Randall (2012) designed a "The Pod Room" space and found that the new type of space enhances teacher-student interaction and student-student interaction. Bdiwi *et al.* (2019) found that the

proper distance between teacher and students increase learners' learning motivation, participation, and learning effectiveness. A finding from a large-scale survey of smart classroom indicated that digital device and Internet were the basis for equipping smart classroom, technology equipment and advanced technology could lead to the success of learning (J. Yang *et al.*, 2018).

The 2017 Horizon Report (K-12 Edition) stated "redesigning learning spaces" as a trend of accelerating K–12 school transformation in future 3-5 years. The report predicted that "innovative thinking in architecture and space planning is influencing the sustainable design and construction of new school infrastructures. This has the potential to impact classroom practices and student learning significantly." (Freeman *et al.*, 2017) Learning spaces are designed to support, facilitate, stimulate, or enhance learning, and teaching. Previous studies have shown that the reasonable design the elements in learning space can beneficial for enhancing students' social interaction, improving their learning motivation, cultivating problem-solving ability, teamwork ability, and active learning ability.

1.2 Perception of Future Learning Space

Future learning space is technology rich learning space, so the study selected the research about teachers' perception of technology integrated learning space. Aldridge et al. (2004) developed the Technology Rich Outcomes Focused Learning Environment Inventory (TROFLEI), including 10 dimensions: Student Cohesiveness, Teacher Support, Involvement, Investigation, Task Orientation, Cooperation, Equity, Differentiation, Computer Usage and Young Adult Ethos. Wu *et al.* (2009) developed Technology Integrated Classroom Inventory (TICI) including 8 dimensions: Technological Enrichment, Inquiry Learning, Equity and Friendliness, Student Cohesiveness, Understanding and Encouragement, Competition and Efficacy, Audiovisual environment, and Order. Li *et al.* (2015) developed a smart classroom scale, which includes 10 dimensions: Physical Design, Flexibility, Technology Usage, Learning Data, Differentiation, Investigation, Cooperation, Students Cohesiveness, Equity, and Learning Experience, with a focus on obtaining learning data and spatial flexibility. MacLeod *et al.* (2018) developed a perception of smart classroom learning environments scale including 8 dimensions: Student Negotiation, Inquiry Learning, Reflective Thinking, Ease of Use, Perceived Usefulness, Multiple Sources, Connectedness, and Functional Design.

These instruments have been proven to effectively measure the teachers and students' perception of technology classrooms. The all focus on technology equipment and usage in classroom, the personalized leaning, constructivism learning, and interpersonal relationships. The later the instruments developed the more attention paid to learning data, and user experience on technology tools and digital learning resources. For future learning spaces, current research is more limited to the classroom environment in schools, the future learning space should not only be classroom space, but extends to campuses and even opens up to society, effectively meeting the needs of fragmented and informal learning for teachers and students, connect with real life, and meet diverse teaching and learning activities, the scenario about future learning space is concentrated into the follow aspects.

Firstly, the future learning space is an emerging technology-rich learning space. The use of Internet of Things technology will be widespread, with more devices and appliances connected to the internet, enabling greater automation and control over the school environment (What Could the School of 2050 Look Like?). The temperature, humidity, sound, air quality could be detected and adjusted automatically, it can provide green and comfortable learning space (Liu *et al.*, 2022). High speed network connectivity conduce hard drive storage replaced by virtual clouds; in-progress documents accessible from multiple devices. Virtual and augmented reality technology can create a sufficiently immersive and interactive learning space, even linked in with the real world. Secondly, the learning space is flexibility and openness. Future school learning space should design and iterate different modes of teaching and learning to meet the evolving needs of learners and the wider world. Schools should be seriously porous, with many active partners in organizing learning. It should be deeply connected to its local community (and to the global community through technology) to provide richer learning experiences and diverse pathways for learners (UCL, 2023). Thirdly, there is an increase in home school communication based on information-based learning platforms. This is because the family plays an indispensable role in the growth and learning process of students. Paying attention to communication between home and school is beneficial for teachers and parents to have a more comprehensive understanding of students and promote the development of adolescents (Epstein, 2013; Hod, 2017; Xue & Li, 2021).

