



International Journal of Knowledge-Based Development

ISSN online: 2040-4476 - ISSN print: 2040-4468

<https://www.inderscience.com/ijkbd>

The quality evaluation model of open education learning support services under the background of digital transformation

Yanhui Chen

DOI: [10.1504/IJKBD.2025.10068636](https://doi.org/10.1504/IJKBD.2025.10068636)

Article History:

Received:	16 April 2024
Last revised:	18 September 2024
Accepted:	30 October 2024
Published online:	01 April 2025

The quality evaluation model of open education learning support services under the background of digital transformation

Yanhui Chen

Teachers College,
Xinxiang Vocational and Technical College,
Xinxiang, 453006, China
Email: sfxycyh@163.com

Abstract: In order to enhance the effectiveness of educational learning support services, this paper designs a quality evaluation model for open education learning support services in the context of digital transformation. Firstly, a quality model for educational learning support services is constructed. Secondly, the evaluation dimensions are analysed and an indicator system is designed using the service quality (SERVQUAL) model. Then, the reliability of the indicators is tested using Cronbach's alpha analysis method. Finally, the weights are calculated using the average assignment method, and the factor weights are estimated using the Advanced Mortar System (AMOS) software to obtain service scores, achieving the quality evaluation of learning support services. The results show that college students have high expectations and perceived values for the quality of learning support services, but their satisfaction is relatively low due to unsatisfactory service quality in the actual learning process.

Keywords: digital transformation; education and learning; SERVQUAL model; Cronbach's analysis method; reliability analysis.

Reference to this paper should be made as follows: Chen, Y. (2025) 'The quality evaluation model of open education learning support services under the background of digital transformation', *Int. J. Knowledge-Based Development*, Vol. 15, No. 1, pp.3–23.

Biographical notes: Yanhui Chen received her Master's degree in Education from Southwest University in 2020. She is currently a Lecturer in the Teachers College of Xinxiang Vocational and Technical College, where she teaches courses such as education and psychology. She is currently the head of the integration section of industry and education in Teachers College. Her research interests include early childhood education, preschool education and primary education.

1 Introduction

In the context of digital transformation, the research on the evaluation model of the quality of open education learning support services is of great significance and purpose. By studying and establishing a quality evaluation model for open education learning

support services, it is possible to effectively evaluate the quality of learning support services provided by educational institutions, thereby timely identifying problems, improving services, and further enhancing students' learning experience and satisfaction (Gao, 2023). Establishing a quality evaluation model helps to gain a deeper understanding of the key factors and influencing mechanisms of educational learning support services, propose targeted optimisation and improvement measures, and optimise service design through data-driven methods, thereby promoting the improvement of teaching effectiveness (Zhang et al., 2024; Liu et al., 2023; Li and Du, 2023). By studying the quality of open education learning support services, educational institutions can continuously innovate teaching modes and improve teaching quality in the process of digital transformation, promoting the development of the education industry towards a more open, intelligent, and personalised direction. Establishing an effective quality evaluation model helps to evaluate the service level of educational institutions and service providers, thereby helping them identify strengths and weaknesses, guiding the improvement of service quality, enhancing competitiveness, and better adapting to the development needs of digital transformation. In summary, the research significance of the quality evaluation model for open education learning support services lies in improving learning experience, promoting teaching effectiveness, promoting educational innovation and development, and enhancing the competitiveness of educational services (Hu and Zhao, 2023). Through scientific evaluation quality, the education field can be promoted towards a more efficient, convenient, and high-quality direction.

At present, relevant scholars have conducted research on the quality evaluation of education and learning support services, mainly using artificial intelligence analysis methods and Kano model analysis methods. Among them, artificial intelligence methods include sentiment semantic analysis methods and big data analysis methods, both of which have made certain progress, as follows: Ren and Fu (2022) proposed a quality evaluation model for educational learning support services based on emotional semantics. The quality evaluation model for educational learning support services based on emotional semantics is an evaluation method that combines emotional analysis and semantic understanding techniques. By analysing the emotional and semantic information expressed by students during the learning process, the quality of educational learning support services is evaluated. This model not only considers objective data of student learning, but also takes into account emotional and semantic information to comprehensively evaluate the effectiveness of educational services and the learning experience of students. However, the emotional analysis of this method is greatly influenced by subjective factors, and the reliability of service quality evaluation results is poor. Zou and Wu (2023) proposed a quality evaluation model for educational learning support services based on big data, which utilises big data technology to evaluate the quality of educational learning support services and provide reference for educational improvement. This model may involve collecting information from various aspects such as student learning behaviour data, academic performance data, and course satisfaction data, and using data analysis techniques to quantify the quality of educational learning support services. But the security of personal privacy information for students needs to be effectively improved. Yue (2023) proposed a quality evaluation model for educational learning support services based on the Kano model, which evaluates the quality of educational learning support services by meeting the needs of students. Using the Kano model, the characteristics of products or services are divided into four categories: basic

expectations, performance expectations, perceived and moving factors. By investigating the degree of student expectations for different characteristics, the satisfaction and priority of student needs for educational learning support services are determined. This model focuses on exploring the potential needs of students and provides a systematic approach to evaluate the quality of educational learning support services. However, this method needs to be effectively improved in terms of accuracy and objectivity in obtaining students' needs for educational and learning support services.

In response to the above issues, this paper designs an open education learning support service quality evaluation model in the context of digital transformation. The specific design plan is as follows:

- 1 Constructing an open education learning support service quality model in the context of digital transformation, analysing the evaluation dimensions of open education learning support service quality through the SERVQUAL model, and designing a learning support service quality evaluation index system.
- 2 Conduct reliability testing on evaluation indicators using Cronbach's analysis method to verify the credibility of learning support service quality evaluation indicators.
- 3 Using the average assignment method to calculate the weights of evaluation indicators for learning support services, and using Advanced Mortar System (AMOS) software to estimate the score weights of each factor, the open education learning support service score is obtained to achieve the evaluation of the quality of open education learning support services.
- 4 Conduct experimental verification on the expectations and perceived values of learning support service quality among college students, and draw conclusions.

