Research in Higher Education (2026) 67:45
https://doi.org/10.1007/s11162-026-09919-0

Linking Course Experience and Student Engagement: The Combined Effects on University Students' Ability Development in China

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Received: 2 December 2025 / Accepted: 1 July 2026

Abstract
Grounded in the college impact models, this study integrates the perspectives of course experience and student engagement to develop a comprehensive pathway model for student ability development. In this study, Student engagement is defined by using a novel framework that integrates interpersonal and individual engagement. Data from 5221 Chinese undergraduates were analyzed using partial least squares structural equation modeling (PLS-SEM). Results demonstrate that course experiences influence ability development through both direct effects and dual mediation pathways of interpersonal and individual engagement. Furthermore, research indicates that the mechanisms through which subdimensions of course experience and student engagement influence various dimensions of ability development operate via distinct pathways. These findings reveal the potential of combining course experience and student engagement to explain student ability development, and reflect some characteristics of teaching and learning in Chinese higher education institutions. The study offers implications for improving the quality of student ability development.

Keywords Ability development · Course experience · Student engagement · Chinese university

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Published online: 09 July 2026

Introduction

As international higher education undergoes rapid transformation amid intensifying global talent competition, the cultivation of students' well-rounded abilities has become a strategic priority worldwide. These abilities, encompassing both cognitive and non-cognitive dimensions, are determinants of individual social and economic success (Heckman et al., 2006). Yet, the effectiveness of this cultivation in specific contexts, particularly within Chinese higher education, requires closer examination.

There is no consensus in existing research on whether and how China's higher education influences student ability development. While some studies confirm that China's higher education system does influence student ability development (Shen & Zhang, 2017; Lu & Wen, 2024), others suggest that Chinese university students may not demonstrate superior development in crucial cognitive skills like critical thinking compared to their international peers (Gong & Lv, 2012; Loyalka et al., 2021). Meanwhile, scholars argue that the domestic system lacks sufficient focus on nurturing non-cognitive abilities, potentially compromising the overall quality of talent development (Zheng, 2020).

This issue is also evident in public discourse. Concepts like "GPA reigns supreme" (Lu et al., 2023) and the "new uselessness of education" (Hou & Xu, 2014) have sparked debate. The former captures a campus culture where an excessive pursuit of grades may distort learning commitments and narrow academic objectives, potentially hindering holistic ability development. The latter reflects a social sentiment that questions the value of knowledge amid graduate employment difficulties and perceived diminishing returns, reducing higher education to a mere tool for credentialing. These phenomena underscore the need to conduct a comprehensive, empirical analysis of the current state and driving mechanisms behind Chinese university students' ability development.

Course experiences and student engagement have become widely adopted perspectives for explaining student ability development, but they primarily emerge through parallel development. Course experience reflects students' perceptions and evaluations of the quality of the teaching environment. Originating from instruments like the Course Experience Questionnaire (CEQ) in Australia, this perspective has been widely adopted as an effective tool for diagnosing teaching quality from the student perspective (Fryer et al., 2012; Kreber, 2003; Lu & Li, 2020; Marsh, 1987; Wilson et al., 1997). Student engagement refers to the quantity and quality of students' investment in learning activities. Spearheaded by surveys like the National Survey of Student Engagement (NSSE), this approach has sparked an international movement in understanding learning processes (Coates & McCormick, 2014). However, the interaction between these two critical factors—the teaching environment (course experiences) and the learning state (student engagement)—in jointly shaping ability development remains a significant, underexplored gap.

This study aims to achieve two primary objectives. Firstly, it will provide a systematic examination of the current state of Chinese university students' ability development, encompassing both cognitive and non-cognitive dimensions. Secondly, it will analyze the mechanisms of ability development through the integrated lenses of course experience and student engagement. This study seeks to address this theoretical gap by integrating these two perspectives and examining their synergistic effects within the Chinese context, thereby contributing to a more comprehensive theory of university student development.

Literature Review

University Students' Ability Development

Cognitive and non-cognitive abilities are both crucial to social and economic success, in terms of educational attainment, employment outcomes, and earnings (Heckman et al., 2006). Cognitive ability, often associated with the psychological "g factor," includes fluid and crystallised intelligence required for learning and problem-solving (Heckman & Kautz, 2013; Jensen, 1998). Non-cognitive abilities, conversely, refer to personal attributes beyond IQ, such as personality traits and social and emotional skills (Heckman & Kautz, 2013).

The conceptualization of ability has been operationalised by many international organizations, which have developed frameworks to specify the concrete abilities essential for modern life and work. As illustrated by the frameworks from the United Nations Educational, Scientific, and Cultural Organization (UNESCO), the Organization for Economic Cooperation and Development (OECD), and the European Union (EU) (see Table 1), these models share three key commonalities. First, they integrate both cognitive and non-cognitive abilities. Second, within the cognitive domain, they emphasise core skills like critical thinking, alongside digital and research capacities. Third, their non-cognitive dimensions assess abilities such as self-awareness and global citizenship.

University students' ability development refers to the cultivation of individual abilities within the higher education context (Yu et al., 2009). It follows that concerns regarding its development should encompass both cognitive and non-cognitive dimensions. Despite the diversity of measurement tools, existing studies on university student ability development

Table 1 International ability frameworks

The four pillars of education for the 21st century	Definition and Selection of Competencies: Theoretical and Conceptual Foundations	Transversal Skills	Key Competences for Lifelong Learning	OECD Learning Compass 2030
UNESCO,1996	OECD, 2003	UNESCO, 2013	EU, 2018	OECD, 2019
Learning to know	Act autonomously	Critical and innovative thinking	Literacy competence	Creating new value
		Interpersonal skills	Multilingual competence	
	Use tools interactively		Mathematical competence and competence in science, technology and engineering	
Learning to do		Media and information literacy	Digital competence	Reconciling tensions and dilemmas
			Personal, social and learning to learn competence	
Learning to be	Interact in heterogeneous groups	Intrapersonal skills	Entrepreneurship competence	
Learning to live together		Global citizenship	Citizenship competence	Taking responsibility
			Cultural awareness and expression competence	

(see Table 2) point to several shared patterns. They consistently emphasise abilities relevant to work and daily life, as well as responsibilities as members of society and global citizens (Yang & Xiang, 2025). Specifically, while the operational definitions differ, cognitive abilities generally include fundamental skills such as listening, speaking, reading, and writing, alongside critical thinking, problem-solving, numerical literacy, and research capabilities. Non-cognitive abilities primarily focus on self-awareness, civic competence, and global competence. Naturally, distinctions exist among measurement tools: some prioritize cognitive competencies (e.g., KEDI), while others assess both cognitive and non-cognitive competencies (e.g., SERU).