Therefore, based on existing research on future learning spaces and the development trends of future learning spaces, this study develops a scale for future learning spaces based on teachers' perception of the environment as shown in Table 1.

Table 1. The description of future learning space instruments

Dimension	Description	Item sample
Comfortability (COM)	The indoor environment, such as air condition, illumination, temperature, furniture make people feel comfortable and safety.	There is no pungent odor in various places of the school
Connectivity (CON)	The learning space connect with other partners for sharing or exchanging resources online and offline.	School connects with other schools for learning resource sharing and public facility exchange.
Diversity (DIV)	Learning space with rich spatial scene design to meet the different learning scenario.	The school building uses energy-saving designs such as solar energy systems and rainwater recovery systems.
Cloud Technology (CT)	Cloud resources and cloud facility construction of the learning space	Online learning platform and system provide digital learning resources to assist teacher in teaching preparation.
Technology Application (TA)	The support of information technology for learning activities in learning space	Student assignments can be checked through online platforms or tools.
Differentiation Learning (DL)	The support of learning space for individualized teaching	Different learning tasks are designed for students based on their individual learning situation.
Constructive Learning (CL)	The support of learning space for constructive teaching	Students are required to provide some explanations or answers for their own tasks.
User Experience (UE)	The feelings of teaching and learning in learning spaces.	Online learning is more effective than offline learning.

1.3 Research Question

China is undergoing large-scale construction and renovation of future schools, it is necessary to investigate the teachers' perception of learning space for improvement of learning space designing (Zainuddin & Idrus, 2018). This study aimed at exploring teachers' perception of future learning space. This study attempted to answer the following research questions:

1) What are the teachers' perceptions of the new type learning space for schools future education transformation?

2) What aspects can be improved in the current school learning environment construction?

2. Methods

2.1 Participant Characteristics

A total of 355 teachers participated the survey online in the study. The demography of the participants is shown in Table 2.

Table 2. Demographic information of the participants (N=355)

Characteristics	Categories	Frequency	Percentage (%)
Gender	Female	287	80.2
	Male	68	19.8
Age	Lower than 30	88	24.7
	31-35	54	15.2
	36-40	55	15.5
	41-45	72	20.3
	46-50	61	17.2
	Upper than 50	25	7.0
Experience of Education	Bachelor	311	87.6
	Graduate	43	12.1
	Doctor	1	0.3
Years of Teaching Experience	Lower than 3	50	14.1
	3-5	36	10.1
	6-10	46	13
	11-20	87	24.5
	More than 20	136	38.3
Type of School	Elementary school	48	13.5
	Secondary school	160	45.1
	High school	39	11.0
	Elementary and secondary school	50	14.1
	Other	58	16.3

2.2 Instrument

The questionnaire consists of two parts: demographic information of participants and the level of perception of learning space, the description of each subscale is shown in Table 1. All items are designed on a 5-point Likert scale from 1 “almost never” to 5 “almost always”.

2.3 Data Analysis

All the data were analyzed by SPSS 25.0. Independent-samples t-tests were used to compare the differences between the different groups, including gender, teaching experience, and primary and elementary schools.

3. Results

3.1 Validation of the Instruments

According to exploratory factor analysis, the KMO value is 0.955 and the spherical test result is $p<0.001$, indicating that the data is suitable for factor analysis. The principal component method combined with orthogonal rotation was used for analysis, and the obtained item aggregation situation basically conforms to the preset classification (a total of 67.01% was explained by 8 factors). Items with factor loadings below 0.4 are deleted, as well as items with obvious duplicate loadings and logically difficult to explain, ultimately 35 valid items are retained.

Internal reliability was tested using the individual learner as a unit of analysis for the Cronbach’s alpha coefficient. As shown in Table 3, the Cronbach’s alpha coefficient is 0.96, the Cronbach’s alpha coefficients of each subscale ranged from 0.65 to 0.93.

