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COGNITIVE ENGAGEMENT, ACADEMIC ACHIEVEMENT, AND PERCEIVED 21ST-CENTURY SKILLS: AN ICAP-INFORMED MIXED-METHODS STUDY IN TEACHER EDUCATION

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ABSTRACT

Purpose – This study examined how learning strategies and professional development orientations were associated with self-reported GPA and perceived 21st-century skills among teacher education students. It also investigated how latent groups and students' accounts explained differences between these outcomes.

Methodology – A sequential explanatory mixed-methods design combined hierarchical regression, latent class analysis, and latent profile analysis of data from 464 students. Interviews were conducted with 12 respondents who volunteered to participate in this aspect of the study. The interview data were analysed through inductively oriented two-cycle coding and then integrated with the quantitative findings.

Findings – Predictors explained substantially more variance in perceived skills than in the GPA. Elaboration and monitoring, as well as voluntary major, choice predicted the GPA; study habits, elaboration and monitoring, motivation, and initiating professional development activities predicted perceived skills, although the professional development block added no significant variance. Perceived skills increased across low, moderate, and high strategy profiles, whereas the GPA was lower only in the low-profile category. Five themes contextualised these patterns, namely instructional fit and meaning-making; strategic repertoire, calibration, and assessment fit; regulation breakdowns under load; identity, professional growth, and success criteria; and perceived transfer of 21st-century skills.

Novelty – Participant-linked integration showed that the reported engagement had different meanings across outcomes, while individual accounts revealed contextual variation and counterexamples within latent groups. ICAP informed interpretation without treating profiles as direct measures of its modes.

Significance – Grades, perceived skills, and engagement profiles provide complementary rather than interchangeable evidence; profiles may be most useful as starting points for inquiry rather than as fixed learner labels.

Keywords: ICAP framework, cognitive engagement, perceived 21st-century skills, learning strategies, academic achievement, teacher education, latent class analysis, latent profile analysis.

INTRODUCTION

Active learning research distinguishes visible participation from the cognitive quality of engagement. Students may complete an activity without transforming the information encountered, whereas deeper engagement entails explaining, connecting, applying, or jointly constructing knowledge (Chi & Wylie, 2014; Prince, 2004). This distinction is particularly relevant in teacher education, where future teachers must acquire disciplinary and pedagogical knowledge while learning to adapt, communicate, evaluate information, and engage in continuous professional learning (Cengelci & Egmir, 2022; Yenel & Selçuk, 2024).

Learning Strategies, Engagement and Educational Outcomes

Learning strategies are the thoughts and behaviours with which students select, organise, elaborate, monitor, and regulate learning (Weinstein & Mayer, 1986; Zimmerman, 2002). Although strategy use is generally associated with academic achievement, the strength and form of this relationship vary. Specific motivational and self-regulatory components, including effort regulation and metacognitive self-regulation, have been linked to achievement, though these associations may be weak (Bernabé Lillo et al., 2022; Cosma et al., 2025; Floris et al., 2024). Similarly, person-centred studies have associated higher-strategy profiles with stronger achievement or retention (Gargallo López et al., 2023; Han et al., 2018; Liu et al., 2014). However, such findings do not establish that progressively higher strategy profiles could differentiate all educational outcomes in the same way.

Recognising effective strategies does not guarantee consistent enactment. Students may know which practices support learning, yet resort to less effective approaches because of effort, time, emotional, or contextual demands (Rea et al., 2022). Strategy effectiveness also depends on task and assessment conditions, as an approach that supports conceptual understanding may not align with what an examination rewards. Treating strategies as general predictors of grades may therefore obscure differences among strategy knowledge, strategy enactment, and assessment fit.

These issues become more complex when outcomes extend beyond grades. International frameworks define 21st-century skills as multidimensional combinations of critical thinking, problem-solving, communication, collaboration, adaptability, digital competence, and self-directed learning (Chen, 2023; Edwards-Jones et al., 2016; Griffin & Care, 2015; Trilling & Fadel, 2009; UNESCO-UNEVOC, n.d.; Voogt & Roblin, 2012).

