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ENHANCING ACTIVE LEARNING SKILLS OF SOFTWARE ENGINEERING STUDENTS: AN EVALUATION USING THE SERVQUAL MODEL*

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Abstract

In light of the contemporary landscape characterized by the swift advancement of novel technologies and the escalating societal demands for software professionals, this study endeavors to enhance students' proactive learning capabilities to align with societal requisites. To achieve this objective, the study employs the service quality (SERVQUAL) model to assess and scrutinize the pivotal factors that contribute to the enhancement of students' self-directed proficiencies, thereby refining and augmenting the higher education system. The SERVQUAL model was employed to construct a questionnaire, with a specific focus on surveying students enrolled in software major and related disciplines. By conducting data analysis and employing weighting operations on the survey findings, a comparison and evaluation were conducted on the disparities in students' perceptions and expectations regarding service quality. The outcomes indicate a fundamental alignment between students' perceptions and expectations concerning the enhancement of active learning capabilities, thereby affirming the overall commendable service quality. These findings further suggest that the teaching standards of the major and the students' active learning abilities have successfully fulfilled the anticipated criteria.

Keywords: *SERVQUAL model, active learning, ability improvement, higher education.*

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1. INTRODUCTION

The exponential advancement of information technology, exemplified by artificial intelligence, cloud computing, big data, and the Internet of Things, has propelled the global community

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into an era characterized by extensive digitization. Software, being the essence of information technology and the bedrock of the digital society epoch, has emerged as a pivotal catalyst for worldwide industrial progress and metamorphosis. Consequently, academic programs specializing in software within tertiary institutions play a crucial role in facilitating the cultivation and dissemination of skilled software professionals. The mission of colleges and universities in talent cultivation is to develop software professionals who can effectively adapt to the demands of the digital society. Graduates majoring in software should possess strong self-management skills and a proactive approach to learning, enabling them to continuously enhance their professional competencies. In addition to imparting software technical knowledge, educators should also foster students' active learning abilities, enabling them to apply and expand their acquired knowledge in alignment with industry requirements. Hence, enhancing students' active learning capacity assumes significance as it establishes the groundwork for self-education formation and advancement. Moreover, it aligns with the demands of the digital society in terms of software talent cultivation and addresses the imperative of colleges and universities to holistically enhance the quality of talent development. The concept of active learning ability pertains to learners' capacity to deliberately strategize their learning content and progression, select suitable learning approaches, and autonomously assess and appraise the effectiveness of their learning outcomes in accordance with predetermined learning objectives and individual needs [1]. The cultivation of active learning capabilities necessitates a harmonious amalgamation of external environmental facilitation and inherent motivation. Based on the service trade classification by the World Trade Organization (WTO), educational services are classified within the fifth category of service trade, wherein higher education falls under the third category of educational services [2]. Consequently, this classification implies that service quality methodologies can be employed to assess the instructional procedures within higher education.

This study aims to enhance the monitoring and enhancement of active learning proficiency among college students majoring in software, while also addressing the high-quality demands of the digital society for software professionals. To achieve this, the study will focus on evaluating service quality and investigating the external environmental factors and internal psychological aspects that influence students' active learning abilities. Additionally, an evaluation and research will be conducted on the services offered to enhance the active learning proficiency of software major students at the authors' university. The study primarily employed the service quality (SERVQUAL) model to develop a survey methodology tailored to university students majoring in software, aiming to assess their level of awareness regarding factors influencing active learning ability. Additionally, the study evaluated the external environment and intrinsic motivation factors that software majors in higher education institutions employ to enhance the active learning ability of their students. By conducting service quality assessments and comparing students' perceptions with their expectations, the study aimed to identify gaps and provide valuable recommendations for enhancing students' learning abilities.

2. RELATED WORKS

2.1. Active learning ability

The introduction of competency education presents a significant obstacle to the conventional education paradigm, which prioritizes the transmission of knowledge and the cultivation of intelligence. This approach asserts that students should proactively undertake the responsibility for their own learning and skill development, engage in self-directed and exploratory learning, and foster students' capacity to adapt to societal demands and effectively address real-world

