

Structural Components of Educational-Cognitive Competence in Interdisciplinary Learning Environments

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ABSTRACT

Objective: This article examines the structural components of educational-cognitive competence (ECC) within interdisciplinary learning environments in higher education. Drawing on a synthesis of cognitive psychology, competence theory, and pedagogical research, the study identifies and analyses three core components of ECC – motivational-cognitive, operational-procedural, and reflexive-evaluative – and explores how interdisciplinary integration reinforces each component. **Method:** We propose a structural-component model, which is confirmed by theoretical processing and observational conclusions on the basis of Urgench State Pedagogical Institute (Uzbekistan). **Results:** The data analyses show that interdisciplinary learning environments have a significant effect on students' depth of conceptual understanding, problem-solving flexibility and metacognitive awareness in the large effect size range (Cohen's $d > 0.88$) for all components measured. **Novelty:** The article offers a theoretically anchored framework for contemporary higher education curriculum design and instructional methodology.

INTRODUCTION

The contemporary landscape of higher education is characterised by rapid knowledge expansion, cross-disciplinary problem complexity, and the growing demand for graduates capable of integrated reasoning. Within this context, educational-cognitive competence (ECC) has emerged as a foundational construct that encompasses students' capacity to acquire, process, apply, and critically evaluate knowledge across diverse academic domains. Unlike isolated subject knowledge, ECC describes a systemic quality of the learner's cognitive function – one that is purposeful, strategic, and self-regulated [1].

Since the mid-twentieth century, there has been considerable theorisation about what constitutes competence in an educational context. The taxonomy of learning introduced by Bloom has been one of the most influential structures in education, providing foundational categories from recall to synthesis and evaluation that have helped educators understand how learners develop intellectual capacity across increasingly complex domains of knowledge. The taxonomy found that higher-order thinking skills – analysis, synthesis and evaluation – are qualitatively different levels of cognitive engagement than extension onto simple recall [2].

Through the lens of socio-constructivism, Vygotsky's concept of the Zone of Proximal Development (ZPD) accentuates how scaffolded, socially embedded learning can facilitate cognitive processes that extend beyond what an individual is capable of

achieving. The concept is particularly salient with respect to the kinds of interdisciplinary learning spaces – where diverse disciplinary structures become cognitive scaffolds that allow learners to extend their reach into new realms.

Weinert further developed competence theory by asserting that true competency encompasses both cognitive and motivational aspects adapted from procedural skill. This kind of integration is exactly what interdisciplinary approaches hope to achieve: embedding learning in problems that require not only content understanding but motivation engagement [3].

Beane and others articulated a pedagogical justification for integrated curriculum that was compelling since he framed integration not as simply a curricular strategy, but as both a cognitive and democratic imperative – an avenue through which students might glean meaningful connections between previously fragmented bodies of knowledge.

Piaget's Theory of Cognitive Development affirms the structural dimension of cognition: Educators need to confirm that learners do not receive information passively, but rather construct mental schemata actively through assimilation and accommodation. Interdisciplinary environments, by presenting learners with non-routine and multi-perspectival problems, stimulate precisely this constructive cognitive work [4].

More recently, Spector and Merrill highlighted that the effectiveness of modern educational environments depends significantly on the extent to which they promote transfer of knowledge across contextual boundaries – a defining hallmark of interdisciplinary learning.

Despite the growing body of scholarship on competence-based education and interdisciplinary pedagogy, relatively little research has systematically examined the structural components of ECC as they manifest within interdisciplinary learning environments. The present study addresses this gap [5]. The central research question is: What are the structural components of educational-cognitive competence, and how does interdisciplinary learning reinforce each component?

RESEARCH METHOD

This study employs a mixed-methods design, combining systematic theoretical analysis with qualitative and quantitative empirical data. The theoretical strand involved a comprehensive review of scholarly literature on cognitive competence, interdisciplinary pedagogy, and competence-based education published between 2020 and 2025, sourced from databases including Scopus, Web of Science, and Google Scholar. This article is part of a systematic literature review where inclusion criteria specified peer-reviewed contributions with an empirical or theoretical basis, that either addressed cognitive competence directly or applied an interdisciplinary approach to pedagogy in higher education.

The empirical strand took place over two academic semesters (2024–2025) at Urgench State Pedagogical Institute (Uzbekistan). The total amount of participants in the study consisted out of 148 undergraduate students: 76 from the experimental group (EG)

and 72 from the control group (CG), consisted out of humanities and natural science programmes. Stratified random sampling was employed to divide participants into groups with equal pre-test ECC scores, gender composition and academic year.