2 Research on the quality evaluation model of open education learning support services under the background of digital transformation

2.1 Construction of a quality model for open education learning support services

Against the backdrop of global digital transformation, the digital economy is rapidly developing at an unprecedented pace, increasingly becoming an important factor in global resource integration, economic growth, and obtaining competitive advantages. Therefore, countries attach great importance to the development of the digital economy, and digital transformation plays a huge driving role in the construction and development of the digital economy and digital China. At present, China's digital market has begun to take shape, and has achieved certain results in areas such as economic digital transformation, social digital transformation, and industrial digital transformation (Wang et al., 2021). Digital transformation is a national development strategy, and all fields should accelerate the completion of digital transformation to promote the structural adjustment and power transformation of China's economy, and achieve high-quality economic development under the guidance of new development concepts.

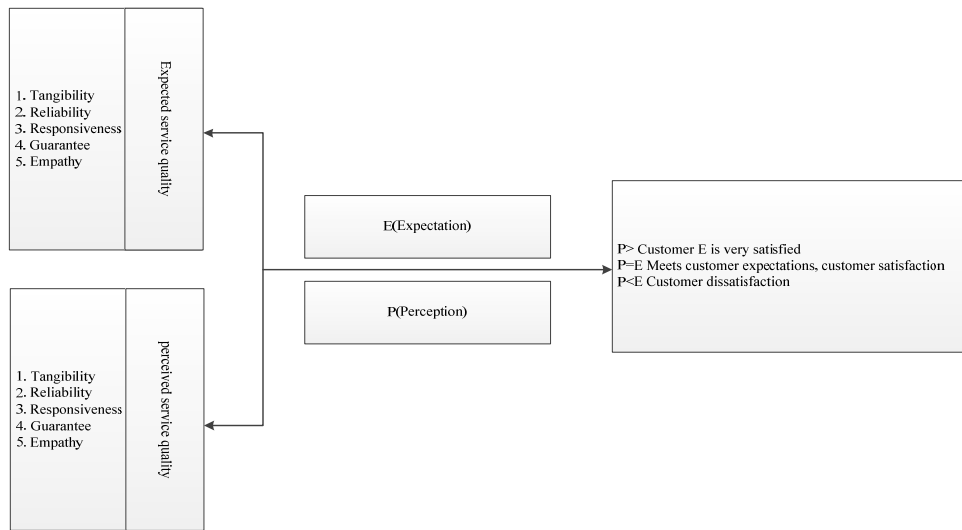
During the 14th Five Year Plan period, China entered a new stage of development, embarked on a new journey of modernisation construction, ushered in a new era of digitalisation, and also faced new opportunities and challenges (Meng et al., 2023; Dong et al., 2022; Liao, 2022). The 14th Five Year Plan proposes to accelerate China's digital development, build a digital China, integrate into the global digital era, and continuously promote the modernisation of the national governance system and governance capacity. The current pace of technological and knowledge updates is advancing at an unprecedented pace.

In the context of global digital transformation, Chinese universities should also follow the trend of digital transformation, accelerate the construction of digital universities, take higher education as the forefront of reform, promote the modernisation of higher education through digitalisation of higher education, promote the transformation of university governance through digital transformation, empower the development of university teaching with data, and comprehensively achieve the modernisation of university governance system and governance capacity. Education digitisation is an important engine driving educational innovation and modernisation, and higher education digitisation bears the important mission of theoretical innovation, technological exploration, and industrial cultivation.

This study mainly adopts questionnaire survey method and case analysis method to study the learning support services of open education under the background of digital transformation. According to the research of domestic and foreign scholars on the quality of higher education services, the SERVQUAL scale has a high degree of applicability to the gap theory of service quality in the evaluation of higher education service quality (Cao and Li, 2022). Compared with other service industries, the SERVQUAL scale has its own characteristics in higher education. Therefore, if it is necessary to evaluate the quality of higher education services, the indicators of the SERVQUAL scale need to be modified, moderately added or removed, and the reliability and validity of the scale need to be re-evaluated (Wu et al., 2022). Based on this, an evaluation was conducted from five dimensions (tangibility, reliability, responsiveness, assurance, and empathy) around students' perception and expectations of the quality of learning support services, and an open education learning support service quality model was constructed, as shown in Figure 1.

Using the Delphi method to send a preliminary list of dimensions and indicators to the expert group, the experts provide feedback based on their professional knowledge and experience. Based on the feedback from the first round, adjust and refine the dimensions and indicators, and send them back to the expert group for evaluation. Repeat the above process until the expert group reaches a consensus on the dimensions and indicators.

After constructing the evaluation index system, Cronbach's Alpha is used to conduct reliability testing on the evaluation indicators of each dimension. Collect evaluation data from students on the quality of learning support services through a questionnaire survey. Use statistical software to calculate the Cronbach's Alpha coefficient for each dimension. When the Cronbach's Alpha coefficient is greater than 0.7, this paper is considered to have an acceptable level of reliability. Use the equal distribution method to evenly distribute the total weight of each dimension to all evaluation indicators under that dimension, calculate the final weight of each indicator, and ensure that the total weight of all indicators is 1.

Figure 1 Learning support service quality model

Use AMOS software for structural equation modelling analysis, estimate the score weight of each factor, evaluate the overall model fit, run the model, evaluate the model fit index, estimate the score weight of each factor based on the model results, and achieve evaluation.

The model covers all key dimensions of service quality, providing a comprehensive perspective on students' perceptions and expectations. The model design is easy to implement in various open education environments, facilitates standardised quality assessment, uses statistical methods to ensure that the model is based on empirical data, generates reliable and actionable insights, allows customisation according to specific institutional needs and backgrounds, ensures relevance and effectiveness, supports continuous evaluation and improvement of learning support services, and helps improve student satisfaction and learning outcomes. By integrating these methods and utilising the advantages of the model, this study aims to provide a powerful tool for evaluating and improving the quality of learning support services in open education, ultimately benefiting students and educational institutions.

2.2 Design of evaluation system for open education learning support services

2.2.1 Selection criteria for quality evaluation indicators of open education learning support services

1 Selection of quality evaluation indicators for open education learning support services

The quality evaluation indicators of open education learning support services have a certain guiding role for the learning support services of universities (Ren and Jiang, 2023). Therefore, this study summarises and concludes that open education learning support services have seven common dimensions: infrastructure, basic support platforms, smart applications, digital resources, network security, guarantee systems, and characteristic development.

By selecting four evaluation systems for the quality of open education learning support services in universities. Summarise the common dimensions: infrastructure, application services, digital smart resources, guarantee mechanisms, talent cultivation, and distinctive development. Emphasis is placed on smart resources, talent cultivation, and infrastructure.