Based on the cognitive and non-cognitive ability framework proposed by Heckman, this study defines university students' ability development as students' positive changes in cognitive and non-cognitive abilities through higher education. The measurement tool is adapted from the University Student Ability Development Scale in the SERU, which comprehensively reflects the developmental state of students' cognitive and non-cognitive abilities. Considering the actual characteristics of Chinese university students, these items were grouped into three dimensions: core skills development, research capacities development, self-awareness & globalization ability development (Lu & Hu, 2015; Lu & Liu, 2017a; Lu & Wen, 2024). Core skills include students' fundamental communication skills such as listening, speaking, reading, and writing, as well as critical thinking and problem-solving abilities; Research capacities include students' computer and internet skills, ability to understand academic literature, and presentation skills; Self-awareness & globalization ability include students' self-awareness, sense of social responsibility, and understanding of global cultural differences. The first two dimensions pertain to cognitive abilities, while the latter pertains to non-cognitive abilities.

The development of university students' abilities is influenced by multiple factors. Based on relevant theoretical models, such as Astin's (1993) Input-Environment-Output (I-E-O)

Table 2 University student ability development instruments

Instruments	Dimensions/items
National Survey of Student Engagement, NSSE (Kuh, 2013)	Writing clearly and effectively, speaking clearly and effectively, thinking critically and analytically, analyzing numerical and statistical information, solving complex real-world problems, acquiring job- or work-related knowledge and skills, working effectively with others, developing or clarifying a personal code of values and ethics, understanding people of other backgrounds (economic, racial/ethnic, political, religious, nationality, etc.), being an informed and active citizen
Student Experience in the Research University, SERU (Chatman, 2009, 2011; Flacks et al., 2004)	Gains in critical thinking and communication, gains in cultural appreciation and social awareness, gains in computer and research skills
The Korean Educational Development Institute data, KEDI (Choi & Rhee, 2014)	Analytical thinking, problem-solving, communication, working with others
Chinese College Student Survey, CCSS (Shi, 2016)	Critical and open-minded thinking, communication skills, organizational leadership and teamwork abilities, ability to apply technology and tools to solve problems
National Assessment of Collegiate Capacity, NACC (Shen & Zhang, 2017)	Critical thinking skills, creativity, interpersonal skills, and problem-solving skills
Shaanxi Universities Graduates' Employment and Entrepreneurship Quality Tracking Survey (Lu, 2021)	Core skills, research capacities, self-awareness & globalization ability

model and Pascarella's and Terenzini (1991) General Model for Assessing Change in College Students, these influencing factors of university students' ability development can be categorized into two primary types: input factors and process factors. Input factors comprise students' background characteristics and institutional characteristics. Process factors encompass the teaching environment and student engagement, among others. This study focuses on process factors, as these represent the most amenable to intervention within higher education.

Course Experience

Since the late twentieth century, student evaluations of the teaching they receive have been widely used in higher education internationally, with the Course Experience Questionnaire (CEQ) emerging as one of the most widely adopted instruments for gathering university students' feedback on their teaching. Grounded in the recognition that students' learning is shaped not by objective teaching practices alone but by how they experience and make sense of those practices (Ramsden, 1979, 1991), this line of inquiry was first operationalized through the Course Perceptions Questionnaire (CPQ) developed by Ramsden and colleagues in the 1980s—the precursor to what would later evolve into the CEQ. The CEQ encompasses dimensions such as clear goals and standards, good teaching, emphasis on independence, appropriate assessment, and appropriate workload. The CEQ has been adopted nationally in Australia, where it is administered to graduates to assess and benchmark teaching quality across higher education institutions (Ramsden, 1991). A significant revision was undertaken by McInnis, Griffin, and colleagues (2001), who enhanced the CEQ by adding dimensions including learning resources, learning community, student support, intellectual motivation, and graduate quality, thereby providing a more comprehensive reflection of the student-perceived teaching environment.

In the Chinese context, the CEQ framework has been subsequently adapted and applied to domestic higher education research (Lu et al., 2011; Yin et al., 2014). A significant development in this line of inquiry was the creation of a comprehensive course experience survey for the Shaanxi Higher Education Graduate Employment and Entrepreneurship Tracking Survey. This instrument, developed by Lu and Li (2020), integrated the refined CEQ with a locally developed University Mathematics Classroom Environment Questionnaire (UMCEQ) resulting in 11 dimensions encompassing learning resources, student supports, course organizations, clear goals and standards, good teachings, appropriate workloads, appropriate assessments, independence and self-determination, learning communities, intellectual motives, and graduate qualities. These dimensions evaluate specific aspects of the teaching environment. Clear goals & standards, course organizations, and good teachings examine instructors' teaching practices. Learning communities and independence & self-determination assess how the learning environment supports collaborative and autonomous learning, respectively. Appropriate assessments and appropriate workloads investigate the nature of learning demands and evaluation. Intellectual motives and graduate qualities gauge students' perceptions of instructional effectiveness in promoting personal development. Learning resources and student supports evaluate institutional support provided by the university.

In this study, course experience is conceptualized as students' perceptions and evaluations of the quality of their teaching environment. This concept was operationalized

using the Course Experience Questionnaire from the Shaanxi Higher Education Graduate Employment and Entrepreneurship Tracking Survey. There are two advantages to using this instrument. First, it offers a more comprehensive coverage of the teaching environment than previous versions, integrating dimensions from both the refined CEQ and a locally developed classroom environment questionnaire (UMCEQ). Second, it has been extensively validated among Chinese university students.

Student Engagement

The National Survey of Student Engagement (NSSE) defines student engagement as comprising both the extent to which students participate in educationally effective activities as well as their perceptions of facets of the institutional environment that support their learning and development (Kuh, 2013). NSSE operationalizes this construct across four dimensions: academic challenge, learning with peers, experiences with faculty, and campus environment. As student engagement research has gained global popularity, large-scale surveys like NSSE have begun to face controversy. First, they often equate engagement primarily with observable behavioral indicators, potentially neglecting the internal psychological dimensions of learning. This behavioral focus risks oversimplifying the student engagement, as a disjuncture may exist between outward actions and inner cognitive or emotional states (Barnett & Coate, 2005; Solomonides, 2013). Second, these instruments risk conflating the manifestation of student engagement with its antecedent conditions (such as campus environment), thereby creating conceptual ambiguity (Brint, 2008).

In response to these limitations, multi-perspective models have gained prominence. Fredricks and colleagues (2004) proposed an influential tripartite framework that distinguishes between behavioral engagement (active participation in academic activities), emotional engagement (affective reactions to learning), and cognitive engagement (the investment of mental effort in mastering complex ideas). This model offers a more holistic account of students' engagement in learning (Salanova & Schaufeli, 2000).