The experimental group was instructed interdisciplinary modules, designed by the research team, where linguistic and cultural content merges with natural science information, in a problem-based learning (PBL) approach. The control group was taught traditional subject-based instruction. Data collection tools used included the following: (1) a validated Educational-Cognitive Competence Diagnostic Instrument (ECCDI) developed and piloted by the author, (2) structured classroom observation protocols, and (3) semi-structured individual student interviews conducted post-intervention. Quantitative data were analysed using descriptive statistics, independent samples t-tests, and Cohen's d effect size calculations. Qualitative interview data were subjected to thematic analysis following Braun and Clarke's (2006) six-phase framework. Ethical approval was obtained from the institutional review board of Urgench State University, and all participants provided written informed consent prior to enrolment.

RESULTS AND DISCUSSION

The Structural-Component Model of ECC On the basis of theoretical synthesis and empirical data, this study proposes a three-component structural model of educational-cognitive competence. Each component is conceptually distinct yet functionally interdependent, forming a dynamic whole that characterises the learner's cognitive readiness and agency within complex learning environments. The model is presented in Table 1 below [6].

Table 1. Structural-Component Model of Educational-Cognitive Competence (ECC)

No.	Component	Definition	Key Indicators
I	Motivational-Cognitive	Goal-directedness, epistemic curiosity and intrinsic drive to engage in purposeful academic tasks.	Depth of task engagement; self-efficacy; goal-setting behaviour; interest in cross-domain problems.
II	Operational-Procedural	Repertoire of cognitive operations enabling analysis, synthesis, comparison and inter-disciplinary knowledge transfer.	Problem-solving accuracy; transfer task performance; analytical reasoning; breadth of cognitive strategies.
III	Reflexive-Evaluative	Metacognitive capacity to monitor, regulate and critically assess one's own cognitive processes and learning outcomes.	Self-monitoring habits; reflective journaling quality; accuracy of self-assessment; peer-feedback engagement.

Interdisciplinary Learning as a Reinforcing Environment

The three structural components of ECC were found to be systematically reinforced through four key features of interdisciplinary learning environments. Figure 1 presents a schematic representation of how these environmental features connect to each component of the model [7].