Extract the dimensions related to this study after sorting: smart environment, digital resources, organisational structure, smart applications, and integrated innovation.

2 Selection of evaluation dimensions for learning support services

Based on the definition and dimension division of learning support services by relevant scholars, this study has summarised and analysed five evaluation contents: environmental support, resource support, personnel support, learning process support, and emotional support. The evaluation index extraction content elements are shown in Table 1.

Environmental support: refers to the physical environment, network environment, and related teaching facilities provided to learners.

Resource support: mainly refers to learning resources, including various course materials, learning materials, printed textbooks, audiovisual textbooks, multimedia courseware, online courses, digital libraries, databases, etc.

Personnel support: Personnel assistance involved in learner learning, including teachers, technical personnel, management personnel, learning partners, etc.

Learning process support: refers to teachers providing various information consultations, effective guidance and assistance for students to learn normally in terms of learning conditions, learning methods, and related media facilities, including the design of learning activity content, support for the learning process, and guidance on student learning methods.

Emotional support: provided for the lack of communication in remote learning. Including helping students organise study groups and creating learning communities.

Table 1 Evaluation index extraction content elements

<i>Quality evaluation indicators for learning support services</i>	<i>Evaluation indicators for learning support services</i>	<i>Key point</i>
Smart environment	Environment support	Physical environment, network environment, and related equipment
Digital resources	Resource support	Resource type, resource quality, resource application, and resource presentation
Organisation	Personnel support	Teachers, technicians, students
Smart applications	Learning process support	Learning conditions, learning methods, information consultation, etc.
Smart Services	Emotional support	Interaction between teachers and students

2.2.2 Dimension analysis of quality evaluation of open education learning support services

Through a specific analysis of the secondary sub indicators under the five dimensions, this study based on the five dimensions and 22 secondary indicators of the SERVQUAL evaluation scale, and fully combined with the characteristics of open education learning support services, revised the five dimensions and 22 secondary indicators of the SERVQUAL evaluation scale appropriately, and preliminarily constructed an open education learning support service quality evaluation index system that includes tangibility, reliability, responsiveness, assurance, and empathy. As shown in Table 2.

Tangibility refers to the physical facilities, target environment, and the image of the staff, which users can personally feel, such as the modernisation and completeness of equipment, the mental state of the staff, and the perception of the target environment. The tangibility of learning support services in the smart campus environment of universities should not only include the physical environment of the actual service, but also the tangible elements of the network environment. On the one hand, it should mainly be reflected in the tangible environment, facilities, equipment, and on the other hand, it should also be reflected in the interface design of the network environment, website platforms that support learning services, WeChat mini programs, etc.

Reliability: refers to the ability to reliably and accurately fulfil service commitments. Specifically, it is reflected in the timeliness and accuracy of service institutions in fulfilling their commitments, as well as their ability to perform the services they have promised. In this study, reliability mainly refers to the degree to which schools can accurately fulfil their commitment to learning support services and the availability of school learning resources. Specifically, it includes reliable personnel and reliable learning resources.

Responsiveness: refers to being willing to help customers and provide timely and fast services. For learning support services in the smart campus environment of universities, responsiveness includes not only the rapid response of traditional service personnel, but also the rapid response of the network. Therefore, the responsiveness of this study is also reflected in two aspects: firstly, teachers actively care for students and provide timely and fast services for them; The second is that the network of universities should have good responsiveness (such as network connection quality, webpage opening speed, etc.).

Guarantee: refers to the knowledge and politeness of employees, as well as the ability to inspire customer trust and trust. In the learning support services in the smart campus environment of universities, assurance refers to the friendly service attitude, competent service skills, and technical knowledge related to disciplines or information provided by university staff, as well as the guarantee channels after service.

Empathy: refers to catering to customers and giving them personalised attention. School staff have a good service attitude, can empathise with students, provide targeted services, promote emotional communication between students, support service personnel, and other students, thus forming a good atmosphere (Dong et al., 2022; Liao, 2022; Cao and Li, 2022).

Table 2 Preliminary evaluation scale for SERVQUAL model

<i>Dimension</i>	<i>Project/Issue</i>
Tangibles	1. Modern teaching facilities
The tangible items and network environment elements involved in the process of providing learning support services to students by the school (4)	The school provides teaching facilities that can meet my learning needs, such as online classrooms, online teaching platforms, etc.
	2. Learning resources
	The school provides learning resources that can meet my learning needs, such as various books, e-books, online courses, databases, etc.
	3. Learning platform
	I am satisfied with the beautiful interface design and clear navigation design of the learning support platforms provided by the school, such as library systems and resource platforms
	4. Self service facilities
	The school has life support facilities such as copying, printing, and self-service borrowing and returning machines that provide services for students
Reliability	1. The trustworthiness of schools
The school is able to accurately fulfil its commitment to learning support services	The school conscientiously fulfils various learning commitments to students (such as learning assistance, project guidance, professional skill enhancement, etc.)
Degree and availability of learning resources (4)	2. Reliability of learning resources
	The learning resources provided by the school have high reliability, accuracy, stability, and convenience.
	3. Reliability of problem-solving
	School teachers and staff are able to provide reliable and accurate answers to questions raised by students.
	4. Reliability of learning evaluation
	Teachers make fair and reliable evaluations of students' learning situations
Responsiveness	1. Teacher's willingness
Schools and teachers have a willingness to help students with their studies and the ability to provide timely assistance. Firstly, teachers actively care for students and provide timely and fast services for them; Secondly, university networks and platforms should have good responsiveness (4)	Teachers are always willing to actively monitor the situation of students through browsing learning data (such as homework submission, homework quality, student interaction and participation, etc.)
	2. Opinion adoption
	Schools can effectively adopt suggestions from students regarding learning support services
	3. Campus network
	The school provides a convenient and smooth campus network
	4. Learning website
	The school's website can provide fast response services and real-time updated information resources

Table 2 Preliminary evaluation scale for SERVQUAL model (continued)