These competencies involve applying knowledge across contexts and continuing to learn in evolving professional environments. However, in the present study, they were not assessed directly. The outcome therefore would only reflect students' self-reported perceptions of their 21st-century skills rather than independently demonstrated competence.

Pre-service teachers often report strong perceptions of their 21st-century competencies, which have been linked to metacognitive awareness and early teacher identity (Cengizci & Egmir, 2022; Yenel & Selçuk, 2024). Although stakeholders across educational settings value these competencies, expectations and implementation barriers vary (Bakay, 2022; Chun & Abdullah, 2022). Much of this evidence, however, is self-reported. Perceived skills may reflect confidence and strategic awareness, but are not equivalent to externally assessed competence. Measuring learning strategies and perceived skills in the same survey may also inflate observed associations through the effect of common method variance.

Professional development orientations constitute an additional dimension of engagement, as career goals, voluntary commitment, and development activities may encourage persistence beyond course requirements. Career-planning research links goal clarity and development activities to persistence and achievement, although motivation may be insufficient without effort regulation and action (Floris et al., 2024; Hansen et al., 2017; Hull-Blanks et al., 2005). Curriculum and skills frameworks also link independent goal management and learning beyond formal requirements to life, career, and continuing learning competencies (Correia, 2014; Mistree et al., 2014; Partnership for 21st Century Learning, 2016). In teacher education, professional identity profiles have been associated with varying levels of learning engagement (Chen et al., 2025). These findings suggest that professional orientation may be related to engagement, but do not imply that such orientations should uniformly correspond to academic performance.

Assessment further complicates the relationship between engagement and achievement. Grades aggregate performance across tasks, courses, instructors, and assessment formats, whereas professional competence is multidimensional and developmental. Summative assessment shapes what students attend to, but does not fully determine their learning practices or evaluative judgements (Boud & Falchikov, 2007; Fischer et al., 2024; Rust, 2007). Engagement-related variables may therefore show different associations with cumulative GPA and perceived 21st-century skills without implying deficiencies or misalignment in institutional assessment.

Analytical Framework: ICAP and Engagement

The Interactive–Constructive–Active–Passive (ICAP) framework was selected for this study because it distinguishes engagement by how learners cognitively process information, rather than treating participation as a single quantity (Chi & Wylie, 2014). Passive engagement involves receiving information without an observable learning-related action. Active engagement involves manipulating or acting on the provided material. Constructive engagement involves generating an output that extends beyond the information given, while interactive engagement involves the responsive co-construction of understanding through dialogue.

This process-oriented distinction suits the present study because learning strategies vary in organisation, monitoring, explanation, application, and interaction. The ICAP framework therefore offers a more precise

account of engagement quality than broad behavioural, emotional, and cognitive classifications. Students perceive instructional strategies as differing in cognitive activation, and their reported use varies across instructional contexts (Theelen et al., 2025). GenAI may support explanation, questioning, and representation, but self-reports do not establish that human–AI exchanges meet ICAP’s criteria for interactive engagement (Chi & Wylie, 2014). Such a determination would require direct evidence of process and performance. Because ICAP modes were not measured directly, the framework was used as an interpretive heuristic rather than as a measurement model or as a hierarchy assigned to the latent profiles.

The Present Study

ICAP-informed research with pre- and in-service teachers has examined how cognitive engagement is supported by designed lesson tasks and lesson plans (Lawson et al., 2023; Wekerle & Kollar, 2022). Recent person-centred studies have identified heterogeneity in teacher education students’ self-regulated learning and professional identity (Chen et al., 2025; Schel & Drechsel, 2025) and in university student profiles of 21st-century skills (Uras et al., 2025). These lines of research establish the value of process-oriented and person-centred perspectives, but leave open how engagement-related configurations relate to different outcomes within the same students and how individual accounts may qualify the meaning of latent groups.