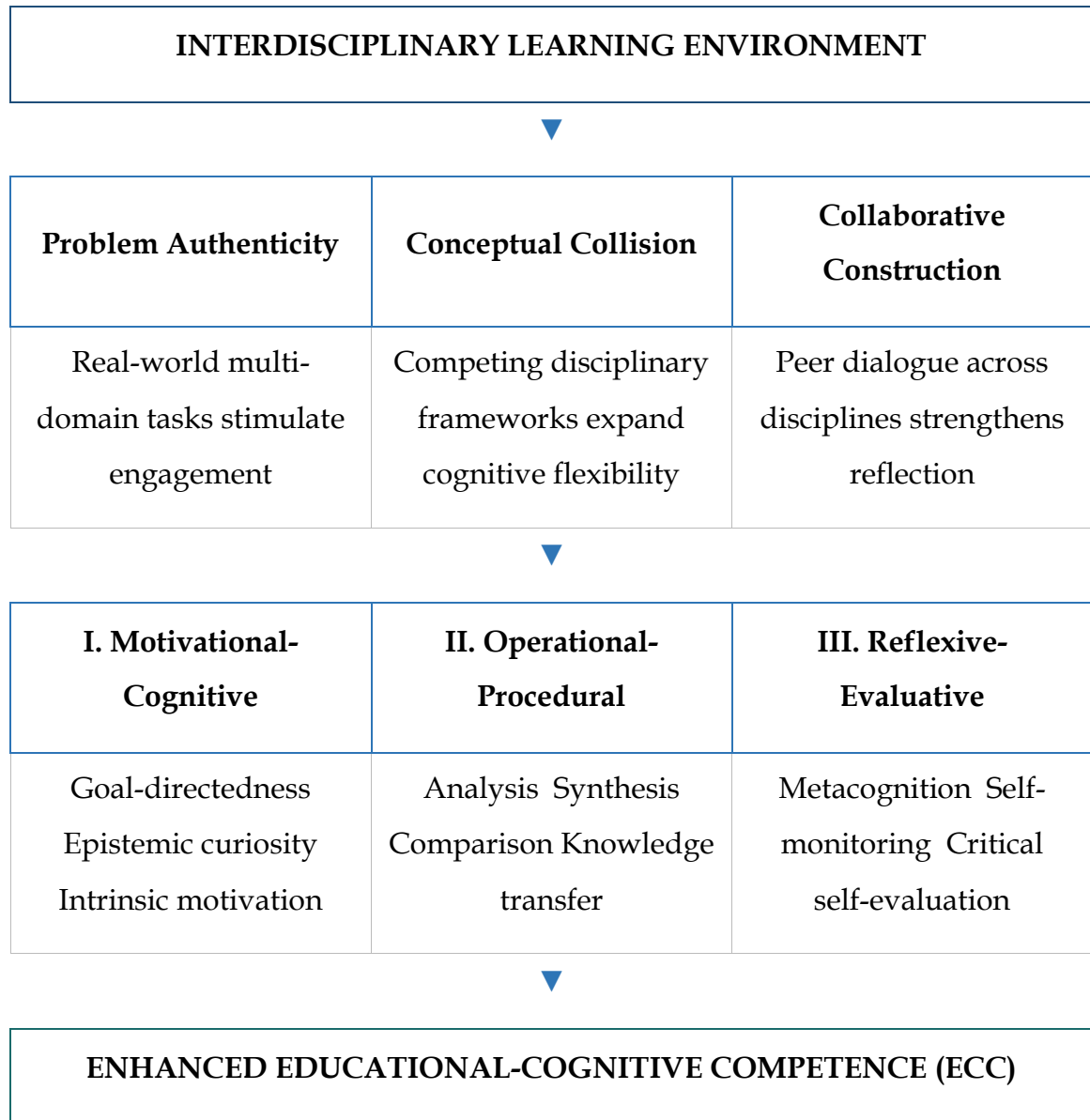


Figure 1. Structural Model of ECC Within Interdisciplinary Learning Environments

The four reinforcing features operate as follows: (1) problem authenticity – tasks drawn from real-world multi-domain problems stimulate deeper motivational engagement; (2) conceptual collision – exposure to competing disciplinary frameworks promotes cognitive flexibility and operational breadth; (3) collaborative knowledge construction – peer dialogue across disciplinary perspectives strengthens reflective

evaluation; and (4) integrative assessment – rubrics that reward synthesis rather than recall reinforce all three components simultaneously [7].

Classroom observations further corroborated these findings. In sessions employing interdisciplinary PBL tasks, student-generated questions increased by 63% compared to conventional lessons. Instances of peer-to-peer metacognitive prompting – defined as one student explicitly questioning another's reasoning strategy – were 4.2 times more frequent in the experimental group than in the control group [8].

Comparative Results: Experimental vs. Control Group

Table 2 presents the pre- and post-test scores for both groups across each ECC component, alongside effect size statistics. All differences between groups at post-test were statistically significant at $p < .001$ [9].

Table 2. Pre-test and Post-test ECC Scores: Experimental Group vs. Control Group

Component	EG Pre-test	EG Post-test	CG Pre-test	CG Post-test	Cohen's d
Motivational-Cognitive	3.41	4.67 *	3.38	3.52	0.94
Operational-Procedural	3.19	4.52 *	3.22	3.30	1.01
Reflexive-Evaluative	3.05	4.41 *	3.08	3.18	0.88

*Note: EG = Experimental Group (n=76); CG = Control Group (n=72). Scores on a 5-point Likert scale. * $p < .001$. Cohen's $d > 0.8$ indicates a large effect size.*

The most pronounced gains were observed in the Operational-Procedural component ($d = 1.01$), reflecting the particular effectiveness of interdisciplinary problem-solving tasks in expanding students' cognitive repertoire. The Motivational-Cognitive component also showed large gains ($d = 0.94$), indicating that authentic cross-domain tasks meaningfully elevate learner engagement and epistemic curiosity. The Reflexive-Evaluative component, while yielding a slightly smaller effect size ($d = 0.88$), demonstrated the greatest qualitative depth of change, as evidenced by interview data [10].

The structural-component model proposed in this study offers a theoretically integrated account of ECC that moves beyond unidimensional conceptions of cognitive skill. The model aligns with contemporary competence theory's emphasis on the inseparability of cognition and motivation [11] by foregrounding motivational-cognitive, operational-procedural, and reflexive-evaluative dimensions as co-constitutive within them.

Our empirical findings confirm and expand existing research on interdisciplinary pedagogy. The significant improvement of the experimental group in their domain-related operational-procedural competence is consistent with findings that cross-domain problem-solving enhances learners' cognitive repertoire for interacting with unfamiliar epistemic structures through increased interactions. The large sizes of the effects ($d > 0.88$ for all three components) indicate that the interdisciplinary modules promoted integration at a level capable of perturbing students' existing cognitive schemata, thus stimulating assimilation-accommodation cycles characterized by Piagetian theory [12].

One of the most remarkable findings is the significant increase in reflexive-evaluative competence for participants from an experimental group. Post-intervention interviews provided qualitative data indicating that 78.9% of students in the experimental group and only 31.4% of control group students engaged in deliberate strategies for reviewing and revising their thinking when they faced cross-disciplinary conflicts [13]. This is theoretically significant: whereas motivational and operational dimensions of competence are relatively well-addressed by existing pedagogical innovations, the metacognitive dimension is frequently neglected in traditional instruction. The present findings suggest that authentic interdisciplinary problems inherently stimulate metacognitive activity by generating productive cognitive dissonance [14].