<i>Dimension</i>	<i>Project/Issue</i>
Guarantee	1. Teacher guarantee
Refers to university staff who possess competent skills in learning support services, as well as technical knowledge related to disciplines or information technology, as well as post service guarantee channels. (5)	The school has a well-equipped and capable faculty that meets my learning needs
	2. Technical guidance
	The school can provide learning technology services and guidance, including providing students with detailed instructions on how to use software and hardware, and how to operate online exams.
	3. Professional teachers
	Teachers have sufficient professional knowledge to solve my learning problems.
Empathy	4. Problem handling
	When the school's learning equipment or system malfunctions, it can be quickly and effectively addressed
	5. Complaint mechanism
	The school has a dedicated complaint channel and can provide timely and effective responses
	1. Service attitude
School staff have a good service attitude, can empathise with students, provide targeted services, promote emotional communication between students, support service personnel, and other students, thus forming a good atmosphere (5)	The school staff have a friendly attitude and can answer questions quickly and politely. At the same time, feedback and complaints can be promptly and reasonably resolved
	2. Humanised services
	Schools can provide psychological counselling services for learning and carry out mental health activities
	3. Training assistance
	The school can organise training activities related to learning (such as literature search courses, lectures)
	4. Personalised services
	Teachers can provide targeted guidance for individual students' prominent problems
	5. Service time
	The school provides convenient study time for students (such as suitable opening hours for learning venues)

The survey questionnaire is divided into three parts. The first part investigates the basic situation of students, the second part is the actual perceived score of students towards open education learning support services, and the third part is the expected score of students towards open education learning support services. The specific content of the survey questionnaire is shown in Table 3.

After the completion of questionnaire preparation, 200 college students were randomly selected from N school for pre testing. A total of 200 questionnaires were distributed, and 200 were collected. There were 196 valid questionnaires, with an effective rate of 98%.

Table 3 Survey questionnaire content

<i>Dimension</i>	<i>Concrete content</i>
Part I	Personal information of students
Part II	Actual Perceived Scores of Students towards Open Education Learning Support Services
Part III	The actual expected score of students for open education learning support services

2.2.3 Reliability analysis

Reliability refers to the consistency, reliability, or homogeneity of experimental results, which can be divided into intrinsic reliability and extrinsic reliability depending on the researcher's focus. Intrinsic reliability refers to whether a set of questions in a survey questionnaire measures the same concept, that is, how consistent these questions are. Common analysis methods include Cronbach's and half reliability. External reliability refers to the degree of consistency in repeated measurements of the same research object at different times for the same questionnaire. The commonly used analysis method is test-retest reliability, and the most commonly used measurement is the Cronbach coefficient (Wu et al., 2022), which is completed through SPSS. Generally, the main consideration is the internal reliability of the scale – whether there is high internal consistency between items. It is generally believed that if the reliability coefficient of the scale is below 0.7, it indicates that the scale needs to be abandoned; If the coefficient is greater than 0.7, the reliability of the questionnaire is considered acceptable, and if it is greater than 0.8, the reliability of the questionnaire is considered ideal.

According to Table 4, it can be seen that the Cronbach of the five dimensions in the survey questionnaire of this study α The coefficients all exceed 0.7 and are close to 0.8, indicating a high degree of consistency among these five dimensions of the survey questionnaire. The overall Cronbach of the questionnaire α The coefficients are also above 0.9, indicating that this study has good reliability.

Table 4 Reliability statistical analysis

<i>Scale</i>	<i>Dimension</i>	<i>Question items</i>	<i>Cronbach's coefficient</i>	<i>Number of questions</i>
Actual perceived scale	Tangibles	Q1–Q4	0.793	4
	Reliability	Q5–Q8	0.817	4
	Responsiveness	Q9–Q12	0.826	4
	Guaranteed	Q13–Q17	0.867	5
	Empathy	Q18–Q22	0.842	5
	Whole	Q1–Q22	0.962	22
Perceived importance scale	Tangibles	Q23–Q26	0.850	4
	Reliability	Q27–Q30	0.824	4
	Responsiveness	Q31–Q34	0.820	4
	Guaranteed	Q35–Q39	0.822	5
	Empathy	Q40–Q44	0.847	5
	Whole	Q1–Q44	0.961	22

The final evaluation index system for the quality of open education learning support services is obtained through reliability testing.

Table 5 Selection system of quality evaluation indicators for open education learning support services

<i>Primary indicators</i>	<i>Secondary indicators</i>
Tangibles	Modern teaching facilities Resources Learning platform Self service facilities
Reliability	The trustworthiness of schools The reliability of learning resources Reliability of problem-solving The reliability of learning evaluation
Responsiveness	Teacher's willingness Opinion adoption Campus Network Learning website
Guaranteed	Teacher guarantee Technical guidance Professional teachers Problem Handling Complaint mechanism
Empathy	Service attitude Humanised services Training assistance Personalisation Service time

The final design of the open education learning support service evaluation system has been completed and shown in Table 5.

2.3 Quality evaluation of open education learning support services

In order to achieve the evaluation of the quality of open education learning support services, this paper uses the average assignment method to calculate the weights of the evaluation indicators of open education learning support services obtained in Section 2.2, estimates the score weights of each factor, and obtains the score of open education learning support services.

Learners often have different expectations and actual perceptions of the quality of support services, so there is often a gap in the rating of the same issue. This gap is used as a quantitative indicator of overall quality in this study and is expressed by the following formula:

$$DLSSQ = \frac{1}{n} \sum_{i=1}^n (\overline{P}_i - \overline{E}_i) \quad (1)$$

Among them, $DLSSQ$ represents the quantitative indicator of the overall quality of school support services; n represents the total number of gap items in the problem; $\overline{P}_i$ represents the average value of the learner's perception of the i th question; $\overline{E}_i$ represents the average value of the learner's expectations for the i th question.

However, the meaning of this quantitative indicator is not intuitive and does not conform to reading habits. Therefore, this paper uses a percentage system to describe $DLSSQ$. The method is: when the learner's perception of support services matches their expectation of support services (Ren and Jiang, 2023) (i.e., the perceived decrease in expectation is zero), take $DLSSQ = 100$; When the negative score of the gap between perceived and expected services is the highest, which is $\min(p) = \max(E)$, take $DLSSQ = 0$; And generally, it is represented by one of the real numbers in $DLSSQ = 0 \sim 100$, that is:

$$DLSSQ \in (0, 100) \quad (2)$$

So, the formula for calculating the percentage score of service quality for each learner is:

$$DLSSQ_p = \frac{DLSSQ - [\min(p) - \max(E)]}{0 - [\min(p) - \max(E)]} \times 100 \quad (3)$$

Formulas (1) and (3) assume that in the minds of learners, the importance of each dimension of supporting services is the same. However, in reality, the importance of each factor and its corresponding dimension in the minds of learners varies greatly. Therefore, when evaluating the quality of learning support services, consideration can be given to assigning weights to the $DLSSQ$ score, and then the quantitative value of service quality can be calculated.