Overall, prior research provides a foundation for the present study, but three issues remain insufficiently addressed. First, studies often examine academic achievement and perceived 21st-century skills separately, leaving unclear whether the same predictors relate differently to the two outcomes within a common analytical framework. Second, variable-centred analyses may obscure subgroups with distinct professional or strategic patterns, while quantitative profile descriptions alone offer limited evidence of how students enact these tendencies across contexts. Third, although teacher education research links metacognition, professional identity, and perceived skills, little is known about how students explain convergence or divergence among these constructs, grades, and professional goals. Together, these gaps concern whether engagement-related configurations have consistent meanings across outcomes and whether aggregate classifications adequately capture engagement as enacted in context.

The present study addresses these gaps through hierarchical regression, latent class and latent profile analyses, and follow-up interviews, using a sequential explanatory design. The quantitative phase compared associations with the GPA and perceived skills, identifying person-centred patterns. The qualitative phase examined how students across latent classes and profiles described instructional fit, strategy calibration, regulation, professional identity, and transfer. The ICAP framework informed the interpretation without treating the latent groups as direct measures of its categories.

The present study addresses the following research questions:

1. How are learning strategies and professional development orientations associated with the GPA and perceived 21st-century skills?
2. What professional development-related latent classes and learning-strategy profiles emerge, and how do they differ across the GPA and perceived 21st-century skills?
3. How do participants’ qualitative accounts explain and qualify the quantitative patterns and latent groups?

Accordingly, the mixed-methods objective was to examine whether reported engagement showed consistent patterns of association with self-reported GPA and perceived 21st-century skills, and to identify contextual patterns and individual counterexamples that any single analytical approach might obscure. Thus, the study connects ICAP-informed and person-centred teacher education research by comparing the meaning of engagement-related configurations across outcomes and linking latent-group membership to participants' accounts of engagement across instructional, assessment, regulatory, and professional contexts.

METHODOLOGY

Study Design

A sequential explanatory mixed-methods design (Creswell & Creswell, 2023) was employed. The quantitative phase examined associations between learning strategies and professional development orientations, on the one hand, and self-reported GPA and perceived 21st-century skills, on the other. Subsequent participant accounts were used to explain and qualify the quantitative patterns. The quantitative phase combined variable-centred and person-centred analyses, while the qualitative phase examined convergence, divergence, and within-group variation from the participants' perspectives. Integration linked interviewees' accounts with their quantitative records, including latent class and profile memberships, and used ICAP as an interpretive lens rather than a measurement or classification framework.

Research Context

The study was conducted in 2025 at the Faculty of Education of a state university in Türkiye. The faculty uses the European Credit Transfer System, and courses are designed to promote active learning through case- and problem-based learning, project design, demonstrations, experimentation, fieldwork, and collaborative tasks.

Participants

From a total of 521 volunteers, data from 464 students who provided written informed consent were analysed (331 females, 127 males, and six who did not disclose their gender). The sample comprised 20 first-year, 250 second-year, 167 third-year, and 27 fourth-year students. Incomplete submissions ($n = 44$) and multivariate outliers identified using Mahalanobis distance ($n = 13$) were excluded. The final dataset contained no missing values for the regression variables, as all relevant items were required.

All 464 participants were invited to volunteer for a follow-up interview. Sixty-three provided an email address and were contacted; 12 responded, and all 12 were interviewed without further selection. The qualitative phase, therefore comprised the complete volunteer-response subsample and was not purposively sampled to represent specific latent classes or profiles. Post hoc linkage showed representation of both classes, Class 1 ($n = 8$) and Class 2 ($n = 4$), and all the three strategy profiles: low ($n = 2$), moderate ($n = 8$), and high ($n = 2$). Table 1 presents their quantitative characteristics and latent memberships.