challenges [3]. Active learning is a significant aspect of education that enhances abilities. It encompasses the capacity to structure the process of acquiring knowledge, which involves establishing educational objectives, formulating learning materials and procedures, selecting independent educational methods and techniques, applying acquired knowledge, and evaluating self-education [4]. As competency education becomes increasingly globalized, perspectives on the significance and applicability of active learning competency theory are gradually solidifying. According to Robertson [5], the active learning method entails learners taking charge of the learning process, thereby facilitating a student-centered approach to attain specific objectives. This method allows learners to actively engage with the subject matter and adapt their learning according to their individual developmental requirements. Grandinetti [6] asserts that active learning serves as a basis for lifelong learning and necessitates ongoing enhancement of active learning abilities. Stewart [7] conducted a study on active learning and project-based outcomes, and observed that learners exhibit a strong motivation for learning, which drives them to exert considerable effort in order to successfully accomplish their tasks and acquire practical experience. In China, active learning research was initiated at an early stage. Lin [8] employed empirical research to demonstrate that active learning and self-education can yield favorable learning outcomes. According to the findings of Zhang et al. [9], it was determined through a questionnaire survey that both active learning strategies exhibit robust learning motivation. However, the former strategy demonstrates limited integration of learning and lacks initiative in the selection of learning materials. In a similar vein, Qin et al. [10] expounded upon the conceptualization of active learning in the context of the “Internet +” era, which offers students a novel learning experience. The ability to engage in active learning serves as a fundamental prerequisite for individual lifelong development, enabling individuals to actualize their own life value through continuous self-improvement. Xu et al. [11] have highlighted the importance of fostering students’ active learning ability as a crucial objective in educational and pedagogical research, in response to the need for talent in the knowledge economy era. They propose that this can be achieved by enhancing students’ self-motivation, self-planning, information acquisition, utilization of human and external resources, as well as the development of systems thinking skills. In the domain of software talent development, Guo et al. [12] undertook the task of reconfiguring the instructional framework of software engineering courses with the objective of enhancing students’ engagement in active learning and fostering their practical skills. Similarly, Jian et al. [13] devised a model for nurturing computational thinking proficiency within computer courses at the university level. Empirical evidence from the implementation of these curricular systems demonstrates a noticeable improvement in students’ capacity for active learning. Furthermore, Su [14] directed efforts towards cultivating active learning abilities and sought to bring about pedagogical reforms in the domain of software testing talent development. The findings from the implementation demonstrate that the active learning capacity of students has been significantly improved, with quality development exerting a positive influence.

2.2. Evaluation of higher education services

By conducting an assessment of the services provided by colleges and universities, it is possible to identify issues that exist within the process of talent training services. Consequently, adjustments can be made to the goals of talent training, as well as improvements to the models and specific strategies employed in talent training. This continuous improvement in the quality of talent training is essential. Following the inclusion of higher education in service trade as per the regulations of the WTO, scholars have started to exhibit a growing interest in study-

ing and examining the evaluation of service quality in higher education. Shank et al. [15] assert that higher education services are a direct result of higher education and emphasize the importance of aligning these services with the needs and expectations of students, who are considered the consumers. Liu [16] further examines the attributes of higher education service quality and posits that it is contingent upon students, who serve as evaluators of educational service quality, and the assessment of the disparity between their anticipated level and the actual perceived level of educational services, taking into account their individual educational requirements. How can the distance between these two be quantitatively compared? Initially, some scholars' investigation into the evaluation of higher service quality centered on the utilization of PZB's uncomplicated SERVQUAL model questionnaire for measurement [17]. Subsequent research on higher education services revealed that education possesses non-profit attributes and exhibits distinct characteristics in comparison to enterprises. Consequently, enhancements were made to the SERVQUAL model and the disparities were examined [18, 19]. Chinese scholars have expanded their research by incorporating the service quality gap theory and employing questionnaire surveys to examine the quality of educational services [20, 21].

A thorough examination of current scholarly literature reveals that the majority of research pertaining to the evaluation of educational services in the field of higher education primarily concentrates on the conventional university talent training connections. Conversely, there is a dearth of research investigating the influence of personalized factors on professional students, thereby impeding the direct promotion and application of the acquired methodologies to foster the development of active learning capabilities among university software talents. This study employs quantitative analysis to assess the principal factors that impact higher education services in relation to the active learning ability of students majoring in software. The findings of this study can be utilized by education administrators and instructors in the field of software engineering to implement a comprehensive range of targeted educational strategies aimed at enhancing students' active learning capabilities, fostering their initiative, enthusiasm, and creativity. These efforts have the potential to facilitate the reform of the software talent training model and ultimately enhance the overall quality of talent development in this domain.

3. THEORIES AND METHODS

3.1. SERVQUAL model theory

The SERVQUAL model is utilized for evaluating service quality by assessing the disparity between the perceived service level by users and their anticipated service level [22]. User expectations are considered a fundamental requirement for delivering services of high quality. Surpassing user expectations is crucial in ensuring the provision of high-quality services. The computation procedure for determining service quality is depicted in Equation 1.

$$SQ = \sum_{i=1}^{n} \overline{P_i} - \overline{E_i}. \tag{1}$$

Among the variables considered, n represents the quantity of survey questions, $\overline{P}$ denotes the metric for assessing the actual evaluation of perceived quality, and $\overline{E}$ signifies the average expected quality value. Based on the aforementioned metric, it becomes evident that when the user's experienced service effect matches or surpasses their anticipated service effect, it indicates satisfaction with the evaluation of the service quality model; conversely, dissatisfaction is implied otherwise.