Using AMOS software, draw five latent variables (Tangible Reliability, Responsiveness, Assurance, Empathy). Use the 'Rectangle' tool to draw the observed variables corresponding to each latent variable. Use the 'one-way arrow' tool to connect each observed variable to its corresponding latent variable. Use the 'one-way arrow' tool to set the influence relationship between latent variables. Ensure that each observed variable is only connected to one latent variable and set the measurement error. Set the influence relationship between latent variables and ensure that the path coefficients are freely estimated. Evaluate the mutual influence between various dimensions of support services and the utility of each dimension level on learners' evaluation of service quality. Quantitatively estimate the score weights of each factor (FactorScore Weights), where the weight of each dimension is equal to the sum of the weights of its corresponding factors. The values of each dimension come from the weighting of the observed variables. Therefore, based on formula (1), the weighted calculation formula (4) is obtained:

$$DLSSQ = \sum_{i=1}^n W_i (\overline{P}_i - \overline{E}_i) \quad (4)$$

Among them, W_i represents the weight of the "perception expectation" gap in question i .

According to formulas (3) and (4), obtain the $DLSSQ$ value of the school. $DLSSQ$ is generally a negative value, and the larger its absolute value, the poorer the quality of support services provided by the school.

When $DLSSQ > 0$, it indicates $\bar{P}_i > \bar{E}_i$. The quality of support services provided by the school exceeds the expectations of learners, the level of service quality is high, and learners are satisfied;

When $DLSSQ = 0$, it indicates that $\bar{P}_i = \bar{E}_i$, the quality of support services provided by the school exactly meets the expected level of learners, and learners feel basically satisfied;

When $DLSSQ < 0$, it indicates that $\bar{P}_i < \bar{E}_i$, the quality of support services provided by the school is lower than learners' expectations, and learners feel dissatisfied. This situation should be avoided as much as possible.

At this point, it is necessary to analyse from the survey form which aspects the school has not done enough and there is still a gap from the expected level of learners, in order to make improvements in subsequent work.

Based on the above results, conduct a quality evaluation of open education learning support services under the background of digital transformation, analyse the advantages and problems of open education learning support services, and determine the direction for improvement in subsequent work.

3 Experimental analysis

3.1 Experimental platform configuration

This paper uses the PyTorch framework to build a deep learning model, which is a Python version developed for GPU accelerated deep neural networks. Torch is a classic tensor library for processing multidimensional matrix data, widely used in fields such as machine learning. Compared to the TensorFlow framework, the PyTorch framework is different from the static calculation charts presented by the TensorFlow framework. Instead, it is a dynamic chart that can change according to calculation requirements, providing Python users with an easy programming environment. The experimental environment configuration were shown in Table 6.

Table 6 Experimental environment configuration

<i>Experimental environment</i>	<i>Environmental configuration</i>
System	Ubuntu18.04
CPU	12th Gen Intel(R) Core(TM) i9-13900K
GPU	RTX3090 24G
Memory	32G
Programming Language	Python3.10
Deep learning framework	PyTorch 12.1
CUDA version	11.3

Evaluate and analyse based on the above parameters.

3.2 Analysis of assessment results for learning support services

This paper evaluates the quality of open education learning support services through the previous section, using average perception and average expectation to assess service quality, where perception is the subjective experience and feeling of learners towards learning support services. It reflects users' subjective evaluation of the service, including their perception of satisfaction, usability, usefulness, and other aspects of the service; Expectations from users regarding the performance, functionality, and experience of learning support services before use. Expectations are usually based on the user's past experience, commitments from service providers, recommendations from others, or other relevant information; Service quality refers to the degree to which learning support services objectively meet user needs. It not only includes the functionality of the service, but also the reliability, responsiveness, assurance, and empathy of the service. The average and difference values of the first level indicators obtained through statistical data results are shown in Table 7.

Table 7 Average and gap values of primary indicators

<i>Dimension</i>	<i>Average perception</i>	<i>Average expectation</i>	<i>Quality of service</i>
Tangibles	4.09	4.19	-0.10
Reliability	4.13	4.29	-0.15
Responsiveness	3.93	4.28	-0.35
Guaranteed	4.07	4.26	-0.19
Empathy	4.06	4.17	-0.11

The evaluation results of SERVQUAL learning support service quality consist of two parts: actual perceived score and expected score. By comparing the results obtained from these two parts, the "gap score" of each of the five dimensions, namely the "service quality" score, is obtained. The smaller the gap value, the higher the evaluation of learning support service quality; The larger the difference, the lower the rating of the quality of learning support services. The calculation formula is:

$$SQ = \sum_{i=1}^{22} (p_i - E_i) \quad (5)$$

Among them, $i = 1, 2, \dots, 22$ and p_i represent the customer's perception of the i th question, and E_i represent the customer's expectations of the i questions.

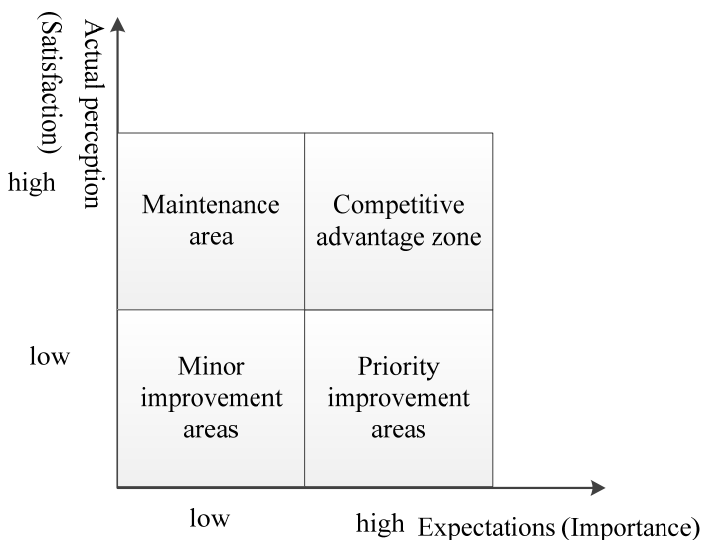
The formula represents the total perceived quality of a single customer. Divide SQ by 22 (the number of questions) to obtain the SERVQUAL score of a single customer. Then, add up the SERVQUAL scores of all survey subjects in the survey and divide by the total number of survey subjects to obtain the average SERVQUAL score. This formula assumes that the five scores of service quality are equally important, that is, the five dimensions are given the same weight. In other studies, negative values are recalculated based on the importance of the five dimensions. In this study, it is believed that the importance of the five dimensions is the same. To this end, five equally weighted

methods were used for calculation, and the formula was used to calculate: $SQ = -0.9$ which means the final score of the SERVQUAL model indicator is -0.9 . It is generally believed that an absolute value of 1 can better illustrate the research problem. In this study, the absolute value of 0.9 is close to 1, indicating that students did not perceive the learning support services provided by N University as expected, and there is room for improvement in the quality of open education learning support services.