Table 1

Qualitative Participant Characteristics and Latent Membership

#	Gender	Year	Programme	GPA	LCA class	LPA profile	Interview
P1	Female	2	Special Education	3.37	1	3	Face-to-face
P2	Female	3	English Language Teaching	2.96	1	2	Face-to-face
P3	Female	3	English Language Teaching	2.70	2	2	Face-to-face
P4	Female	3	Primary Mathematics	2.80	2	1	Face-to-face
P5	Female	2	English Language Teaching	2.99	1	2	Online
P6	Female	2	Guidance and Counselling	3.65	1	2	Face-to-face
P7	Female	2	English Language Teaching	3.86	2	2	Face-to-face
P8	Female	2	Guidance and Counselling	3.19	1	3	Face-to-face
P9	Male	2	Special Education	3.11	1	2	Face-to-face
P10	Female	2	Guidance and Counselling	3.15	1	2	Face-to-face
P11	Female	3	English Language Teaching	3.45	1	1	Face-to-face
P12	Male	2	English Language Teaching	2.83	2	2	Face-to-face

Notes. Year and GPA refer to the quantitative phase. The GPA was self-reported on a 1–4 scale. All 12 students who responded to the interview invitation were included; no further selection procedure was applied. Class 1 = self-directed and development-oriented; Class 2 = passively oriented; Profile 1 = low strategy engagement; Profile 2 = moderate strategy engagement; Profile 3 = high strategy engagement.

Recruitment was guided by responses to the interview invitation rather than by saturation-based stopping; accordingly, saturation is not claimed. Qualitative adequacy was assessed in relation to information power, including study-aim specificity, sample specificity, dialogue quality, and analytical strategy (Malterud et al., 2016). The focused explanatory purpose, linkage of survey and interview records, post-recruitment coverage of both classes and all three profiles, and detailed participant accounts provided information relevant to explaining and qualifying quantitative patterns within the volunteer subsample. This judgement applies only to the stated explanatory purpose and does not imply saturation, purposive or balanced representation, or comprehensive coverage of each latent group.

Research Instruments

In the quantitative phase, participants completed an online eight-item demographic form, the Perceptions of 21st-Century Skills Scale (Durmuş & Güven, 2023), and Küçüker et al.'s (2014) Turkish adaptation of the abridged ACRA–Higher Education Learning Strategies Scale developed by de la Fuente Arias and Justicia Justicia (2003). Participants also self-reported their cumulative GPA on the university's 1–4 scale. McDonald's ω (Malkewitz et al., 2023) was 0.84 for the Perceptions of 21st-Century Skills Scale and 0.91 for the total ACRA scale, with subscale values of 0.76 for study habits, 0.83 for elaboration and monitoring, 0.84 for organisation, and 0.74 for motivation.

In the qualitative phase, a semi-structured one-to-one interview protocol was developed to explain and qualify the quantitative findings. The interview questions addressed learning practices, regulation, professional development orientations, understandings of academic success, and perceived links between learning experiences, personal development, and 21st-century skills.

Data Collection Procedures

After ethics approval for both phases of the data collection process, quantitative data were collected online from 10 to 28 May 2025. Written informed consent was obtained at all stages of participation. The qualitative data were collected between 9 and 27 October 2025, following completion of the quantitative analyses and explanatory-phase recruitment. Eleven interviews were conducted face-to-face; P5 was interviewed online because she was studying abroad. Interviews lasted approximately 21–46 minutes, were audio-recorded with consent, and transcribed verbatim in Turkish. Selected extracts were translated into English by the researchers, checked using DeepL, and reviewed against the Turkish originals. The researchers retained responsibility for all final translation decisions.

Data Analysis

Research Question 1 was addressed using two hierarchical regressions in SPSS version 27 (IBM Corp., 2020) to predict self-reported GPA and perceived 21st-century skills. Four learning-strategy dimensions entered Block 1, followed in Block 2 by voluntary major choice, professional development goal setting, and initiation of professional development activities to assess their incremental contribution.