Table 3. Factor loadings and Cronbach's alpha coefficient of the instrument

Dimension	Item	Loading factor	α
Comfortability	There is no pungent odor in various places of the school	0.77	0.65
	Teacher and students will not be disturbed by the sound of adjacent classrooms during teaching	0.74	
	The classrooms in school have good lighting conditions and can clearly watch the content on blackboard	0.56	
	School is equipped with classrooms that can freely assemble seats and desks	0.51	
Connectivity	School supports remote class observation for avoiding disruptions to classroom teaching.	0.71	0.74
	School has installed an access control system and requires identity recognition to enter the relevant premises.	0.67	
	School connects with other schools for learning resource sharing and public facility exchange.	0.62	
Diversity	Different functional spaces on your campus are distinguished using different color designs.	0.64	0.83
	The school building uses energy-saving designs such as solar energy systems and rainwater recovery systems.	0.63	
	In schools, people can touch and feel natural elements such as flowers, plants, trees, flowing water, insects, etc.	0.58	
	The school's corridors and other connecting spaces are designed with educational significance, such as campus cultural walls, corridor museums, etc.	0.53	
	There are some temporary spaces in the school that students can use to discuss or do homework.	0.44	
Cloud Technology	Online learning platform and system provide digital learning resources to assist teacher in teaching preparation.	0.74	0.86
	School has classrooms specifically designed for remote teaching, which can be used for online teaching activities.	0.74	
	Teacher can use campus account to book school resources such as libraries or conference rooms.	0.62	
	Teacher can access school teaching resources anytime through your mobile phone.	0.61	
Technology Application	Student assignments can be checked through online platforms or tools.	0.78	0.87
	Extracurricular learning resources can be delivered to students through online platforms.	0.76	
	Teacher and students communicated by online platforms or social network.	0.60	
	Students are asked to submit assignments through online platforms.	0.75	
	Through technical support, teacher can pay attention to each student in the class.	0.41	
Differentiation Learning	Different learning tasks are designed for students based on their individual learning situation.	0.83	0.93

	Students are evaluated using different standards based on their individual learning situation.	0.80	
	Different learning goals are set for students based on their individual learning situation.	0.80	
	Different learning content are recommended to students based on their individual learning situation.	0.63	
Cooperation Learning	Students are required to provide some explanations or answers for their own tasks.	0.77	0.90
	When students express some opinions, some evidence should be provided.	0.75	
	Students collaborate with other classmates to complete a learning task.	0.72	
	Some guidance are provided for students to design and implement their tasks.	0.66	
	Students have the chance of collaborating with their parents or classmates from other classes to complete a learning task.	0.47	
User Experience:	By utilizing devices and software, people can directly access to learning objects or immerse oneself in the situation.	0.58	0.78
	The devices or software in the classroom are easy to use.	0.49	
	The blended learning method of online and offline is more likely to stimulate students' learning motivation.	0.43	
	Online teaching implementation is very smoothly	0.53	
	Online learning is more effective than offline learning.	0.75	

The study used Pearson correlation analysis to obtain the correlation analysis between various factors. Result is shown in Table 4, it can be seen that these 8 factors are significantly positively correlated at the 0.01 level. The degree of correlation between various dimensions is relatively high.

Table 4. Pearson correlation coefficients for each subscale

	COM	CON	DIV	CT	TA	DL	CL	UE
COM	1	0.43**	0.58**	0.44**	0.40**	0.40**	0.39**	0.45**
CON		1	0.61**	0.59**	0.53**	0.44**	0.43**	0.47**
DIV			1	0.64**	0.66**	0.60**	0.61**	0.65**
CT				1	0.65**	0.53**	0.53**	0.66**
TA					1	0.72**	0.77**	0.73**
DL						1	0.86**	0.69**
CL							1	0.71**
UE								1

*Note. **p<.01*

3.2 Teachers' Perception of Future School Learning Space

The result of descriptive statistical in Table 5 shows that teachers' perception of Comfortability of learning space

is highest among the 8 subscales (3.88), and then Cooperation Learning (3.74), Differentiation Learning (3.70), User Experience (3.30), Technology Application (3.27), Diversity (3.10). Cloud Technology (2.84) and Connectivity (2.54) are both under average 3. China have promoted teachers to integrate technologies into their teaching innovation and transformation for almost decade years and initiated a classroom lighting renovation plan to prevent myopia among students. As the result of such works, the classroom environment is relative good, and teachers are familiar with constructivism teaching (Swanson & Valdois, 2022). Although Covid-19 has promote online learning in China, after the pandemic there are widespread criticism of students' inappropriate use of mobile phones, so it make teachers unwilling to use online learning in the class, the item "Students are asked to submit assignments through online platforms."(2.26) and "Through technical support, teacher can pay attention to each student in the class."(3.02) are very low. Cloud Technology and Connectivity are the new trend in technology application in learning space, so both have low perception.