3.3 IPA analysis of learning support services

Based on the analysis of the perceived differences in the quality of open education learning support services in various dimensions, this study uses the importance performance analysis (IPA) method to clarify the importance of evaluation indicators for learning support services in N schools and the priority order for improvement (the IPA analysis chart is shown in Figure 2). The indicators located in the first and second quadrants are the indicators that need to be maintained and can be collectively referred to as maintenance areas. The indicators located in the third and fourth quadrants are indicators that need improvement, which can be collectively referred to as improvement areas. Especially, the indicators located in the fourth quadrant are indicators that require universities to focus on improvement, and have a certain degree of urgency. In open education learning support services, university administrators often provide services to students based on subjective desires, resulting in the educational services they provide being vastly different from the real needs of students. Therefore, with the help of the importance actual perception quadrant diagram, the weak links and priority improvement directions of educational service quality can be more intuitively reflected. Various problems can be solved in an orderly manner according to their importance, in order to improve the actual perception of educational service quality among graduate students, thereby quickly and effectively improving the quality of educational services in schools and enhancing their competitiveness.

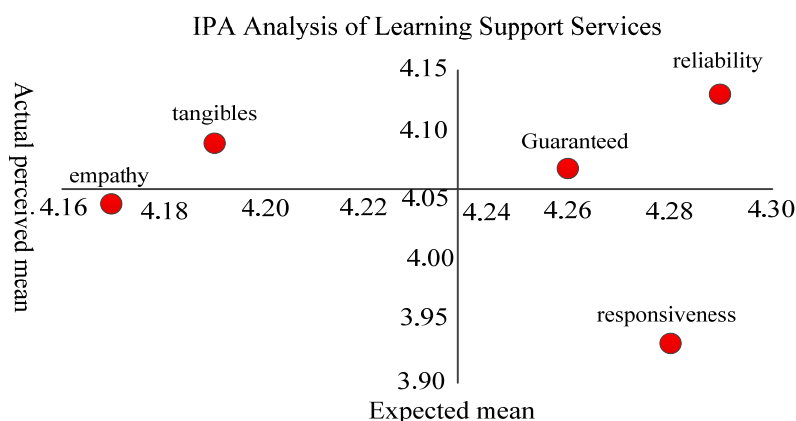
Figure 2 IPA analysis chart



3.3.1 Five dimensional IPA analysis of learning support services

This study is based on the perceived expected values of various dimensions of learning support service quality at N University. By drawing a five dimensional IPA four quadrant positioning map of learning support service quality, the importance of evaluation indicators and student satisfaction evaluation are analysed. Among them, the X-axis represents the average expectation of students for learning support services, which is distributed as “importance” on the horizontal axis; The Y-axis represents the average perceived quality of learning support services, which is distributed as “satisfaction” on the vertical axis. The origin (4.238, 4.056) represents the average expected value and actual perceived satisfaction of each dimension. The coordinate graph is divided into the following four quadrants, as shown in Figure 3.

Figure 3 IPA analysis of learning support services (see online version for colours)



As shown in Figure 3, the reliability and assurance dimensions are located in the first quadrant. It can be seen that college students have high expectations and perceived values for the quality of learning support services, indicating that the evaluation indicators of learning support service quality in this dimension are of high importance, and student satisfaction is also high, belonging to value-added factors. Therefore, resources need to be invested to ensure the stability of the quality of their learning support services.

The tangibility dimension is located in the second quadrant, indicating low importance, but in reality, it is a dimension of high student satisfaction with the quality of learning support services. The significance of the tangible dimension of learning support service quality for students is relatively low, but their actual perception is sufficient to meet their learning needs and belongs to the area of continued maintenance. Therefore, it is possible to shift the direction of investment in learning support services and appropriately tilt towards other evaluation dimensions while maintaining this advantage. Maintaining the recognition of elements in the district and providing tangible learning support services to meet the expectations of students is an aspect that needs to be continued.

Empathy is in the third quadrant, indicating a dimension where the importance of evaluating the quality of learning support services is not high and the actual satisfaction of students is also low. At present, students pay less attention to the emotional investment reflected by the learning support service indicators in this dimension, but there is

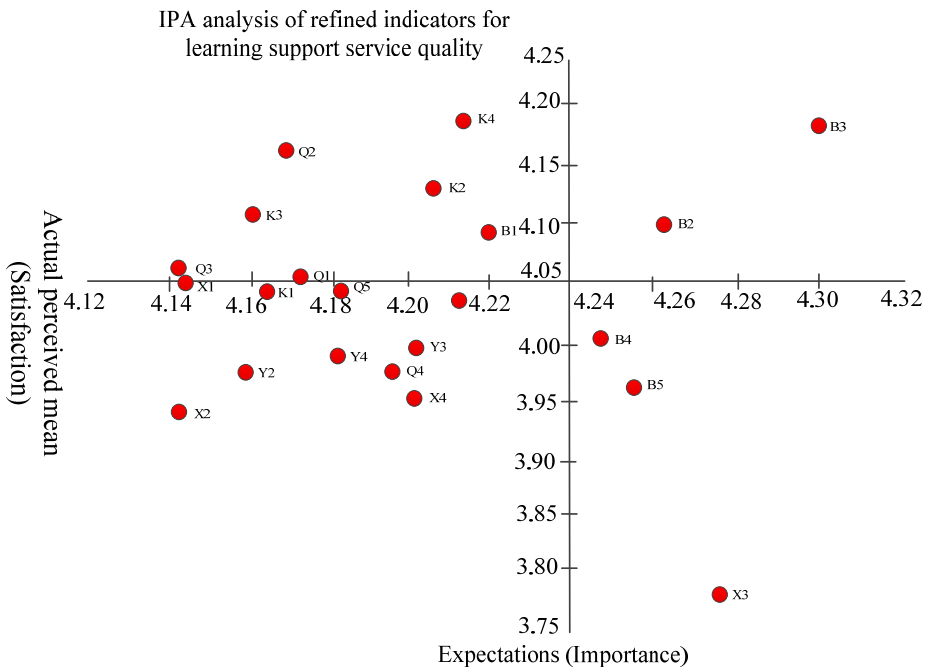
dissatisfaction in actual learning. Therefore, without a significant impact on student learning, student satisfaction with the quality of learning support services will not decrease. Once it exceeds student expectations, student satisfaction will significantly increase, which is an opportunity area for future improvement of learning support service quality and belongs to the basic factor. Therefore, sample universities should always pay attention to the quality of learning support services reflected in the dimension of empathy and make timely improvements.