Regression assumptions were assessed before interpretation. Histograms and normal probability plots indicated approximately normal residuals, and residual-versus-predicted plots showed no clear curvature or funnel pattern, supporting linearity and homoscedasticity. Durbin–Watson statistics were 1.948 for GPA and 1.772 for perceived skills. Tolerance values ranged from approximately 0.35 to 0.98, and VIF values from 1.02 to 2.84, indicating no problematic multicollinearity; the maximum Cook's distances were 0.040 and 0.048. Two standardised residuals in the perceived-skills model exceeded ± 3 , but neither was influential according to Cook's distance. Diagnostics were interpreted using applied statistical guidance (Bennett et al., 2022; Hair et al., 2022; Kemp et al., 2021).

Research Question 2 was addressed in Mplus version 8 (Muthén & Muthén, 2017) using the LCA of the three binary professional development variables and the LPA of the learning-strategy variables. Model

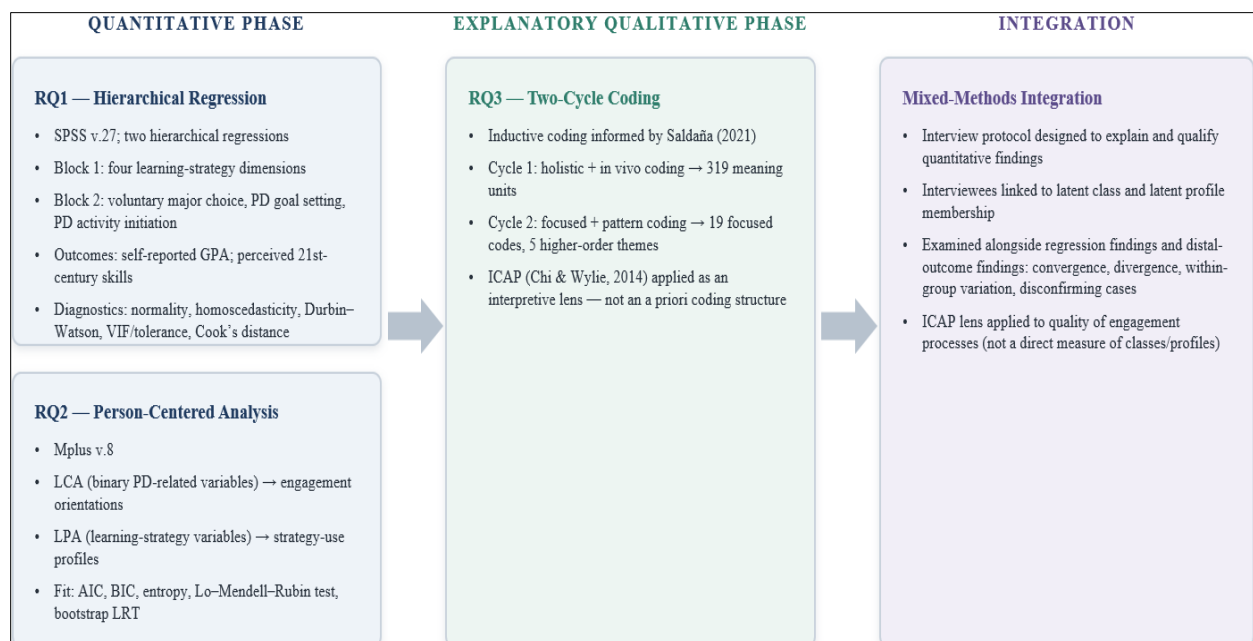
selection was guided by the Akaike and Bayesian information criteria, entropy, the Lo–Mendell–Rubin test, the bootstrap likelihood-ratio test, class or profile size, and substantive interpretability.