Table 5. Teacher's perception of Future School Environment (N=355)

Item	Mean	Std
Comfortability: Mean =3.88 Std =0.84		
There is no pungent odor in various places of the school	4.12	1.12
Teacher and students will not be disturbed by the sound of adjacent classrooms during teaching	3.77	1.10
The classrooms in school have good lighting conditions and can clearly watch the content on blackboard	4.47	0.83
School is equipped with classrooms that can freely assemble seats and desks	3.14	1.66
Connectivity: Mean =2.54 Std =1.19		
School supports remote class observation for avoiding disruptions to classroom teaching.	2.40	1.49
School has installed an access control system and requires identity recognition to enter the relevant premises.	2.42	1.52
School connects with other schools for learning resource sharing and public facility exchange.	2.79	1.39
Diversity: Mean =3.10 Std=1.06		
Different functional spaces on your campus are distinguished using different color designs.	2.62	1.45
The school building uses energy-saving designs such as solar energy systems and rainwater recovery systems.	2.39	1.51
In schools, people can touch and feel natural elements such as flowers, plants, trees, flowing water, insects, etc.	3.52	1.29
The school's corridors and other connecting spaces are designed with educational significance, such as campus cultural walls, corridor museums, etc.	3.71	1.23
There are some temporary spaces in the school that students can use to discuss or do homework.	3.26	1.44
Cloud Technology: Mean=2.84, Std=1.18		
Online learning platform and system provide digital learning resources to assist teacher in teaching preparation.	3.10	1.35
School has classrooms specifically designed for remote teaching, which can be used for online teaching activities.	2.81	1.44
Teacher can use campus account to book school resources such as libraries or conference rooms.	2.49	1.43

Teacher can access school teaching resources anytime through your mobile phone.	2.97	1.39
Technology Application: Mean=3.27, Std=1.02		
Student assignments can be checked through online platforms or tools.	3.73	1.20
Extracurricular learning resources can be delivered to students through online platforms.	3.75	1.23
Teacher and students communicated by online platforms or social network.	3.61	1.25
Students are asked to submit assignments through online platforms.	2.26	1.36
Through technical support, teacher can pay attention to each student in the class.	3.02	1.32
Differentiation Learning: Mean=3.70, Std=1.011		
Different learning tasks are designed for students based on their individual learning situation.	3.75	1.06
Students are evaluated using different standards based on their individual learning situation.	3.74	1.12
Different learning goals are set for students based on their individual learning situation.	3.72	1.08
Different learning content are recommended to students based on their individual learning situation.	3.61	1.18
Cooperation Learning: Mean=3.74, Std=0.86		
Students are required to provide some explanations or answers for their own tasks.	3.95	0.91
When students express some opinions, some evidence should be provided.	3.93	0.92
Students collaborate with other classmates to complete a learning task.	3.99	0.92
Some guidance are provided for students to design and implement their tasks.	3.61	1.10
Students have the chance of collaborating with their parents or classmates from other classes to complete a learning task.	3.20	1.24
User Experience: Mean=3.30, Std=0.81		
By utilizing devices and software, people can directly access to learning objects or immerse oneself in the situation.	3.42	1.18
The devices or software in the classroom are easy to use.	3.67	1.05
The blended learning method of online and offline is more likely to stimulate students' learning motivation.	3.53	1.13
Online teaching implementation is very smoothly	3.51	1.05
Online learning is more effective than offline learning.	2.40	1.14

3.3 Difference of Teacher Perception of the Learning Environment

The female teachers' perception is higher than male teachers', and there are significant differences in Diversity, Cloud Technology, Technology Application, Differentiation Learning, and Cooperation Learning (show in Table 6).