Within the specific context of Chinese higher education, research suggests a distinctive individual and interactive dual-structure framework (Huai, 2024; Wang, 2020). This structure may be influenced by cultural norms that encourage circumspection in discourse (Gong & Lv, 2012) and a traditionally less pronounced emphasis on interactive pedagogy (Chen et al., 2024). Differentiating between interactive and individual components thus provides a more nuanced understanding of Chinese students' learning engagement.

Accordingly, this study defines student engagement as students' state of engagement in learning activities, consisting interpersonally of active student-faculty interaction and peer collaboration, and intrapersonally of positive emotional states, sustained effort, and deep cognitive processing. In empirical analysis, this concept is operationalized into five dimensions: student-teacher interaction engagement, student-student interaction engagement, emotional engagement, behavioral engagement, and cognitive engagement. This conceptualization aligns with the broader engagement literature in two key respects. First, like the NSSE framework, it recognizes that engagement encompasses both individual dimensions (e.g., academic challenge) and interpersonal dimensions (e.g., learning with peers, experiences with faculty). Second, consistent with Fredricks et al.'s tripartite model, it acknowledges that individual engagement comprises emotional, behavioral, and cognitive components—thereby moving beyond purely behavioral indicators. Meanwhile, our con-

ceptualization is distinct from existing frameworks in two important ways. First, whereas NSSE comprehensively measures both student behaviors and campus conditions to analyze educational quality (e.g., treating campus environment as a dimension of engagement), our study adopts a student-centered perspective, focusing on engagement as a holistic psychological state encompassing cognitive, emotional, and behavioral dimensions to better reveal the internal mechanisms of student learning. Second, our study adopts a dual-structure of interpersonal engagement and individual engagement, a distinction that is theoretically and empirically important for understanding ability development in the context of Chinese higher education.

The Impact of Course Experiences and Student Engagement on University Students' Ability Development

Research examining the relationship between course experiences and university students' ability development remains limited. Existing studies suggest that students' course experiences significantly influence their ability development, though findings regarding the roles of subdimension factors are inconsistent. For instance, research by Lu and colleagues (2017a) found that various course experience factors significantly impact ability development, with dimensions such as intellectual stimulation, mutual cooperation, and social networks positively correlating with the growth of research capabilities, core skills, and social communication abilities. Conversely, factors like autonomous choice and peer competition were negatively associated with the development of research and core skills (Li et al., 2023; Lu & Liu, 2017b). Additionally, Chi et al. (2017) reported positive correlations between course challenge, teacher guidance, academic atmosphere, and students' cognitive ability development. These findings underscore the need to validate the relationship between course experiences and ability development using more systematic measurement tools. Furthermore, the pathways through which course experiences influence ability development are not fully understood, necessitating the introduction of mediating mechanisms to construct a multidimensional analytical framework.

Some studies indicate that student engagement is closely linked to university students' ability development, with higher levels of engagement correlating with better development outcomes (Álvarez-Huerta et al., 2023; Pike & Kuh, 2005; Yin & Wang, 2016), often contributing more significantly to ability development than student background or institutional factors (Franklin, 1995; Terenzini et al., 1995). Teaching environment factors have been shown to positively influence student engagement, which in turn foster ability development (Guo et al., 2022; Lu, 2012). However, the relationship may not be purely linear—recent research suggests a potential inverted U-shaped curve, indicating that beyond a certain point, increased engagement does not necessarily yield better outcomes (Lu et al., 2023), a complexity requiring further validation.

Existing research has insufficiently discussed the combined effects of course experiences and student engagement on ability development. Most studies have examined only one or a few isolated aspects of the course experiences rather than adopting a comprehensive, systematic framework, such as course challenge (Chi et al., 2017), teaching clarity and organization (Gray & DiLoreto, 2016; Roksa et al., 2017), good teaching (Fong et al., 2019; Umbach & Wawrzynski, 2005), and course sense of acquisition (Li & Xu, 2024). This isolated approach limits comparisons of the relative effects of different course

experience dimensions. Research integrating course experiences, student engagement, and ability development remains particularly scarce. Only a few relevant studies offer insights: Yin and Ke (2017) examined how a six-dimensional model of course experiences—clear goals and standards, generic skills, emphasis on independence, good teaching, appropriate workload, and appropriate assessment—affected Chinese university students' engagement, measured using the Motivation and Engagement Scale for University and College Students (MES-UC). Their findings revealed differential impacts: clear goals and standards, generic skills, and appropriate workload positively influenced engagement, while appropriate assessment served as a double-edged sword, reducing both maladaptive and adaptive engagement. Surprisingly, emphasis on independence and good teaching negatively affected student engagement.

In summary, the interrelationships between course experiences, student engagement, and ability development are underexplored. Firstly, few studies adopt a course experience perspective to analyze teaching environments and subsequently examine these three variables. Secondly, the mediating role of student engagement between course experiences and ability development remains unclear and warrants further investigation.

Conceptual Framework

This study is grounded in college impact models, which provide theoretical explanations for how institutional environment and student engagement shape development outcomes.

Astin's I-E-O model provides an input-environment -outcome logic, framing development as the result of both input factors (e.g., gender, family background) and environment factors (e.g., curriculum, peer group, student engagement). This study focuses on environmental factors, specifically examining course experiences and student engagement. Input factors are treated as control variables in this study.

Pace's Quality of Student Effort Model argues that the quality of students' effort is the most proximal determinant of learning gains. Effort quality is defined as the time and energy students devote to educationally purposeful activities. Accordingly, we draw on Pace's model to justify the mediating role of student engagement.

Pascarella's General Model for Assessing Change in College Students specifies how institutional environment, social interactions, and student effort jointly shape development. According to Pascarella's model, the institutional environment (e.g., course experiences) influences development outcomes primarily through students' social interactions and the quality of their effort. This study adopts the logic of this model by positioning interpersonal engagement and individual engagement as mediators linking course experiences to ability development.

Based on this theoretical foundation, the present study proposes and tests an integrated course experiences-student engagement-ability development model (Fig. 1). The model examines the following hypotheses:

Hypothesis 1 *Positive course experiences have a positive direct effect on university students' ability development.*

Hypothesis 2 *Interpersonal engagement mediates the relationship between course experiences and ability development.*

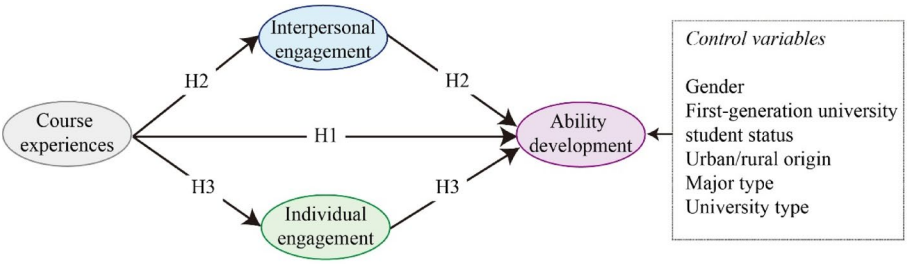

Fig. 1 Conceptual framework

Hypothesis 3 *Individual engagement mediates the relationship between course experiences and ability development.*

Research Design

Participants

This study was conducted in Shaanxi Province, China. Shaanxi Province is a higher education hub in western China, hosting a diverse range of universities, including both Double First-Class universities (an elite institutional designation under a national policy that prioritizes funding and development) and non-Double First-Class universities. These universities encompass nearly all academic majors offered in Chinese higher education. This diversity makes Shaanxi highly representative of China's regional higher education landscape, providing an appropriate context for this study.