The responsiveness dimension is located in the fourth quadrant, and the dimension within this quadrant indicates that it plays an extremely important role in measuring the quality of open education learning support services. Evaluation indicators are of high importance, but in the actual learning process, students perceive that the quality of learning support services is not satisfactory, resulting in lower student satisfaction.

3.3.2 IPA analysis of refined indicators for the quality of open education learning support services

This study is based on the expectations and satisfaction evaluation values of college students towards the quality of learning support services provided by N University. The IPA analysis method was used to draw an IPA quadrant localisation map of 22 sub indicators, as shown in Figure 4.

Figure 4 IPA analysis of refined indicators for learning support service quality (see online version for colours)



Among them, the first quadrant is high and high regions, and the evaluation index for measuring the quality of learning support services is very important. This index reflects the actual quality of learning support services, which is also relatively high in terms of

student perceived satisfaction. The corresponding strategy is to continue to maintain and further optimise it. The second quadrant is the low high zone, and the evaluation indicators of learning support services are generally important. However, the satisfaction ratings of students with actual learning support services reflected in the indicators are relatively high. The corresponding strategy is to change the direction of learning resource investment and focus on the main factors that affect the quality of learning support services. The third quadrant is low and low, indicating indicators that are not important for measuring the quality of learning support services or actual cognitive satisfaction of students. These indicators should be divided into “low priority” or “high priority” areas. The fourth quadrant has high and low evaluation indicators for the importance of learning support services, but low satisfaction. The corresponding strategy is to focus on timely and effective measures to improve the quality of learning support services. This study is based on a three-point location map of the PA four quadrant, dividing 22 secondary indicators into value-added factors, variables, improvement factors, and basic factors.

Table 8 Perceived expectations for learning support services

<i>Serial number</i>	<i>Content</i>	<i>Perceived value</i>	<i>Expectant</i>	<i>Perception expectation</i>
Y1	Modern teaching facilities	4.13	4.21	−0.08
Y2	Resources	4.06	4.16	−0.10
Y3	Learning platform	4.08	4.20	−0.12
Y4	Self service facilities	4.09	4.18	−0.09
K1	The trustworthiness of schools	4.05	4.32	−0.27
K2	The reliability of learning resources	4.14	4.25	−0.11
K3	Reliability of problem-solving	4.12	4.30	−0.18
K4	The reliability of learning evaluation	4.20	4.27	−0.07
X1	Teacher’s willingness	4.06	4.26	−0.20
X2	Opinion adoption	3.94	4.30	−0.36
X3	Campus network	3.78	4.25	−0.47
X4	Learning website	3.95	4.31	−0.36
B1	Teacher guarantee	4.10	4.22	−0.12
B2	Technical guidance	4.11	4.26	−0.15
B3	Professional teachers	4.19	4.30	−0.11
B4	Problem handling	4.01	4.25	−0.24
B5	Complaint mechanism	3.96	4.25	−0.29
Q1	Service attitude	4.06	4.17	−0.11
Q2	Humanised services	4.17	4.17	0
Q3	Training assistance	4.07	4.14	−0.07
Q4	Personalisation	3.98	4.19	−0.21
Q5	Service time	4.05	4.18	−0.13

As shown in Figure 4, two evaluation indicators are located in the first quadrant, accounting for only 0.09% of the total elements, which belong to value-added factors

with high expected perceived values; Six evaluation indicators are positioned in the second quadrant, accounting for 27.2% of the total elements and belonging to variable factors; Nine evaluation indicators were positioned in the third quadrant, accounting for 40.9% of the total elements and belonging to improvement factors; Three evaluation indicators are positioned in the fourth quadrant, accounting for 13.7% of the total elements and belonging to the basic factor. Due to its high importance and low satisfaction, this area is a key improvement area. Therefore, the evaluation elements of learning support services falling into this area are the focus of analysis, and also the aspect that needs to be focused on to improve the quality of learning support services in sample universities.

Overall, when it comes to the first quadrant, there are only two dimensions of assurance: B2 (technical guidance) and B3 (professional teachers), while the other four dimensions do not meet the requirements of the first quadrant. There are many dimensions that fall into the third quadrant, and all four dimensions, except for assurance, are involved. From the perspective of support types, it involves learning process support, learning environment support, and emotional support. From specific indicators, it can be seen that there are two indicators of responsiveness, namely X2 (opinion adoption) and X4 (learning website), two indicators of empathy, namely Q4 (personalised service) and Q5 (service time), and one indicator of reliability, namely K1 (school trustworthiness). All tangible indicators, namely Y1 (modern teaching facilities), Y2 (learning resources), Y3 (learning platform), and Y4 (self-service facilities), fall within this range and belong to evaluation indicators with low importance for measuring the quality of learning support services. Moreover, students' actual perceived satisfaction is not high. According to the principle of IPA analysis, students have a significant perception of these teaching quality evaluation elements. Both and satisfaction evaluation are relatively low. Although the importance of these two indicators in the entire evaluation index system is relatively low, as long as they are slightly lower than the quality standard, it will lead to student dissatisfaction and affect the overall evaluation results of learning support service quality. They belong to secondary improvement projects, and can be improved after the priority project is completed.