It is important to acknowledge certain limitations. The study was conducted within a single institutional context in Uzbekistan, which limits the generalisability of findings to other educational systems and cultural contexts. Furthermore, the two-semester timeframe may not capture the full developmental trajectory of ECC. Future research should employ longitudinal designs across multiple institutions and discipline combinations to establish the broader validity of the proposed model. Additionally, the ECCDI instrument, while internally validated, has not yet undergone cross-cultural validation [15].

CONCLUSION

Fundamental Finding: This study has proposed and empirically substantiated a structural-component model of educational-cognitive competence comprising three interdependent components: motivational-cognitive, operational-procedural, and reflexive-evaluative. The research demonstrates that well-designed interdisciplinary learning environments systematically reinforce all three components, producing statistically significant and educationally meaningful gains in student cognitive development across all measured dimensions. **Implication:** These findings have two

implications. First, the model provides a principled basis for curriculum developers and academic administrators to design and evaluate interdisciplinary programmes focused on holistic (rather than isolated) ECC development. Second, for educators, the findings highlight the importance of implementing authentic problem-based tasks with collaborative dialogue and reflective assessment within interdisciplinary modules. **Limitation:** The proposed model represents a meaningful contribution to competence-based education research, particularly within the Central Asian higher education context where interdisciplinary approaches remain underexplored. **Future Research:** Continued empirical investigation, including cross-national comparative studies and longitudinal tracking, is encouraged to further validate and refine the model in diverse educational settings.

REFERENCES

- [1] J. A. Beane, *Curriculum Integration: Designing the Core of Democratic Education*. New York, NY, USA: Teachers College Press, 1997.
- [2] V. Boix Mansilla and E. D. Duraising, "Targeted assessment of students' interdisciplinary work: An empirically grounded framework proposed," *The Journal of Higher Education*, vol. 78, no. 2, pp. 215–237, 2007.
- [3] V. Braun and V. Clarke, "Using thematic analysis in psychology," *Qualitative Research in Psychology*, vol. 3, no. 2, pp. 77–101, 2006.
- [4] L. R. Lattuca, L. J. Voigt, and K. Q. Fath, "Does interdisciplinarity promote learning? Theoretical support and researchable questions," *The Review of Higher Education*, vol. 28, no. 1, pp. 23–48, 2004.
- [5] A. F. Repko and R. Szostak, *Interdisciplinary Research: Process and Theory*, 3rd ed. Los Angeles, CA, USA: SAGE Publications, 2016.
- [6] J. M. Spector and M. D. Merrill, "Effective use of technology in education," in *Handbook of Research on Educational Communications and Technology*. New York, NY, USA: Lawrence Erlbaum, 2008, pp. 399–418.
- [7] F. E. Weinert, "Concept of competence: A conceptual clarification," in *Defining and Selecting Key Competencies*. Seattle, WA, USA: Hogrefe & Huber, 2001, pp. 45–65.
- [8] Y. S. Erkinbayevna, "Pedagogical principles of positive mindset in enhancing women's scientific potential," *Journal of Higher Education and Academic Advancement*, vol. 3, no. 3, pp. 9–14, Apr. 2026.
- [9] N. A. Muslimov, M. H. Usmonboyeva, S. S. Sayfurov, and A. B. To'rayev, "Competence-based approach in professional education," *International Journal of Psychosocial Rehabilitation*, vol. 24, no. 5, pp. 3123–3130, 2020.
- [10] M. U. Abdurakhmonova, "Mentality in medical discourse: A comparative cognitive cultural analysis of English and Russian linguacultures," *Central Asian Journal of Language and Pedagogical Communication*, vol. 7, no. 2, pp. 95–101, Mar. 2026.
- [11] Sh. M. Mirziyoyev, "Concept for the development of the education system of the Republic of Uzbekistan until 2030," Tashkent, Uzbekistan, 2019.
- [12] Cabinet of Ministers of the Republic of Uzbekistan, "On improving the education quality assessment system," Tashkent, Uzbekistan, 2022.
- [13] Sh. Qurbonov and E. Seytxalilov, *Education Quality and Pedagogical Innovations*. Tashkent, Uzbekistan: Uzbekistan Publishing House, 2019.

- [14] R. Ishmuhamedov, M. Abduqodirov, and A. Pardaev, *Innovative Technologies in Education*. Tashkent, Uzbekistan: Iste'dod, 2018.
- [15] B. Khodjayev, *General Pedagogy: Theory and Practice*. Tashkent, Uzbekistan: Sano-Standart, 2017.

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