This study utilized data from the "2021 Shaanxi Universities Graduates' Employment and Entrepreneurship Quality Tracking Survey," administered by the China Western Higher Education Evaluation Center at Xi'an Jiaotong University. The survey employed a standardized, independently developed questionnaire focusing on graduates' employment outcomes, entrepreneurial activities, course experiences, student engagement, and ability development. It was conducted online between January and April 2022, approximately six months after graduation. The present analysis restricted the sample to undergraduate graduates. A total of 29,493 valid questionnaires were returned, representing a response rate of approximately 17.2%. Following data cleaning procedures that excluded records with missing values on the analysis indicators, the final analytical sample comprised 5,221 valid responses. Given the considerable number of cases excluded, we compared the final sample with the full returned sample on major type, university type, and gender (variables with no missing values). The distributions were nearly identical, indicating no systematic bias from listwise deletion (see Table 3).

The background characteristics of the participants were as follows. Males constituted 53.5% of the sample, compared to 46.5% females. In terms of first-generation university student status, a majority (88.4%) were first-generation university students, defined as those whose parents had not attended a university, while 11.6% were non-first-generation students. In terms of urban/rural origin, 58.8% of students came from urban areas and 41.2% from rural regions. In this study, first-generation status captures family cultural and educa-

Table 3 Sample background characteristics

Variable	Category	Effective sample		Overall sample	
		Frequency	Percentage (%)	Frequency	Percentage (%)
Major type	Humanities & social sciences	2360	45.2	13,170	44.7
	Natural sciences	2861	54.8	16,323	55.3
University type	Double First-Class universities	1269	24.3	6682	22.7
	Non-Double First-Class universities	3952	75.7	22,811	77.3
Gender	Male	2795	53.5	16,317	55.3
	Female	2426	46.5	13,176	44.7
First-generation university student status	First-generation	4615	88.4		
	Non-first-generation	606	11.6		
Urban/rural origin	Rural origin	2151	41.2		
	Urban origin	3070	58.8		
Total		5221	100	29,493	100

tional capital, and urban/rural origin serves as a proxy for family economic background. Regarding major type, 54.8% majored in natural sciences and 45.2% in humanities and social sciences. By university type, 75.7% of students graduated from non-Double First-Class universities, and 24.3% from Double First-Class universities.

Instruments

This study examined three primary variables: ability development, student engagement, and course experiences. All items were measured using five-point Likert scales ranging from 1 (strongly disagree) to 5 (strongly agree).

Ability Development

The ability development scale assessed students' growth in analytical thinking, critical thinking, communication, digital literacy, research skills, self-awareness, and understanding of global cultures. This scale was selected because it covers both cognitive and non-cognitive abilities, matching the conceptualization of ability development in this study, and because it has been validated in previous studies with Chinese university students (Lu & Hu, 2015; Lu & Liu, 2017a; Lu & Wen, 2024). Core skills (CS): measures development in analytical, communication, and writing abilities (6 items; e.g., "University studies have developed my critical thinking skills"); Research capacities (RC): assesses improvement in academic literature comprehension and digital competence (6 items; e.g., "University studies have developed my computer and internet skills"); Self-awareness & globalization abilities (SGA): captures growth in understanding racial and cultural diversity, self-awareness, and social responsibility (6 items; e.g., "University studies have enhanced my self-awareness and comprehension abilities"). The CS and RC dimensions reflect cognitive ability development, while SGA corresponds to non-cognitive ability development.

Student Engagement

Student engagement was operationalized as a dual-structure framework comprising interpersonal and individual engagement, which has been shown to be suitable for Chinese university students (Huai, 2024; Wang, 2020). First, individual engagement, comprising: Emotional engagement (EE): enthusiasm and interest in coursework (6 items; e.g., "I feel passionate about this course"); Behavioral engagement (BE): effort and energy invested in learning (4 items; e.g., "I give my best effort to study this course"); Cognitive engagement (CE): attentiveness in class and diligence in preparation/review (4 items; e.g., "I listen carefully in class"). Second, interpersonal engagement, comprising: Student-student interaction (SSI): proactive communication with peers about course learning (8 items; e.g., "I discuss course content with classmates through various methods"); Student-teacher interaction (STI): proactive communication with instructors for academic support (7 items; e.g., "I can initiate discussions with my teacher").

Course Experiences

Course experiences were measured using a self-developed, 11-dimensional adaptation of the CEQ. This instrument was chosen for two reasons: it provides a more comprehensive assessment of the teaching environment, and it has been demonstrated to be reliable and valid among Chinese undergraduate students (Lu & Li, 2020). These 11 dimensions are: Learning resources (LRS): adequacy of teaching resources (3 items; e.g., "The resources and services of the university library meet my learning needs"); Student supports (SSS): accessibility of institutional support (3 items; e.g., "I can obtain the necessary information technology resources and services during my university studies"); Course organizations (COS): logical structure of the curriculum (4 items; e.g., "The organization of the school's curriculum content is systematic"). Clear goals & standards (CGS): clarity of program objectives (5 items; e.g., "The teaching objectives and requirements of the university's curriculum are clear"); Good teachings (GTS): teaching competence of faculty (3 items; e.g., "University faculty are highly skilled at explaining course content to us"); Appropriate workloads (AWS): alignment of learning demands with capacity(4 items; e.g., "The learning tasks in the university's curriculum are appropriate and manageable for us to comprehend"); Appropriate assessments (AAS): orientation of assessments toward deep learning (4 items; e.g., "School assessments evaluate our understanding rather than memorization"); Independence & self-determination (IS): student autonomy in academic decisions (5 items; e.g., "We have choices in how to study courses at school"); Learning communities (LCS): social support in learning (3 items; e.g., School teachers incorporate student opinions and suggestions in course instruction); Intelligent motives (IMS): effectiveness in motivating students (4 items; e.g., University courses motivated my learning); Graduate qualities (GQS): promotion of student development and lifelong learning (6 items; e.g., What I learned at school is useful for my future development).