As shown in Table 8, it involves two dimensions: responsiveness and assurance, with assurance being the main focus. Responsiveness involves one indicator, X3 (campus network), while assurance dimensions include B4 (problem handling) and B5 (complaint mechanism). From the perspective of the types of learning support, what is lacking is the support of environmental learning and personnel. From the specific indicators, college students are not satisfied with the campus network provided by the school, but they have higher expectations. I am also dissatisfied with the problem handling and complaint mechanism of school personnel and hope for improvement.

This method can effectively evaluate the quality of open education learning support services, because it uses the average assignment method to calculate the weight of learning support service evaluation indicators, and uses AMOS software to estimate the score weight of each factor, obtaining the score of open education learning support services and improving the reliability of the evaluation results.

3.3.3 Accuracy of evaluation

To further verify the effectiveness of the method proposed in this paper on the quality of learning support services, the accuracy of the evaluation of learning support service

quality was compared between Ren and Fu (2022) and Zou and Wu (2023), and the method proposed in this paper. The results are shown in Table 9.

Table 9 Accuracy of learning support service quality assessment

<i>Number of experiments</i>	<i>Accuracy of learning support service quality assessment/%</i>		
	<i>Ren and Fu (2022)</i>	<i>Zou and Wu (2023)</i>	<i>Proposed method</i>
1000	80.5	76.2	99.6
2000	79.6	79.1	99.8
3000	81.3	80.0	99.9

According to Table 9, the method proposed in this paper can achieve high accuracy in evaluating the quality of learning support services in multiple experiments, with a maximum accuracy of 99.6%, while the methods in Ren and Fu (2022) and Zou and Wu (2023) have the highest accuracy of only 81.3% and 80.0%, respectively. The above results indicate that the method proposed in this paper can effectively improve the accuracy of learning support service quality assessment.

4 Conclusion

In the context of digital transformation, this paper designs an open education learning support service quality evaluation model, constructs a learning support service quality evaluation index system, uses Cronbach’s alpha analysis method to test the reliability of the evaluation indicators, calculates the weight of the learning support service evaluation indicators using the average assignment method, and estimates the score weight of each factor using AMOS software, achieving the quality evaluation of open education learning support services. Through experiments, the following conclusions can be drawn:

- 1 College students have high expectations and perceived values for the quality of learning support services, indicating that the evaluation indicators of learning support service quality in this dimension are of high importance, and student satisfaction is also high, belonging to value-added factors. Therefore, resources need to be invested to ensure the stability of the quality of their learning support services.
- 2 Empathy is in the third quadrant, indicating a dimension where the importance of evaluating the quality of learning support services is not high and the actual satisfaction of students is also low. This indicates that students currently pay less attention to the emotional investment reflected by the learning support service indicators in this dimension. However, in actual learning, there are situations of dissatisfaction. Once the expectations of students are exceeded, their satisfaction will significantly increase, which is an opportunity area for improving the quality of learning support services in the future and belongs to the basic factor. Therefore, sample universities should always pay attention to the quality of learning support services reflected in the dimension of empathy and make timely improvements.

- 3 The responsiveness dimension is located in the fourth quadrant, and the dimension within this quadrant indicates that it plays an extremely important role in measuring the quality of open education learning support services. Evaluation indicators are of high importance, but in the actual learning process, students perceive that the quality of learning support services is not satisfactory, resulting in lower student satisfaction.

References

- Cao, X. and Li, J. (2022) 'Exploration of building a learning support service system for elderly education in the context of a learning society', *Journal of Beijing Xuanwu Hongqi Amateur University*, Vol. 13, No. 02, pp.24–29.
- Dong, Z., Shao, Y. and Sun, T. (2022) 'Survey and analysis of online learning support services in 'Double First Class' university libraries', *Library Work and Research*, Vol. 21, No. 01, pp.100–107.
- Gao, X. (2023) 'Optimization analysis of professional technology and skill quality evaluation model based on machine learning', *Adhesive*, Vol. 50, No. 6, pp.140–143.
- Hu, Y. and Zhao, F. (2023) 'A study on the impact of learning support service quality on the satisfaction and sense of belonging of online learning students in open universities', *Journal of Guangdong Open University*, Vol. 32, No. 3, pp.5–11.
- Li, H. and Du, L. (2023) 'Design of precision learning support service system for open education in the big data environment', *China Adult Education*, Vol. 31, No. 05, pp.8–13.
- Liao, J. (2022) 'Construction of an open education learning support service model in a smart learning environment', *Journal of Guangxi Radio and Television University*, Vol. 33, No. 3, pp.26–31.
- Liu, L., Ding, Q., Han, P., Chen, K. and He, Q.P. (2023) 'Quality evaluation of community elderly education based on service quality gap model', *China Adult Education*, Vol. 11, No. 19, pp.27–31.
- Meng, F., Hai, T., Sheng, X., Hu, M. and Liu, K.L.(2023) 'The evaluation index system of deep learning under STEAM education', *Electronic Devices*, Vol. 46, No. 3, pp.795–808.
- Ren, S. and Fu, C. (2022) 'Research on service quality evaluation based on emotional semantics', *Jiangsu Business Review*, Vol. 17, No. 08, pp.16–18+29.
- Ren, X. and Jiang, X. (2023) 'Research on online training and learning support services for primary and secondary school teachers in a blended learning environment', *Science and Education Journal*, Vol. 11, No. 29, pp.79–81.
- Wang, H., Lin, H. and Mo, S. (2021) 'Evaluation of learning support services in distance higher education in a smart learning environment', *Journal of Inner Mongolia Normal University (Education Science Edition)*, Vol. 34, No. 04, pp.75–81.
- Wu, H., He, J. and Chen, K. (2022) 'Empirical study on the satisfaction model of MOOC learning support services from the perspective of learning perception', *Digital Education*, Vol. 8, No. 5, pp.39–45.
- Yue, J. (2023) 'Analysis of the demand for learning support services in elderly open education based on the Kano model', *Continuing Education Research*, Vol. 21, No. 12, pp.67–73.
- Zhang, Y., Lin, D. and Wei, G. (2024) 'Service quality prediction based on outlier detection matrix decomposition', *Journal of Yunnan University (Natural Science Edition)*, Vol. 46, No. 02, pp.255–264.
- Zou, Y. and Wu, N. (2023) 'Construction and implementation approach of a data based personalized learning support service model for online learning', *China Vocational and Technical Education*, Vol. 9, No. 07, pp.34–40.