The service quality evaluation system, as proposed by PZB scholars in the SERVQUAL model, encompasses five dimensions: tangibles, reliability, assurance, responsiveness, and empathy. Corresponding items in the questionnaire have been specifically designed for each of these dimensions [23]. Tangibles encompass the physical elements of a service, typically including the tangible product or the external environment and equipment. Reliability pertains to the service personnel's capability to fulfill their commitments, ensuring service reliability and accuracy. Responsiveness denotes the service personnel's willingness to assist customers and deliver timely services, as well as the enterprise's efficiency and effectiveness in fulfilling customer requirements. Assurance pertains to the development of service personnel's knowledge and their level of confidence in delivering services to customers, as well as the extent of trust customers place in the service personnel's service delivery. On the other hand, empathy denotes the capacity of service personnel to offer personalized services and cater to individual perceptions of service quality while serving customers. Given the existence of subjective variations in individual assessments of service quality, it becomes imperative to assign appropriate weights to the acquired values during research endeavors, specifically to the five dimensions and n questions, in order to rectify any potential biases. As demonstrated in Equation 2, the ultimate outcome of this process is the attainment of service quality results.

$$SQ = \sum_{j=1}^{5} W_j \sum_{i=1}^{n} W_i(\overline{P_i} - \overline{E_i}). \tag{2}$$

Among the aforementioned elements, W_j represents the weight assigned to the j-th dimension, while W_i denotes the weight assigned to the i-th question.

3.2. Service quality evaluation method

Based on the SERVQUAL model theory, this study considered various factors, including the training program for software talents in higher education institutions, hardware support measures, and individual initiative of students. Consequently, a survey questionnaire was developed to align with the factors influencing the active learning ability of software talents in colleges and universities. Following the acquisition of the questionnaire data, the questions are subjected to validity testing and analysis, resulting in their classification into specific dimensions. Additionally, the reliability of the questionnaire is assessed through reliability testing. Equation 3 demonstrates the normalization of factor loading values for each dimension and question item, enabling the determination of the overall service quality difference value pertaining to the active learning ability of college software major students.

$$W_i = F_i \Big/ \sum_{j=1}^{m} F_j. \tag{3}$$

Among the aforementioned variables, F_i represents the factor loading value associated with the i-th item, while m denotes the total number of questions within a specific dimension.

4. DATA COLLECTION AND EMPIRICAL RESEARCH

4.1. Questionnaire design and collection

This study focuses on students majoring in software at a specific university as the subject of research. It employs the aforementioned theories and methodologies to categorize factors in-

fluencing students' active learning ability service evaluation into five dimensions. A detailed description of these dimensions is provided in Table 1.

Table 1. Dimension description

Dimension	Description
Tangibles	The hardware equipment and educational environment provided during the implementation of higher education.
Reliability	It signifies the students' capacity to engage in active learning practices that enhance their abilities.
Responsiveness	The impact of students actively enhancing their professional skills through their willingness to improve their active learning capabilities.
Assurance	The degree of confidence exhibited by students in factors that augment their active learning abilities.
Empathy	Students' individual perceptions of the challenges associated with improving their active learning capacities.

Based on the specific attributes of software major students in universities and in accordance with the SERVQUAL model, as depicted in Table 2, a total of 23 items were formulated in the Questionnaire across five dimensions. The survey instrument primarily encompasses two facets: firstly, it gathers data pertaining to students' individual characteristics, encompassing variables such as gender, academic year, and major specialization; secondly, it assesses the extent to which colleges and universities adhere to the provision of services aimed at fostering students' active learning capabilities. Hence, the assessment of the questionnaire is bifurcated into two distinct components, specifically the affective scale and the anticipatory scale. The outcomes of the evaluation are categorized into five levels of assessment based on the Likert scale, encompassing "highly congruent," "congruent," "neutral," "incongruent," and "highly incongruent," with the evaluation scores ranging from 1 to 5 points.

4.2. Single factor analysis

The single factor analysis is a testing method employed to assess the influence of a singular factor on dimensions and questions. The magnitude of this influence is indicated by the significance level p value, which aids in determining whether the variable has a substantial impact on the results of the questionnaire [24]. In this study, the independent samples T test was utilized to examine the impact of gender, while the one-way ANOVA test was employed for other factors. Table 3 demonstrates that the significance levels of the three factors tested, namely gender, grade, and professional direction, on the five dimensions, are all below the threshold value of 0.05. The influence of gender on reliability, responsiveness, and empathy, as well as the impact of grade on reliability, assurance, responsiveness, and empathy, are noteworthy. Furthermore, the influence of professional direction extends to all five dimensions.