Table 6. Comparison of perception of the learning environment between female and male teachers

Dimension	Female (N=287)		Male(N=68)		t
	Mean	Std.	Mean	Std.	
Comfortability	3.88	0.85	3.87	0.83	0.68
Connectivity	2.58	1.22	2.35	1.06	1.46
Diversity	3.17	1.04	2.81	1.13	2.38*
Cloud Technology	2.91	1.20	2.55	1.09	2.41**
Technology Application	3.34	1.01	2.98	1.05	2.69**
Differentiation Learning	3.78	0.97	3.37	1.11	2.85**
Constructive Learning	3.80	0.85	3.49	0.89	2.56*
User Experience	3.34	0.76	3.14	0.87	1.78

*p <.05, **p<.01

Teachers with long teaching experience have relative higher perception of learning space, especially in Technology Application and Cooperation Learning, as show in Table 7.

Table 7. Comparison of perception of the learning environment between teaching experience

Dimension	<10 years(N=132)		>10 years(N=223)		t
	Mean	Std.	Mean	Std.	
Comfortability	3.90	0.89	3.86	0.82	0.41
Connectivity	2.56	1.18	2.52	1.20	0.29
Diversity	3.17	1.06	3.06	1.07	0.86
Cloud Technology	2.82	1.10	2.86	1.23	-0.28
Technology Application	3.09	1.04	3.38	1.00	-2.61**
Differentiation Learning	3.58	1.00	3.78	1.02	-1.83
Constructive Learning	3.56	0.91	3.84	0.82	-2.96**
User Experience	3.22	0.85	3.36	0.77	-1.52

**p<.01

Secondary school teachers have relative higher perception of learning space, especially in Comfortability, Diversity and Differentiation Learning, as show in Table 8.

Table 8. Comparison of perception of elementary schools and secondary schools

Dimension	Elementary (N=48)		Secondary (N=247)		t
	Mean	Std.	Mean	Std.	
Comfortability	3.64	0.92	3.96	0.81	-2.26*
Connectivity	2.31	1.28	2.56	1.19	-1.29
Diversity	2.74	0.98	3.15	1.05	-2.58*
Cloud Technology	2.57	1.19	2.87	1.19	-1.62
Technology Application	3.03	1.01	3.30	1.01	-1.67
Differentiation Learning	3.41	0.97	3.73	1.02	-2.05*
Constructive Learning	3.53	0.84	3.76	0.89	-1.72
User Experience	3.17	0.89	3.33	0.79	-1.18

*p <.05

4. Discussion

The results indicate that the Future School Learning Space Scale is reliable and effective. The survey results confirm that existing future learning spaces generally meet the needs of teachers in terms of Comfortability, Differentiation Learning, and Constructive Learning. However, in terms of Technological application, Cloud Technology, Diversity of learning space construction is not mature enough. Teachers in different group, such as gender, teaching experience and type of school have significant difference in their perception of future learning space.

Based on the statistic of Chinese MOE, female teachers account for over 59% in secondary schools and over 69% in primary schools. As the majority of teachers, the female teachers undertake important teaching tasks, this group has received comprehensive and systematic pedagogical training and practice. We think maybe this is the reason why female teachers have significant higher scores in Technology Application, Differentiation Learning, and Constructive Learning. The differences in teaching experience among teachers are also very similar, teachers with more than 10 years teaching experience have significant higher scores in Technology Application, and Constructive Learning. Of course, we notice that they have lower scores in Connectivity, and Diversity. The two dimensions are some new characters in future learning environment, we think teachers with longer teaching experience always mean most of them are elder, they need more time to learn and adapt the new environment. The secondary school teachers have higher scores than the elementary schools, especially have significant differences in Comfortability, Diversity, and Differentiation Learning. In China, secondary schools have relative larger students scale than elementary schools, then the secondary schools have more investment in learning space. China implements 9-year compulsory education, this means secondary school students have the competition to enter high schools, under this circumstance secondary school teachers will tent to apply the technology to tailored teaching than the elementary school teachers.

Based on our analysis and explanation of the result, this study provides the following suggestions for the future learning space construction.