Reliability and Validity

As shown in Table 4, reliability was assessed using Cronbach's α and composite reliability (CR). Cronbach's α measures internal consistency, with values of 0.70 or higher generally

considered acceptable (Nunnally, 1978). All Cronbach's α values in this study ranged from 0.861 to 0.978, indicating strong reliability. CR is a more robust measure of internal consistency, for which a value above 0.70 is recommended (Hair et al., 2019). All CR values exceeded 0.90. Convergent validity was evaluated using average variance extracted (AVE). AVE quantifies the proportion of variance that a construct captures from its indicators relative to measurement error. An AVE of 0.50 or higher indicates adequate convergent validity (Fornell & Larcker, 1981). All AVE estimates ranged from 0.707 to 0.947, confirming convergent validity.

Discriminant Validity

Discriminant validity refers to the extent to which a construct is truly distinct from other constructs in the model. It indicates that the measures of different constructs are not overly correlated with each other. In this study, discriminant validity was assessed using the heterotrait-monotrait (HTMT) ratio of correlations. As shown in Table 5, all HTMT values were below the recommended threshold of 0.90 (Henseler et al., 2015), ranging from 0.783 to 0.896, thus supporting the distinctiveness of the variables.

Common Method Bias

Common method bias refers to systematic measurement error that can arise when all data are collected from the same source using the same method (e.g., self-report Likert scales). Such bias may artificially inflate or deflate observed relationships among variables. To

Table 4 Construct reliability and convergent validity

First-order Variable	Cronbach's α	CR	AVE	Second-order Variable	Cronbach's α	CR	AVE
Appropriate assessments	0.861	0.906	0.707	Course Experiences	0.978	0.981	0.822
Appropriate workloads	0.925	0.947	0.817				
Clear goals & standards	0.936	0.952	0.797				
Course organizations	0.894	0.934	0.824				
Graduate qualities	0.953	0.962	0.809				
Good teachings	0.915	0.946	0.855				
Intelligent motives	0.950	0.964	0.870				
Independence & self-determination	0.914	0.936	0.745				
Learning communities	0.876	0.924	0.802				
Learning resources	0.860	0.914	0.781				
Student supports	0.902	0.939	0.836				
Student-student interaction	0.963	0.968	0.793	Interpersonal Engagement	0.944	0.973	0.947
Student-teacher interaction	0.964	0.970	0.822				
Emotional engagement	0.964	0.971	0.848	Individual Engagement	0.951	0.968	0.910
Cognitive engagement	0.941	0.958	0.850				
Behavioral engagement	0.950	0.964	0.871				
Core skills	0.951	0.961	0.803	Ability Development	0.969	0.980	0.942
Research capacities	0.944	0.956	0.782				
Self-awareness & globalization abilities	0.939	0.952	0.768				

Table 5 Discriminant validity (HTMT Ratios)

Course Experiences	Course Experiences	Interpersonal Engagement	Individual Engagement	Ability Development
Interpersonal Engagement	0.842			
Individual Engagement	0.783	0.896		
Ability Development	0.828	0.827	0.829	

Table 6 Assessment of common method bias

	Correlation with marker variable
Course experiences	0.045
Interpersonal Engagement	0.078
Individual Engagement	0.061
Ability Development	0.039

address this potential issue, the marker variable technique was employed. A theoretically unrelated item ("I often feel worthless"), measured on a five-point Likert scale, was selected as the marker. As shown in Table 6, the correlations between this marker variable and the core variables ranged from 0.039 to 0.078—all below the critical value of 0.10. This indicates that common method bias is unlikely to confound the interpretation of the results.

Data analysis

This study employed partial least squares structural equation modeling (PLS-SEM) to develop and validate a university student ability development pathway model. The analysis proceeded in two stages.

First, a second-order structural model was constructed with ability development as the dependent variable, course experiences as the independent variable, and both interpersonal engagement and individual engagement as mediating variables. The control variables comprised gender, urban/rural origin, first-generation university student status, major type, and university type. Model validity was evaluated using multiple criteria, including explained variance (R^2), predictive relevance (Q^2), standardized root mean square residual (SRMR), normed fit index (NFI), and the root mean square residual covariance matrix (RMS Theta). Following established guidelines, R^2 values above 0.75 and 0.50 indicate high and moderate explanatory power, respectively; Q^2 values exceeding 0.50 and 0.25 represent high and moderate predictive relevance; SRMR should be below 0.08; NFI above 0.90; and RMS Theta should approach zero (Hair et al., 2019; Henseler et al., 2016). The significance of path coefficients was tested using bootstrapping with 10,000 subsamples.

Second, a first-order structural model was specified to examine relationships at the dimensional level. In this model, the three subdimensions of ability development constituted the dependent variables, the 11 subdimensions of course experiences served as independent variables, the two subdimensions of interpersonal engagement and three subdimensions of individual engagement functioned as mediating variables. The same set of control variables was incorporated into the first-order model. Following an assessment of model validity, the significance of path coefficients between these dimensional constructs was examined.

All analyses were conducted using Smart PLS 3.0 statistical software.

Table 7 Descriptive statistics for university students' ability development

Dimension	Mean	Std. Error	Overall	Mean	Std. Error
Core skill development	3.78	0.741	Ability development	3.81	0.716
Research capacity development	3.82	0.736			
Self-awareness & global ability development	3.83	0.734			

Table 8 Model fit indices for the university student ability development pathway model

	R^2	Q^2	SRMR	NFI	RMS Theta
Interpersonal engagement	0.659	0.620	0.032	0.894	0.152
Individual engagement	0.578	0.521			
Ability development	0.739	0.692			

Results

Characteristics of University Students' Ability Development

Table 7 presents the descriptive statistics for university students' ability development. The overall mean score was 3.81, indicating a moderately positive level of development. Scores across the three dimensions were relatively balanced. Core skill development received the lowest mean score (3.78), followed by research capacity development (3.82). Self-awareness and global ability development scored highest (3.83).

University Student Ability Development Pathway Model

The fit indices of the structural equation model are summarized in Table 8. The R^2 values for ability development, interpersonal engagement, and individual engagement were 0.739, 0.659, and 0.578, respectively, indicating moderate to substantial explanatory power. The Q^2 values for these constructs were 0.692, 0.620, and 0.521, all exceeding the threshold of 0.50, which confirms the model's high predictive relevance. Regarding model fit, SRMR was 0.032, below the recommended cutoff of 0.08; NFI was 0.894, approaching the 0.90 benchmark; and RMS Theta was 0.152. Collectively, these indices support the acceptability of the model's validity and fit.

As shown in Fig. 2, after controlling for student and institutional characteristic variables, course experiences had a significant positive direct effect on ability development ($\beta = 0.415$, $p < 0.001$). It was also positively associated with interpersonal engagement ($\beta = 0.812$, $p < 0.001$) and individual engagement ($\beta = 0.760$, $p < 0.001$). In turn, both interpersonal engagement ($\beta = 0.157$, $p < 0.001$) and individual engagement ($\beta = 0.350$, $p < 0.001$) were positively related to ability development.