4.3. Attribution of factor evaluation dimensions

1. Validity test. Validity is a measure of the extent to which a questionnaire accurately captures the true characteristic data of the object under investigation. In this study, the factor analysis method in statistics is employed to assess the validity of the questionnaire. The Kaiser-Meyer-Olkin (KMO) value, calculated using the Statistical Package for the Social Sciences (SPSS), is used

Table 2. Evaluation indicators of factors affecting active learning ability

Encode	Test item
Q1	The enhancement of students' active learning abilities can be achieved through their comprehension of the requisites for cultivating software talents in the contemporary technological era.
Q2	The active learning ability of students can be influenced by their level of interest in this particular field of study.
Q3	The active learning ability of students can be heightened by their proactive approach towards acquiring knowledge relevant to their chosen profession.
Q4	Students exert diligent efforts in acquiring professional knowledge to secure favorable employment opportunities.
Q5	The active learning abilities of students can be improved by dedicating sufficient effort towards comprehending the subject matter being studied.
Q6	The emotional fluctuations experienced by students when confronted with the study of this particular discipline will have an impact on their capacity for active learning.
Q7	When students are confronted with challenges, they will proactively seek resolutions independently, thereby enhancing their active learning capabilities.
Q8	The deliberate allocation of time for active learning by students can contribute to the improvement of their active learning abilities.
Q9	The exercise of self-control by students can significantly augment their active learning capacities.
Q10	The formulation of study plans by students can lead to the enhancement of their learning abilities.
Q11	The identification and adoption of a learning approach that aligns with their individual preferences can enable students to enhance their active learning capabilities.
Q12	It is crucial to consider the balance between work and rest in order to attain favorable learning outcomes.
Q13	The act of self-evaluation and summarization of experiences by students during the learning process can enhance their capacity for active learning.
Q14	Students employ software to document their learning progress and facilitate self-management and adjustment throughout the learning journey.
Q15	Internet resources serve as a valuable platform for enhancing students' active learning abilities in the pursuit of this particular field of study.
Q16	The possession of specialized knowledge by students can contribute to the improvement of their learning capabilities.
Q17	The university places emphasis on the ideological leadership of its students and frequently invites accomplished role models to foster a positive atmosphere.
Q18	The university offers a wide range of software science and technology activities, showcasing their abundance and diversity.
Q19	The university employs diverse teaching methods that prioritize the integration of theory and practice.
Q20	The classroom teachers at the university adopt an innovative teaching model that centers on the development of students' abilities and qualities.
Q21	The university provides learning and practical facilities that effectively cultivate students' proactive learning skills.
Q22	The university's active learning environment has the potential to foster students' enthusiasm towards the pursuit of knowledge.
Q23	Regular self-assessment of students' learning performance can enhance their capacity for active learning.

Table 3. Variance test p value for single factor analysis

Dimension	Test item	Gender	Grade	Major
Reliability	Q9	0.005	0.007	0.061
	Q23	0.076	0.024	0.002
	Q14	0.462	0.002	0.037
	Q10	0.95	0.068	0.238
	Q8	0.549	0.591	0.140
	Q16	0.002	0.000	0.001
	Q1	0.029	0.003	0.037
	Q13	0.008	0.268	0.009
Tangibles	Q20	0.160	0.981	0.021
	Q19	0.077	0.873	0.062
	Q18	0.246	0.592	0.001
	Q21	0.316	0.853	0.021
	Q22	0.773	0.053	0.061
	Q17	0.845	0.426	0.205
Assurance	Q11	0.564	0.010	0.064
	Q12	0.182	0.004	0.069
	Q15	0.305	0.025	0.004
	Q5	0.106	0.105	0.036
	Q7	0.181	0.104	0.001
Responsiveness Empathy	Q2	0.000	0.025	0.000
	Q3	0.004	0.081	0.000
	Q6	0.000	0.009	0.001

Note: a p value of less than 0.05 indicates statistical significance, suggesting that this particular factor significantly influences the evaluation results.

to determine the suitability of the model for factor analysis, while the Bartlett sphericity test is also conducted. The Bartlett's sphericity test examines the significance between the variables of the questionnaire. The KMO test standard suggests that a higher KMO value, closer to 1, indicates better suitability. A significance level below 0.01 is considered optimal for Bartlett's sphericity test, indicating a significant difference between the correlation coefficient matrix and the unit matrix. This suggests that the factor analysis method is appropriate [25]. According to the findings presented in Table 4, the KMO value and significance value for feeling P and expectation E are determined to be 0.9 and 0.000, respectively. These results suggest a significant correlation between the factors, thereby justifying the feasibility of proceeding with the subsequent factor analysis.