4.1 Focus on Learning Space Construction for the New Learning Scenario

As we mentioned at the beginning of the paper, to facilitate student's complex skills development for the future society, the school must transform the traditional pedagogy to constructive form, and give students more choice in learning contents. The learning space should strengthen the in-school life's connection to the real world and real working space, and find the economic approach to supply diversity and high-quality learning resources to students. Internet of Things and the sensors should integrate into the physical learning space to enhance the perception abilities of learning environment, and present the authentic feedback to students, or open up scientific landscapes in school garden for students to conduct scientific observation, and project-based learning. By this way, some critical social issues, like energy, environmental protection, and climate change can integrate into the design of school buildings, make the schools learning space itself to be the learning topics and learning resources.

4.2 Focus on Cloud Technology in Learning Space

Online learning enables students to learn anything on anytime in anywhere, and to analyze student' learning process for adaptive learning (Anderson, 2020). During the COVID-19 pandemic, Chinese Ministry of Education has proposed a policy of "suspending classes without stopping learning", which enable teachers and students, and parents to realize the ability of online learning to enrich the students learning content, and to facilitate collaborative communication between school education and family education. For example, homework can assignment online, at the end of the lesson students can download the homework, submit it remotely, and track overall assessments. Parents and teachers will be able to track progress, addressing issues when they arise (Yan *et al.*, 2021). Based on the online merged offline learning, the future learning space should build a digital twin campus, strengthen blended learning and resource sharing and exchange, expand campus openness through cloud technology (Roda-Sanchez *et al*., 2024).

4.3 Focus on Low-cost Solutions for New Generation Learning Space Construction

The elementary school teachers' perception of construction condition of learning space are significantly lower than those of secondary school teachers. The study thinks the difference in financial investment between elementary and secondary schools is the most important reason, and the gap maybe even larger between urban and rural schools. For the reason of educational equity, it is necessary to find economical solutions for future learning space design and building (Guo & Wan, 2022). Schools can design school-based courses and learning spaces based on their nature environment and local culture. In terms of technological space construction, more

robust and alternative solutions should be provided for schools to choose. High-quality learning resources and cloud application should be accessed and used freely as the national public learning service for all the schools (Yan et al., 2021).

4.4 Focus on Improving the Teachers' Teaching Ability in Future Learning Space

As an important part of education ecology, learning space affects teacher's pedagogical approach, student learning outcomes (Zuo *et al.*, 2022). The result of the survey shows that teachers have a relatively low score in the subscales of Technology Application, Diversity, Cloud Technology and Connectivity. The result indicates that teachers do not aware enough of the biggest possible change in their future working places, some new specific topics should be added into the professional development training of Chinese teachers (Din çer, 2018).

Firstly, some teachers should change their negative attitude to the mobile intelligent terminal, especially when generative artificial intelligence begin to instruct the students basic knowledges and skills, mobile intelligent terminal acts as an expert for students to learn anytime, anywhere. under the circumstance teachers should adapt to their new role as student's guides and focus on designing and evaluating the achievement of advanced learning tasks for students with the support of technology (Chai *et al.*, 2023; Parkman *et al.*, 2018). Secondly, teachers should proficient in integrating students' data from online and offline, analyzing and diagnosing the overall learning process of students, and make a comprehensive learning recommendations blend school and home education, online and offline learning, formal and informal learning (Lin *et al.*, 2023; Yang *et al.*, 2023). Thirdly, teachers should reflect the connection between learning space and the specific pedagogy, proactively transforming and utilizing learning spaces based on teaching demands, leveraging the learning space for support and strengthening their designed learning activities (Li & Zhao, 2019).

5. Conclusion

This study investigated Chinese teachers' perception of future school learning space by developing the Future School Learning Space Scale, which including 8 subscales and 35 items. Result indicated that the scale is reliable and effective. For decades yeas of teachers training in the area of integration information and communication technologies into teaching and learning, Chinese teachers' perception of Comfortability of learning space, Constructive Learning, Differentiation Learning are relative higher, while perception of some new scenario in the learning space like Cloud Technology and Connectivity are both lower. Teachers in different group, such as gender, teaching experience and type of school have significant differences in their perception of future learning space.

This study contributes to the teacher development area by the Future School Learning Space Scale, which could provide a framework for observing and understanding how the teachers apply and experience their working place. This study also contributes to design and building future learning space by expanding crucial features of future school like Connectivity, and emerging technology like Cloud Technology, which could help the school administrators make the decision align with future development trends for their schools' improvement.