The indirect effect of course experiences on ability development through interpersonal engagement was significant ($\beta = 0.127$, $p < 0.001$), as was the indirect effect through individual engagement ($\beta = 0.266$, $p < 0.001$). Bootstrap confidence intervals further confirmed the significance of these mediation paths (Table 9).

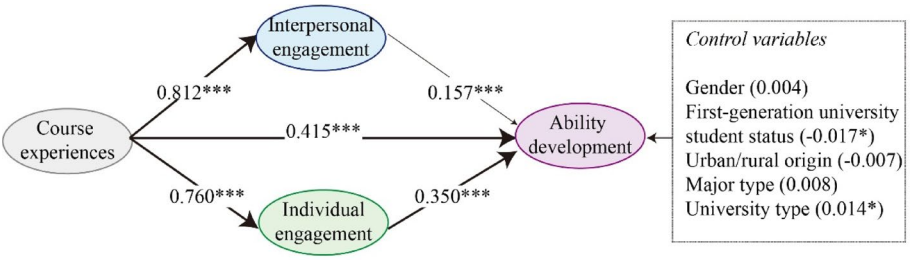

Figure 2 Direct effects in the university student ability development pathway model. *Note* *$p < 0.05$; ***$p < 0.001$. Numbers next to control variables are standardized direct effects of those control variables on ability development.

Table 9 Indirect effects in the university student ability development pathway model

Indirect Path	β	95% CI Lower	95% CI Upper
Course experiences-Interpersonal engagement-ability development	0.127***	0.088	0.168
Course experiences-Individual engagement-Ability development	0.266***	0.220	0.292

***$p < 0.001$

All three hypotheses were supported:

H1 was validated, confirming positive course experiences have a positive direct effect on university students' ability development.
H2 was supported, indicating that interpersonal engagement mediates the relationship between course experiences and ability development.
H3 was supported, indicating that individual engagement mediates the relationship between course experiences and ability development.

University Student Ability Development Pathway Subdimension Model

Building upon the university student ability development pathway model, this study further examines the subdimension relationships through first-order structural equation modeling (Table 10). The model demonstrated acceptable validity and fit, with R^2 ranging from 0.500 to 0.740 across dimensions, indicating moderate explanatory power. Q^2 values ranged from 0.431 to 0.590, confirming the model's predictive capability. Model fit indices were satisfactory: SRMR was 0.032, NFI was 0.877, and RMS Theta was 0.079.

Figure 3 presents the direct effects in the university student ability development pathway subdimension model. The analysis includes the same control variables as the second-order model described above. These control variables are not displayed in the figure to keep the model clear and focus on the main mechanisms.

For core skills, the strongest direct effects come from graduate qualities (β = 0.310, $p < 0.001$) and cognitive engagement (β = 0.265, $p < 0.001$). For research capacities, the strongest direct effects come from graduate qualities (β = 0.289, $p < 0.001$), emotional

Table 10 Model fit indices for the university student ability development pathway subdimension model

	R^2	Q^2	SRMR	NFI	RMS Theta
Student-student interaction	0.675	0.532	0.032	0.877	0.079
Student-teacher interaction	0.648	0.528			
Behavioral engagement	0.500	0.431			
Cognitive engagement	0.527	0.444			
Emotional engagement	0.640	0.539			
Core skills	0.740	0.590			
Research capacities	0.716	0.555			
Self-awareness & globalization abilities	0.710	0.540			

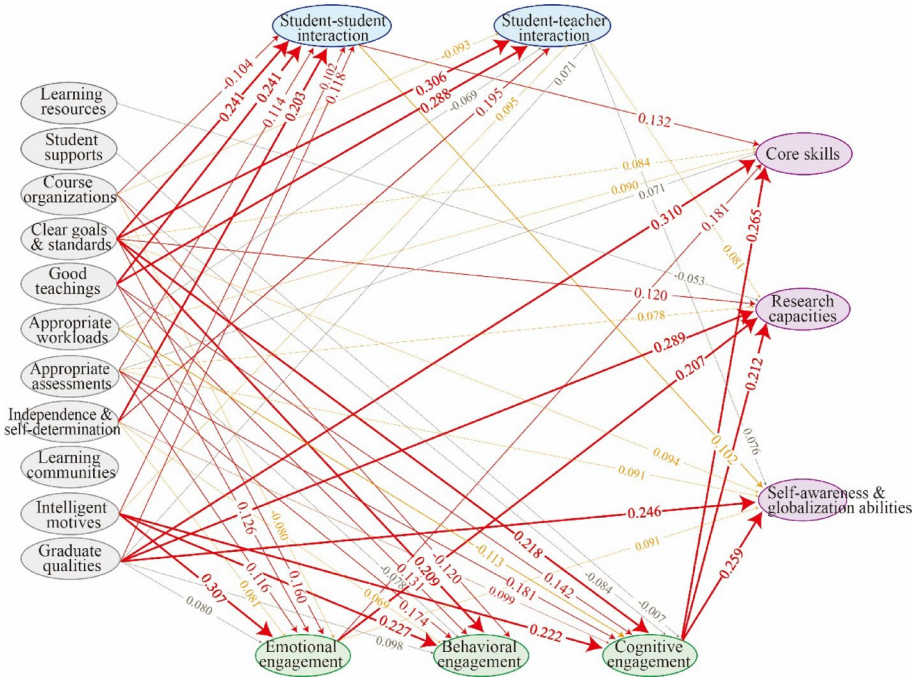

Fig. 3 Direct effects in the university student ability development pathway subdimension model. *Note*: Line color indicates the significance level: ▬ for $p < 0.001$, ▬ for $p < 0.01$, and ▬ for $p < 0.05$; Line thickness is proportional to the magnitude of the standardized path coefficients (thicker lines represent larger coefficients); Non-significant paths are not shown.

engagement (β = 0.207, $p < 0.001$) and cognitive engagement (β = 0.212, $p < 0.001$). For self-awareness & globalization abilities, the strongest direct effects come from graduate qualities (β = 0.246, $p < 0.001$) and cognitive engagement (β = 0.259, $p < 0.001$).