Research Question 3 was addressed through an inductively oriented two-cycle coding process informed by Saldaña (2021). In the first cycle, 319 meaning units were coded holistically and in vivo to retain participants’ language and identify engagement behaviours, learning processes, regulatory difficulties, professional orientations, and understandings of success. In the second cycle, focused and pattern coding consolidated these into 19 focused codes and five higher-order themes. ICAP (Chi & Wylie, 2014) was not used as an initial coding structure, but was applied after inductive coding, during the integration and interpretation of reported cognitive engagement processes.

Mixed-methods integration occurred during the transition to the qualitative phase and during interpretation. The interview protocol was designed to explain and qualify the quantitative findings. After qualitative analysis, interviewees’ accounts were linked to their latent class and latent profile memberships, and examined alongside the regression and distal-outcome findings to identify convergence, divergence, within-group variation, and disconfirming cases. Divergence was treated as analytically informative rather than as an inconsistency to be eliminated. ICAP (Chi & Wylie, 2014) was subsequently used to interpret the quality of reported cognitive engagement processes. Latent classes and profiles were neither derived from ICAP nor treated as direct measures of its modes (see Figure 1).

Figure 1

Data Analysis Procedure



Notes. RQ = Research Question; PD = professional development; LCA = latent class analysis; LPA = latent profile analysis; ICAP = Interactive–Constructive–Active–Passive framework (Chi & Wylie, 2014).

Trustworthiness

Both researchers independently coded all 12 transcripts, compared their decisions transcript by transcript, and resolved discrepancies by consensus. The jointly approved workbooks represented the final coding structure. Microsoft Excel organised coded extracts, participant-by-code matrices, and code-to-theme decisions, and maintained an auditable record; it served as a data management tool rather than an automated qualitative analysis tool.

Analytical transparency was supported by documenting progression from raw extracts to initial codes, focused codes, and higher-order themes. For example, P1 stated: “I connect what I learn ... I transfer it to daily life ... I learned this method, but how can I put it into practice? ... because I build its scenario in my mind.” The extract was initially coded as “meaning-making through transfer to practice and scenario-building,” consolidated as “meaning-making and transfer,” and assigned to Theme 1, “Instructional fit and meaning-making.”

Both researchers hold doctorates in curriculum and instruction and have more than 20 years’ teaching experience in their areas of expertise, including prior contact with some participants. To mitigate potential influence on participant responses and researcher interpretation, the researchers maintained reflexive awareness and adopted a neutral, non-evaluative interview stance. Analytical integrity was further supported by independent coding, consensus, peer debriefing, critical-friend discussions, and analytical memos.

FINDINGS

Quantitative Findings

Prediction of the GPA

A hierarchical regression analysis examined whether four learning strategies and three professional development variables predicted participants’ self-reported GPA. The Step 1 model was significant, $R^2 = 0.029$, adjusted $R^2 = 0.021$, $F(4, 459) = 3.43$, $p = 0.009$. Only the elaboration and monitoring dimension was a significant predictor ($\beta = 0.193$, $p = 0.012$).

In Step 2, adding voluntary major choice, professional development goal setting, and initiation of professional development activities significantly increased explained variance, $\Delta R^2 = 0.022$, $\Delta F(3, 456) = 3.56$, $p = 0.014$. The final model was significant, $F(7, 456) = 3.52$, $p = 0.001$, and explained 5.1% of the GPA variance ($R^2 = 0.051$, adjusted $R^2 = 0.037$). Elaboration and monitoring remained significant ($\beta = 0.221$, $p = 0.004$), as did voluntary major choice ($\beta = 0.131$, $p = 0.005$). No other predictors were significant (see Table 2).