4.4. Attribution of factor evaluation dimensions

1. Validity test. Validity is a measure of the extent to which a questionnaire accurately captures the true characteristic data of the object under investigation. In this study, the factor analysis method in statistics is employed to assess the validity of the questionnaire. The Kaiser-Meyer-Olkin (KMO) value, calculated using the Statistical Package for the Social Sciences (SPSS) [26], is used to determine the suitability of the model for factor analysis, while the Bartlett sphericity test is also conducted. The Bartlett's sphericity test examines the significance between the vari-

Table 4. KMO and Bartlett's test of sphericity

Dimension	Test item	Perception (P)	Expectation (E)
KMO sample measure		0.954	0.931
Bartlett's sphere test	Approximate chi-square	11138.171	7229.255
	variance	253	253
	significance	0.000	0.000

ables of the questionnaire. The KMO test standard suggests that a higher KMO value, closer to 1, indicates better suitability. A significance level below 0.01 is considered optimal for Bartlett's sphericity test, indicating a significant difference between the correlation coefficient matrix and the unit matrix. This suggests that the factor analysis method is appropriate [25]. According to the findings presented in Table 4, the KMO value and significance value for feeling P and expectation E are determined to be 0.9 and 0.000, respectively. These results suggest a significant correlation between the factors, thereby justifying the feasibility of proceeding with the subsequent factor analysis.

2. Exploratory factor analysis. This study employed exploratory factor analysis to ascertain the number of factors and subsequently partition the dimensions of the questionnaire. Principal component analysis and principal axis factor method are the two primary approaches utilized in exploratory factor analysis [27]. The principal component analysis method is employed to identify and diminish the dimensionality of the fundamental outcomes of multivariate variables. After extracting five common factors, the initial factors undergo orthogonal rotation using the varimax method to yield the rotated component matrix and factor loading values post-rotation, as well as the results of principal component extraction. As depicted in Table 5, Q4 exhibits more than two factor loading values exceeding 0.5, suggesting its influence on multiple common factors and rendering it an invalid value. Consequently, this question item is excluded, resulting in a final set of 22 questions that are allocated across five dimensions. Following the rotation process, the factor loading values for each common factor are acquired in order to facilitate the subsequent assignment of weights.

3. Model dimension and item division. The evaluation system employed in this study comprises five dimensions and twenty-two questions. These dimensions, namely reliability, tangibles, assurance, responsiveness, and empathy, are based on the SERVQUAL model. Table 6 presents the reorganized questions based on these dimensions. Dimension 1, "Reliability," encompasses eight questions that gauge students' aptitude for acquiring professional knowledge and enhancing concentration. These indicators serve as a reflection of the reliability of independent and proactive learning abilities among software major students in higher education institutions. Dimension 2, referred to as "Tangibles," encompasses a set of six inquiries that assess the provision of educational resources and environmental facilities by colleges and universities to enhance students' learning experiences. This dimension also serves as an indicator of the institution's dedication to fostering the development of students' initiative through tangible services. On the other hand, Dimension 3, denoted as "Assurance," comprises five questions that gauge students' level of confidence in their ability to enhance their active learning skills. Dimension 4, labeled as "Responsiveness," encompasses two inquiries that assess students' capacity to enhance their initiative and enthusiasm in actively improving their professional abilities through a willingness to learn. On the other hand, Dimension 5, denoted as "Empathy," comprises a single question that gauges the personal challenges and hindrances students face while striving to enhance their active learning capabilities.

Table 5. Rotated component matrix

Test item	1	2	3	4	5
Q19	0.850				
Q20	0.849				
Q18	0.826				
Q17	0.779				
Q21	0.773				
Q22	0.742				
Q9		0.787			
Q10		0.783			
Q14		0.749			
Q23		0.726			
Q8		0.671			
Q13		0.633			
Q16		0.581			
Q1		0.501			
Q11			0.777		
Q12			0.746		
Q5			0.654		
Q15			0.594		
Q7			0.581		
Q2				0.668	
Q3				0.609	
Q4			0.501	0.569	
Q6					0.962

Extraction method: principal component analysis.
Rotation method: Caesar's normalized maximum variance method.
a. The rotation has converged after 6 iterations.