For student-student interaction, the strongest direct effects come from clear goals & standards (β = 0.241, $p < 0.001$), good teachings (β = 0.241, $p < 0.001$) and independence & self-determination (β = 0.203, $p < 0.001$). For student-teacher interaction, the strongest direct effects come from clear goals & standards (β = 0.306, $p < 0.001$) and good teachings (β = 0.288, $p < 0.001$). For emotional engagement, the strongest direct effect comes from

Table 11 Indirect effects in the university student ability development pathway subdimension model

Indirect Path	β	Indirect Path	β	Indirect Path	β
AAS-SSI-CS	0.015**	COS-STI-RC	− 0.007*	GQS-SSI-SGA	0.012*
CGS-SSI-CS	0.032**	GTS-STI-RC	0.023*	GTS-SSI-SGA	0.025**
COS-SSI-CS	− 0.014**	IMS-STI-RC	0.008*	GTS-STI-SGA	0.022*
GQS-SSI-CS	0.016*	IS-STI-RC	0.016**	GTS-EE-SGA	− 0.012*
GTS-SSI-CS	0.032***	AAS-CE-RC	0.038***	IMS-SSI-SGA	0.010*
IMS-SSI-CS	0.013**	AAS-EE-RC	0.024**	IS-SSI-SGA	0.021**
IS-SSI-CS	0.027**	AWS-CE-RC	− 0.024**	IS-STI-SGA	0.015*
AAS-CE-CS	0.048***	CGS-CE-RC	0.046***	AAS-CE-SGA	0.047***
AAS-EE-CS	0.021**	CGS-EE-RC	0.033***	AAS-EE-SGA	0.011*
AWS-CE-CS	− 0.030**	COS-CE-RC	− 0.018*	AWS-CE-SGA	− 0.029**
CGS-CE-CS	0.058***	COS-EE-RC	− 0.017*	CGS-CE-SGA	0.056***
CGS-EE-CS	0.029***	IMS-CE-RC	0.047***	CGS-EE-SGA	0.015*
COS-CE-CS	− 0.022*	IMS-EE-RC	0.064***	COS-CE-SGA	− 0.022*
COS-EE-CS	− 0.015*	IS-CE-RC	0.021**	IMS-CE-SGA	0.058***
IMS-CE-CS	0.059***	IS-EE-RC	0.017**	IMS-EE-SGA	0.028*
IMS-EE-CS	0.056***	SSS-CE-RC	− 0.015*	IS-CE-SGA	0.026**
IS-CE-CS	0.026**	AAS-SSI-SGA	0.012*	IS-EE-SGA	0.007*
IS-EE-CS	0.015**	CGS-SSI-SGA	0.025**	SSS-CE-SGA	− 0.018*
SSS-CE-CS	− 0.019*	CGS-STI-SGA	0.023*		
CGS-STI-RC	0.025**	COS-SSI-SGA	− 0.011*		

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$. Only statistically significant paths are presented

CS: Core skills; RC: Research capacities; SGA: Self-awareness & globalization abilities

SSI: Student-student interaction; STI: Student-teacher interaction; EE: Emotional engagement; CE: Cognitive engagement

SSS: Student supports; COS: Course organizations; CGS: Clear goals & standards; GTS: Good teachings; AWS: Appropriate workloads; AAS: Appropriate assessments; IS: Independence & self-determination; IMS: Intelligent motives; GQS: Graduate qualities

intelligent motives (β = 0.307, $p < 0.001$). For behavioral engagement, the strongest direct effects come from clear goals & standards (β = 0.209, $p < 0.001$) and intelligent motives (β = 0.227, $p < 0.001$). For cognitive engagement, the strongest direct effect comes from clear goals & standards (β = 0.218, $p < 0.001$) and intelligent motives (β = 0.222, $p < 0.001$).

Drawing on both the direct pathways (Fig. 3) and the indirect pathways (Table 11), we identified three distinct influence mechanisms.

Mechanism 1: Positive pathways to ability development through student engagement. A cluster of course experience dimensions, including clear goals & standards (CGS), intellectual motives (IMS), independence & self-determination (IS), appropriate assessments (AAS), and graduate qualities (GQS), promotes ability development by activating student engagement. Specifically: They enhance core skills (CS) primarily through boosting cognitive engagement (CE), emotional engagement (EE), and student-student interaction (SSI); They foster research capacities (RC) largely by strengthening emotional engagement (EE), cognitive engagement (CE), and student-teacher interaction (STI); They develop self-awareness & global abilities (SGA) mainly through promoting cognitive engagement (CE), emotional engagement (EE), student-student interaction (SSI) and student-teacher interaction (STI).

Mechanism 2: Positive interpersonal engagement but negative individual engagement pathways. Good teachings (GTS) operate through a divergent dual-path mechanism: It positively influences different ability dimensions by enhancing student-teacher interaction (STI) and student-student interaction (SSI). Concurrently, it negatively affects self-awareness & global abilities (SGA) by significantly diminishing emotional engagement (EE).

Mechanism 3: Negative pathways through reduced student engagement. Course experience dimensions including appropriate workloads (AWS), student supports (SSS) and course organizations (COS) influence ability development primarily through a constraining mechanism: Appropriate workloads (AWS) negatively impact different ability dimensions through suppressing cognitive engagement (CE). Course organizations (COS) negatively affect different ability dimensions through reducing cognitive engagement (CE), emotional engagement (EE), student-student interaction (SSI) and student-teacher interaction (STI). Student supports (SSS) negatively affect all three ability dimensions by reducing Cognitive Engagement (CE).

Discussion and Conclusion

The overall average of students' self-assessed ability development was 3.81 (out of 5), indicating that students generally agree their abilities have developed through higher education. This positive trend partially alleviates concerns about phenomena such as "GPA reigns supreme" (Lu et al., 2023) and the "new uselessness of education" (Hou & Xu, 2014). It indicates that higher education can effectively fulfill its mission of promoting human development. However, the same score also highlights considerable room for improvement, consistent with existing literature noting the need to strengthen both cognitive and non-cognitive ability development in Chinese universities (Gong & Lv, 2012; Wang & Shen, 2022; Zheng, 2020).

Guided by college impact models, this study constructed and validated a comprehensive pathway model for university student ability development. After controlling for gender, urban/rural origin, first-generation university student status, major type, and university type, our structural equation modeling analysis reveals that course experiences influence ability development through multiple pathways: exhibiting not only direct effects but also operating through the mediating pathways of interpersonal engagement and individual engagement. This integrated framework makes two theoretical contributions. First, it confirms the applicability and explanatory power of college impact models within the Chinese higher education context. Second, it advances theoretical understanding by incorporating both the direct influence of course experiences and the dual mediating role of student engagement, providing a more complete analytical framework for explaining university student ability development mechanisms.

These findings can be interpreted through the three college impact models. First, consistent with Astin's (1993) I-E-O model, our results confirm that environmental factors, specifically course experiences, influence student development outcomes. Second, aligning with Pace and Swayze (1992) Quality of Student Effort Model, our findings show that student engagement serves as a pathway through which course experiences translate into ability gains. Third, our results support Pascarella and Terenzini (1991) General Model for Assessing Change in College Students, which posits that the institutional environment influ-

ences development through students' social interactions and the quality of their effort. In our model, interpersonal engagement and individual engagement function as mediators linking course experiences to ability development. Together, these findings support the utility of college impact models in the Chinese higher education context.

After controlling for the same student and institutional characteristics, the university student ability development pathway subdimension model reveals three distinct mechanisms through which course experiences and student engagement influence ability development.