This study yields some limitations. The first limitation of this study is that a self-report survey was used to collect the data. The second limitation of the study is that many participants from rural schools do not have enough experiences of new type learning space. Further study could collect multimodal data generated in authentic teaching and learning process by smart environments to deepen these findings.

Acknowledgements

This work was funded by the 2020 Beijing Educational Plan Office Priority Projects "The Research on Future School Based on Information Communication and Network Technology" under projects number CHEA2020024.

References

Aldridge, J., Dorman, P., & Fraser, B. (2004). Use of Multitrait-Multimethod Modelling to Validate Actual and Preferred Forms of theTechnology-Rich Outcomes-Focused Learning Environment Inventory (Troflei). *Australian Journal of Educational & Developmental Psychology*, *4*.

Anderson, M. (2020, October 8). *Cloud Technologies in the Education System*. IEEE Computer Society. Retrieved from https://www.computer.org/publications/tech-news/build-your-career/cloud-technologies-in-the-education-system/

Bdiwi, R., De Runz, C., Faiz, S., & Cherif, A. (2019). Smart learning environment: Teacher's role in assessing classroom attention. *Research in Learning Technology*, *27*. https://doi.org/10.25304/rlt.v27.2072

Chai, C. S., Liang, S., & Wang, X. (2023). A survey study of chinese teachers' continuous intentions to teach artificial intelligence. *Education and Information Technologies*.

https://doi.org/10.1007/s10639-023-12430-z

Dinçer, S. (2018). Are preservice teachers really literate enough to integrate technology in their classroom practice? Determining the technology literacy level of preservice teachers. *Education and Information Technologies*, *23*(6), 2699-2718. https://doi.org/10.1007/s10639-018-9737-z

Epstein, J. L. (2013). Ready or not? Preparing future educators for school, family, and community partnerships. *Teaching Education*, *24*(2), 115-118. https://doi.org/10.1080/10476210.2013.786887

Freeman, A., Becker, S. A., & Cummins, M. (2017). *NMC/CoSN Horizon Report: 2017 K-12 Edition*. Retrieved from http://www.editlib.org/p/182003

Guo, C., & Wan, B. (2022). The digital divide in online learning in China during the COVID-19 pandemic. *Technology in Society*, *71*, 102122. https://doi.org/10.1016/j.techsoc.2022.102122

Herodotou, C., Sharples, M., Gaved, M., Kukulska-Hulme, A., Rienties, B., Scanlon, E., & Whitelock, D. (2019). Innovative Pedagogies of the Future: An Evidence-Based Selection. *Frontiers in Education*, *4*. Retrieved from https://www.frontiersin.org/articles/10.3389/feduc.2019.00113

Hod, Y. (2017). Future Learning Spaces in Schools: Concepts and Designs from the Learning Sciences. *Journal of Formative Design in Learning*, *1*(2), 99-109. https://doi.org/10.1007/s41686-017-0008-y

Huang, R., Spector, J. M., & Yang, J. (2019). Learning Space Design. In R. Huang, J. M. Spector, & J. Yang (Eds.), *Educational Technology: A Primer for the 21st Century* (pp. 149-164). Springer. https://doi.org/10.1007/978-981-13-6643-7_9

Li, B., & Zhao, G. (2019). Expectations and Experiences of Technology-Rich Classrooms of Preservice and In-service Teachers in China. *Journal of Education and Development*, *3*, 52. https://doi.org/10.20849/jed.v3i3.673

Li, B., Kong, S. C., & Chen, G. (2015). Development and validation of the smart classroom inventory. *Smart Learning Environments*, *2*(1), 3. https://doi.org/10.1186/s40561-015-0012-0

Lin, R., Yang, J., Jiang, F., & Li, J. (2023). Does teacher's data literacy and digital teaching competence influence empowering students in the classroom? Evidence from China. *Education and Information Technologies*, *28*(3), 2845-2867. https://doi.org/10.1007/s10639-022-11274-3

Liu, C., Zhang, Y., Sun, L., Gao, W., Zang, Q., & Li, J. (2022). The effect of classroom wall color on learning performance: A virtual reality experiment. *Building Simulation*, *15*(12), 2019-2030. https://doi.org/10.1007/s12273-022-0923-y