4. Reliability test. Reliability pertains to the consistency and dependability of the comprehensive outcomes acquired through the measurement questionnaire. A higher degree of reliability in the scale corresponds to a reduced margin of measurement error [28]. In this study, data analysis was performed on the questionnaire using SPSS software, and the reliability of the questionnaire was assessed through Cronbach's coefficient test. As presented in Table 7, in accordance with the criterion for the Alpha coefficient, a value exceeding 0.9 indicates a high level of reliability in the questionnaire results. The Cronbach's coefficients for both the feeling scale and the expectation scale have surpassed 0.9, and the two calculated Cronbach's coefficients of the standardized items are both above 0.9 as well. These results indicate that the questionnaire's overall questions and dimensions exhibit high reliability, thereby confirming the accuracy and feasibility of the instrument.

5. Weight definition. The utilization of principal component analysis method is employed to ascertain the weighting of the evaluation model by considering the factor loadings and factor variance contribution rates derived from the question items [29]. The specific procedure entails utilizing SPSS software to conduct factor analysis. This involves extracting five common factors

Table 6. Evaluation system item division

Primary index	Secondary index	Factor loading
Reliability	Q9	0.787
	Q10	0.783
	Q14	0.749
	Q23	0.726
	Q8	0.671
	Q13	0.633
	Q16	0.581
	Q1	0.501
Tangibles	Q19	0.850
	Q20	0.849
	Q18	0.826
	Q17	0.779
	Q21	0.773
	Q22	0.742
Assurance	Q11	0.777
	Q12	0.746
	Q5	0.654
	Q15	0.594
	Q7	0.581
Responsiveness	Q2	0.668
	Q3	0.609
Empathy	Q6	0.962

Table 7. Perception and expectation reliability test

	Perception (P)	Expectation (E)
Cronbach Alpha	0.945	0.911
Cronbach's Alpha based on standardized terms	0.947	0.915
Number of items	22	22

from the total variance explanation table and subsequently normalizing them to determine the weight of each dimension. Additionally, the rotated components Matrix is obtained to ascertain the factor loadings of each question item. The number of factor loadings for each question item within each common factor is then normalized to establish the weight of each question item. According to the findings presented in Table 8, the dimension weights obtained are arranged in descending order as tangibles, reliability, assurance, responsiveness, and empathy. It is evident that the equipment environment offered by educational institutions across these five dimensions significantly influences students' autonomy. Notably, enhancements in this regard have a more pronounced effect. Additionally, the weight assigned to each question within the respective dimensions has also been determined.

Table 8. Evaluation index weight

Dimension	Dimension weight	Index	Index weight
Reliability	0.117	Q9	0.145
		Q10	0.144
		Q14	0.138
		Q23	0.134
		Q8	0.124
		Q13	0.117
		Q16	0.107
		Q1	0.092
Tangibles	0.677	Q19	0.176
		Q20	0.176
		Q18	0.171
		Q17	0.162
		Q21	0.160
		Q22	0.154
Assurance	0.088	Q11	0.232
		Q12	0.223
		Q5	0.195
		Q15	0.177
		Q7	0.173
Responsiveness	0.069	Q2	0.523
		Q3	0.477
Empathy	0.048	Q6	1

4.5. Service quality evaluation

1. Overall evaluation of the model. By employing the SERVQUAL model theory and integrating Equations 1 and 2, the mean assessment of the perceived quality and service quality across five dimensions and 22 inquiries is determined, taking into account the respective weights [30]. As depicted in Table 9, the disparity between the anticipated perception level and the actual service quality level as perceived by students can be ultimately derived. Notably, the majority of the quality gap outcomes exhibit negative values, with the exception of the tangibility and guarantee dimensions, which yield positive values. Consequently, the gap range is observed to be $[-1.608, 0.906]$. This implies that a majority of students within the institution perceive a discrepancy between their anticipated level of active learning ability-enhancing factors and the actual level provided. The comprehensive analysis of the findings reveals an overall service quality score of -0.001 for the evaluation model, with the service gaps ranked in descending order as reliability, responsiveness, empathy, tangibles, and assurance.