The first mechanism represents universally positive pathways through which course experiences and student engagement influence ability development. Dimensions including clear goals & standards, intellectual motives, independence & self-determination, appropriate assessments, and graduate qualities promote ability development through diverse pathways. In particular, graduate qualities exerts the strongest direct effects on the three ability dimensions. Specifically, these course experience dimensions enhance core skills by boosting cognitive engagement, emotional engagement, and student-student interaction; foster research capacities through strengthening emotional engagement, cognitive engagement, and student-teacher interaction; and develop self-awareness & global abilities via promoting cognitive engagement, emotional engagement, student-student interaction and student-teacher interaction. Among student engagement dimensions, cognitive engagement emerges as the most powerful mediator across all three ability outcomes. The findings are consistent with existing research (Lizzio et al., 2002; Roksa et al., 2017; Wilson et al., 1997).

Based on existing research, the potential mechanisms underlying these supportive course experience dimensions are as follows. Clear goals & standards: offer essential directional guidance that structures engagement and focuses developmental efforts (Seligman & Csikszentmihalyi, 2014; Zhang, 2021). Independence & self-determination: align with the principles of self-determination theory, by satisfying students' fundamental need for autonomy, it catalyzes deeper learning motivation, which in turn amplifies both engagement and ability development (Liu & Shen, 2020; Zheng, 2015). Intellectual motives: serves as a critical driver for sustained engagement, positively recalibrating students' learning goals, attitudes, and strategic approaches, thereby systematically advancing ability acquisition (Alhadabi et al., 2019; Hazrati-Viari et al., 2012). Furthermore, appropriate assessment: plays a pivotal role in steering students toward deep learning strategies, encouraging active intellectual investment, and thereby ensuring ability development (Chen et al., 2025; Zhang & Chen, 2021). Finally, graduate qualities: the significant role of graduate quality perception indicates that when students recognize the future utility of their coursework, it fuels their active participation in learning activities and fortifies their determination to overcome academic challenges, thereby facilitating ability development (Su, 2020; Wang & Ma, 2022).

The second mechanism—good teaching—presents a double-edged sword effect. While it positively influences all three ability dimensions by enhancing interpersonal engagement, it negatively affects self-awareness & global abilities by diminishing emotional engagement. This paradoxical finding both converges with and diverges from existing literature. The positive role of good teaching through interpersonal engagement aligns with the conventional understanding of teacher effectiveness (Fernández-García et al., 2021; Maulana et al., 2017). However, its undermining effect on individual engagement resonates with particularities of the Chinese context, where the persistent teacher-centered approach may foster student dependency rather than intellectual autonomy (Webster et al., 2009; Yin & Ke, 2017; Yin et al., 2016). When good teaching primarily manifests as knowledge transmission

excellence, it may inadvertently reduce students' need for deep cognitive processing and emotional investment, potentially promoting surface learning approaches that compromise ability development.

The third mechanism involves predominantly negative pathways through reduced student engagement, including appropriate workloads, course organizations, and student supports. Appropriate workloads negatively impact different ability dimensions through suppressing cognitive engagement, suggesting that current academic demands may lack sufficient challenge to stimulate meaningful engagement (Gong & Lv, 2012). Course organizations negatively affect different ability dimensions through reducing cognitive engagement, emotional engagement, student-student interaction and student-teacher interaction, indicating that rigid curriculum structures inhibit the active participation and collaborative learning essential for ability development (Bao & Lei, 2024; Lei et al., 2017). The negative impact of student supports contradict the prevailing view that robust support correlates with better outcomes (Chi et al., 2017). We propose that support resources may not be effectively translated into learning gains without sufficient student effort, or a fundamental mismatch may exist between high support and low challenge, creating an environment where students can meet requirements without deep engagement (Hanushek, 1997; Malechwanzi & Lei, 2018).

Based on the current sample and analytical framework, our findings suggest that course experience and student engagement can jointly support students' ability development, offering practical implications for enhancing educational quality and promoting student development.

On the one hand, enhancing the course experience quality. First, strengthen dimensions demonstrating consistent positive effects—clear goals & standards, intellectual motives, independence & self-determination, learning communities, appropriate assessments, and graduate qualities. Educators should: (1) clarify course objectives; (2) provide independence in course choices and assignments; (3) increase collaborative activities; (4) design assessments emphasizing deep understanding; (5) incorporate motivational elements; and (6) demonstrate course relevance to future development. Second, address the dual nature of good teaching. While beneficial for interpersonal engagement, its negative impact on individual engagement necessitates shifting from teacher-centered instruction toward student-centered approaches that stimulate deep learning. Third, improve underdeveloped dimensions—student supports, course organizations, and appropriate workloads. This requires both enhancing these elements and ensuring better alignment between support levels and academic challenge to stimulate meaningful engagement.

On the other hand, leveraging the key role of student engagement. Educational practices should strategically foster both engagement dimensions: Enhance interpersonal interaction by improving good teaching practices, encouraging questions and discussions. Stimulate individual engagement through motivating students, fostering their independence & self-determination, and providing appropriate assessments. Additionally, fostering cognitive engagement is worth particular attention, given its strong mediating role, which can be cultivated through challenging tasks and reflective activities.

Limitations

Several limitations should be acknowledged. First, the regional focus on Shaanxi Province may limit the generalizability of our findings to other parts of China, as local cultural

contexts and student demographics may differ across regions. Nevertheless, Shaanxi has a diverse higher education system encompassing various university types and academic disciplines, which enhances the validity of this study.

Second, the response rate was low, and a considerable number of cases were excluded due to missing values. The survey was conducted about half a year after graduation, during which some graduates had changed their email addresses, others had incomplete baseline information in the sampling frame, and a number were employed in sensitive positions that may have reduced their responsiveness. To assess potential bias, we compared the final sample with the full returned sample on three variables—university type, major type, and gender—which had no missing values and represent institutional characteristics and individual characteristics. The distributions were nearly identical, suggesting that listwise deletion did not introduce systematic bias. Nevertheless, although the sample is large and provides a basis for this exploratory study, our findings require further validation through replication studies.

Third, while this study focuses on the role of course experiences and student engagement, university student ability development is undoubtedly influenced by a wider range of factors. Although we controlled for key student and institutional characteristics, the current model does not account for all potential confounding variables. Future research integrating longitudinal designs, multi-source data, and more rigorous methodological approaches will help expand and refine the theoretical framework, thereby revealing more nuanced underlying mechanisms.

Author Contributions Shuang Wen: Writing—original draft, Conceptualization, Formal analysis; Genshu Lu: Data curation, Writing—review & editing, Supervision.

Funding No funds, grants, or other support was received.

Declarations

Ethics Approval and Consent to Participate Not applicable.

Competing interests The authors declare no competing interests.

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