MacLeod, J., Yang, H. H., Zhu, S., & Li, Y. (2018). Understanding students' preferences toward the smart classroom learning environment: Development and validation of an instrument. *Computers & Education*, *122*, 80-91. https://doi.org/10.1016/j.compedu.2018.03.015

Mogas-Recalde, J., & Palau, R. (2021). Classroom Lighting and Its Effect on Student Learning and Performance: Towards Smarter Conditions. In Ó. Mealha, M. Rehm, & T. Rebedea (Eds.), *Ludic, Co-design and Tools Supporting Smart Learning Ecosystems and Smart Education* (pp. 3-12). Springer. https://doi.org/10.1007/978-981-15-7383-5_1

Parkman, S., Litz, D., & Gromik, N. (2018). Examining pre-service teachers' acceptance of technology-rich learning environments: A UAE case study. *Education and Information Technologies*, *23*(3), 1253-1275. https://doi.org/10.1007/s10639-017-9665-3

Roda-Sanchez, L., Cirillo, F., Solmaz, G., Jacobs, T., Garrido-Hidalgo, C., Olivares, T., & Kovacs, E. (2024). Building a Smart Campus Digital Twin: System, Analytics, and Lessons Learned From a Real-World Project. *IEEE Internet of Things Journal*, *11*(3), 4614-4627. https://doi.org/10.1109/JIOT.2023.3300447

Swanson, B. A., & Valdois, A. (2022). Acceptance of online education in China: A reassessment in light of changed circumstances due to the COVID-19 pandemic. *International Journal of Educational Research Open*, *3*, 100214. https://doi.org/10.1016/j.ijedro.2022.100214

UCL. (2023, January 10). *The Future School*. IOE - Faculty of Education and Society. Retrieved from https://www.ucl.ac.uk/ioe/departments-and-centres/centres/ucl-centre-educational-leadership/thinkpieces/future-school

What *could the school of 2050 look like?* (n.d.). Retrieved 21 February 2024, from https://www.sciencefocus.com/future-technology/the-school-of-2050-technology-education

Wilson, G., & Randall, M. (2012). The implementation and evaluation of a new learning space: A pilot study. *Research in Learning Technology*, *20*. https://doi.org/10.3402/rlt.v20i0.14431

Wu, W., Chang, H.-P., & Guo, C.-J. (2009). The Development of an Instrument for a Technology-integrated Science Learning Environment. *International Journal of Science and Mathematics Education*, *7*(1), 207-233. https://doi.org/10.1007/s10763-007-9116-5

Xue, E., & Li, J. (2021). Shaping the "School-Family-Society" Cooperative Education System in China. In E. Xue, & J. Li (Eds.), *Creating a High-Quality Education Policy System: Insights from China* (pp. 11-26). Springer. https://doi.org/10.1007/978-981-16-3276-1_2

Yan, L., Whitelock-Wainwright, A., Guan, Q., Wen, G., Gašević, D., & Chen, G. (2021). Students' experience of online learning during the COVID−19 pandemic: A province-wide survey study. *British Journal of Educational Technology*, *52*(5), 2038-2057. https://doi.org/10.1111/bjet.13102

Yang, J., Pan, H., Zhou, W., & Huang, R. (2018). Evaluation of smart classroom from the perspective of infusing technology into pedagogy. *Smart Learning Environments*, *5*(1), 20. https://doi.org/10.1186/s40561-018-0070-1

Yang, L., Garc á-Holgado, A., & Mart ínez-Abad, F. (2023). Digital competence of K-12 pre-service and in-service teachers in China: A systematic literature review. *Asia Pacific Education Review*, *24*(4), 679-693. https://doi.org/10.1007/s12564-023-09888-4

Zainuddin, N., & Idrus, R. (2018). Designing Learning Spaces for Effective Learning. *The Maldives National Journal of Research*, *6*, 7-18. https://doi.org/10.62338/y1ytfc72

Zuo, M., Hu, Y., Luo, H., Ouyang, H., & Zhang, Y. (2022). K-12 students' online learning motivation in China: An integrated model based on community of inquiry and technology acceptance theory. *Education and Information Technologies*, *27*(4), 4599-4620. https://doi.org/10.1007/s10639-021-10791-x