In this study, a Likert scale consisting of five points was employed, wherein a rating of 5 denoted “strongly consistent” and a rating of 1 represented “very inconsistent” on the questionnaire. Consequently, when examining the disparity between sentiments and anticipations, the scoring range falls within $[-4, +4]$. Ultimately, when the cumulative evaluation value attains 4

Table 9. Service quality evaluation results of factors improving students' active learning ability

Dimension	Encode	Dimension weight	Item weight Item weight	Perception ($\bar{P}$)	Expectation ($\bar{E}$)	Quality gap
Reliability	Q9	0.117	0.145	3.069	3.928	–0.859
	Q10		0.144	3.245	3.502	–0.257
	Q14		0.138	3.047	3.216	–0.169
	Q23		0.134	2.380	3.988	–1.608
	Q8		0.124	3.514	3.599	–0.085
	Q13		0.117	3.445	3.602	–0.157
	Q16		0.107	3.314	3.372	–0.058
	Q1		0.092	2.736	3.711	–0.975
	Summary		/	3.097	3.622	–0.525
Tangibles	Q19	0.677	0.176	3.579	3.106	0.473
	Q20		0.176	3.502	3.209	0.293
	Q18		0.171	3.599	3.789	–0.190
	Q17		0.162	3.413	3.628	–0.215
	Q21		0.160	3.598	3.623	–0.025
	Q22		0.154	3.700	3.714	–0.014
	Summary		/	3.560	3.499	0.061
Assurance	Q11	0.088	0.232	3.966	3.060	0.906
	Q12		0.223	3.245	3.452	–0.207
	Q5		0.195	4.006	3.979	0.027
	Q15		0.177	3.915	3.291	0.624
	Q7		0.173	3.759	3.097	0.662
	Summary		/	3.768	3.374	0.394
Responsiveness	Q2	0.069	0.523	3.545	3.708	–0.163
	Q3		0.477	3.562	3.599	–0.037
	Summary		/	3.553	3.656	–0.103
Empathy	Q6	0.048	1	2.272	2.463	–0.191
	Summary		/	2.272	2.463	–0.191
Overall rating				3.458	3.460	–0.001

points (equivalent to 100 %), it signifies a highly positive assessment of the service quality offered by the evaluation model. When the overall evaluation value reaches -4 points (0 %), it indicates that the service quality of the evaluation model is at its lowest. Conversely, when the overall service quality is average, signifying equal feelings and expectations, the service quality of the evaluation model is 50 %, with an overall evaluation value of -0.001. To facilitate analysis, this expression is then converted into a more intuitive percentage system. Consequently, the overall evaluation level of factors influencing students' active learning ability is determined to be 49.981 % [31]. This implies that the influencing factors affecting students' active learning ability have attained a level of general conformity with the anticipated level of learning ability factors.

Consequently, the evaluation of the active learning ability factors among college software major students aligns predominantly with the expected evaluation level, exhibiting a degree of consistency ranging from congruent to highly congruent.

2. Evaluate model dimension metrics. Based on the aforementioned analysis of the computation of service quality disparities across the five dimensions and twenty-two items of the model, the dimensional service gap outcomes can be derived. As depicted in Figure 1, the service quality gap pertaining to the "Reliability" dimension emerges as the most significant among the five dimensions, exhibiting a disparity value of −0.525. A substantial discrepancy is observed between students' proactive learning aptitude and their anticipations, signifying their assessment of their own learning accomplishments and capacity to acquire novel knowledge. The disparity between the two indicators pertaining to the comprehension of software talent training requirements in the technological era is notably significant, thereby indicating a deficiency in the assessment of software major students' daily learning performance in higher education institutions. Moreover, it highlights an insufficient level of maturity among students in comprehending the policies governing talent training in the contemporary era. The service quality gap pertaining to "Responsiveness" is −0.103, indicating a lack of effectiveness in students' proactive efforts to enhance their professional competencies. Moreover, the most significant disparity lies in professional interest, suggesting that students' choice of major influences their capacity for active learning improvement. The discrepancy in the attribute of "Empathy" is −0.001, signifying that the influence of students' individual challenges in the learning process on enhancing active learning proficiency has not attained the anticipated standard. Conversely, the discrepancy in the attribute of "Tangibles" is 0.061, denoting a favorable value, suggesting that students hold a positive assessment of the hardware resources and educational setting provided during the execution of higher education. The mean values of the two indicators pertaining to diverse teaching forms and the novel teaching model employed by instructors indicate that the teaching methods implemented by higher education institutions are rational and the teacher's instructional model is successfully executed, thereby positively influencing the enhancement of students' active learning. Additionally, the "Assurance" dimension exhibits the highest positive value of 0.394, denoting the largest disparity in service quality among the five dimensions. The findings indicate that the student

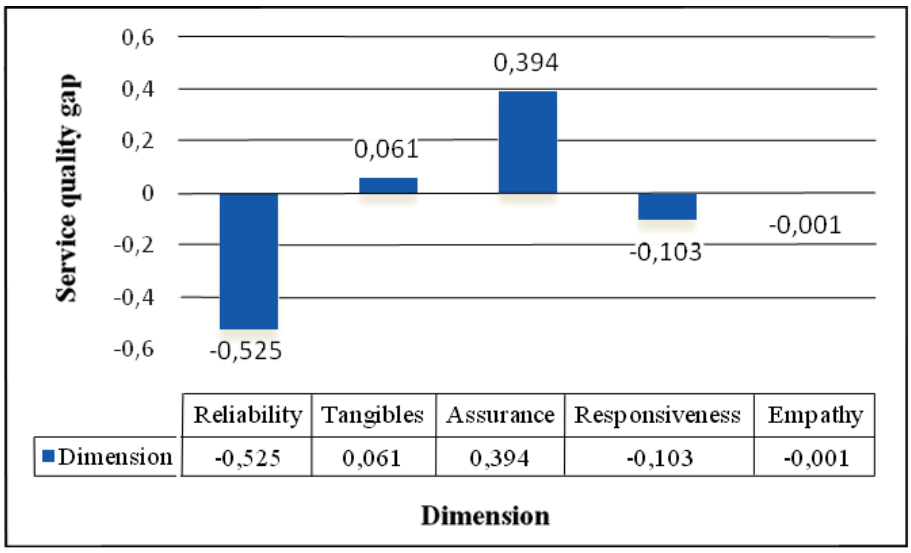

Figure 1. Dimensional service gap

group's confidence in enhancing their learning ability surpasses the expectations of students. Notably, the two indicators of method suitability and students' problem-solving abilities exhibit the greatest disparity. Both of these indicators demonstrate the potential to significantly enhance students' active learning skills and attain a commendable level of evaluation.

5. CONCLUSIONS

1. Enhance students' personal willingness to learn. Based on the findings of this study, the dimension of "Reliability" emerges as the most problematic. This suggests that students' awareness of their own learning capabilities is insufficiently developed, necessitating the provision of external stimuli and college mobilization to enhance their motivation for enhancing their active learning skills. More specifically, a combination of online and offline approaches can be employed to effectively encourage and guide students in the accurate application of their active learning abilities. Online educational institutions have the capacity to employ diverse learning platforms to advocate for the significance of enhancing active learning capabilities, while also devising tailored guidance on learning styles that align with the unique requirements of individual students. Conversely, in traditional brick-and-mortar settings, colleges can conduct lectures to engage in face-to-face discussions with students regarding the cultivation of active learning abilities. Alternatively, they may opt to divide students into smaller class units to offer psychological counseling and personalized educational support through the assistance of counselors.

2. Strengthen students' active response to difficult situations. The negative service quality score for "Empathy" within this dimension suggests that students struggle to effectively address learning difficulties, leading to a pronounced lack of motivation to improve their active learning abilities. To address this issue, students should take into account their individual initiative, and develop personalized response strategies that align with their unique personalities and learning habits. This approach will enable them to calmly analyze and devise solutions when faced with obstacles, while also fostering a heightened enthusiasm and drive for learning.

3. Improving educational processes and methods. Based on the evaluation structure analysis, it is evident that the deficiencies in the five dimensions primarily pertain to individual students. This finding substantiates the need to enhance students' active learning capacity by emphasizing the individual students' efforts in augmenting their own learning abilities, while considering the variations among students. The objective is to facilitate students' active development of practical abilities and utilization of software knowledge through understanding, guiding, and encouraging them.Additionally, organizing a variety of competitions, particularly those related to software majors, can effectively enhance students' active learning capabilities. Furthermore, it is crucial to establish appropriate rewards to incentivize students and foster their enthusiasm for enhancing their professional qualities.

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Развитие навыков активного обучения у студентов программной инженерии: оценка с использованием модели SERVQUAL

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Аннотация

Учитывая современную ситуацию, характеризующуюся стремительным развитием новых технологий и растущими общественными требованиями к специалистам

в области программного обеспечения, данное исследование стремится повысить способность студентов к активному обучению в соответствии с общественными потребностями. Для достижения этой цели в исследовании используется модель качества обслуживания (SERVQUAL) для оценки и изучения ключевых факторов, способствующих повышению самостоятельных навыков студентов, тем самым совершенствуя систему высшего образования. Модель SERVQUAL была использована для составления опросника, ориентированного в частности на опрос студентов программных специальностей и смежных дисциплин. Путем анализа данных и взвешивания результатов опроса было проведено сравнение и оценка расхождений в восприятии и ожиданиях студентов в отношении качества обслуживания. Результаты указывают на фундаментальное соответствие между восприятием и ожиданиями студентов в отношении повышения способности к активному обучению, тем самым подтверждая в целом хорошее качество обслуживания. Эти выводы также предполагают, что стандарты преподавания по специальности и способности студентов к активному обучению успешно соответствуют ожидаемым критериям.

Ключевые слова: *модель SERVQUAL, активное обучение, повышение способностей, высшее образование.*

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