Table 2

Models and Prediction of the GPA

Model 1						
Predictor	B	SE	β	t	p	95% CI (Lower–Upper)
Constant	2.655	0.17	—	15.62	< 0.001	[2.321, 2.989]
Study habits	-0.046	0.062	-0.05	-0.75	0.454	[-0.168, 0.076]
Elaboration and monitoring strategies	0.149	0.059	0.193	2.51	0.012	[0.033, 0.265]
Organisation strategies	-0.015	0.036	-0.026	-0.41	0.679	[-0.086, 0.056]
Motivation strategies	0.025	0.036	0.042	0.72	0.475	[-0.046, 0.096]
Model 2						
Predictor	B	SE	β	t	p	95% CI (Lower–Upper)
Constant	2.557	0.173	—	14.77	< 0.001	[2.217, 2.897]
Study habits	-0.065	0.062	-0.07	-1.04	0.301	[-0.187, 0.057]
Elaboration and monitoring strategies	0.171	0.059	0.221	2.88	0.004	[0.055, 0.287]
Organisation strategies	-0.028	0.036	-0.049	-0.78	0.439	[-0.099, 0.043]
Motivation strategies	0.018	0.035	0.029	0.50	0.615	[-0.051, 0.087]
Voluntary major choice	0.137	0.048	0.131	2.84	0.005	[0.042, 0.232]
Professional development goal setting	0.033	0.05	0.033	0.67	0.501	[-0.065, 0.131]
Initiation of professional development activities	0.043	0.043	0.048	1.00	0.319	[-0.042, 0.128]

Notes. B = unstandardised coefficient; SE = standard error; β = standardised coefficient; CI = confidence interval. Tolerance values ranged from 0.352 to 0.977 and VIF values from 1.023 to 2.842 in the final model. The Durbin–Watson statistic was 1.948, and the maximum Cook’s distance was 0.040.

Prediction of Perceived 21st-Century Skills

The second regression examined perceived 21st-century skills. In Step 1, the learning strategies produced a significant model, $R^2 = 0.378$, adjusted $R^2 = 0.373$, $F(4, 459) = 69.88$, $p < 0.001$. Study habits ($\beta = 0.361$, $p < 0.001$), motivation ($\beta = 0.236$, $p < 0.001$), and elaboration and monitoring ($\beta = 0.157$, $p = 0.011$) were significant, whereas organisation was not. After the professional development variables were added, the final model remained significant and explained 38.5% of the variance, $R^2 = 0.385$, adjusted $R^2 = 0.376$, $F(7, 456) = 40.78$, $p < 0.001$. The additional block was not significant, $\Delta R^2 = 0.007$, $\Delta F(3, 456) = 1.61$, $p = 0.185$. Study habits ($\beta = 0.341$, $p < 0.001$), motivation ($\beta = 0.232$, $p < 0.001$), and elaboration and monitoring ($\beta = 0.166$, $p = 0.007$) remained significant, and initiation of professional development activities had a small positive coefficient ($\beta = 0.079$, $p = 0.043$) (see Table 3).

Table 3

Models and Prediction of Perceived 21st-Century Skills

Model 1						
Predictor	B	SE	β	t	p	95% CI (Lower–Upper)
Constant	1.645	0.134	—	12.30	< 0.001	[1.382, 1.908]
Study habits	0.328	0.049	0.361	6.72	< 0.001	[0.232, 0.424]
Elaboration and monitoring strategies	0.119	0.047	0.157	2.55	0.011	[0.027, 0.211]
Organisation strategies	−0.034	0.028	−0.060	−1.21	0.228	[−0.089, 0.021]
Motivation strategies	0.141	0.028	0.236	5.05	< 0.001	[0.086, 0.196]
Model 2						
Predictor	B	SE	β	t	p	95% CI (Lower–Upper)
Constant	1.671	0.137	—	12.20	< 0.001	[1.402, 1.940]
Study habits	0.310	0.049	0.341	6.26	< 0.001	[.214, .406]
Elaboration and monitoring strategies	0.126	0.047	0.166	2.69	0.007	[0.034, 0.218]
Organisation strategies	−0.038	0.029	−0.066	−1.31	0.192	[−0.095, 0.019]
Motivation strategies	0.139	0.028	0.232	4.97	< 0.001	[0.084, 0.194]
Voluntary major choice	−0.019	0.038	−0.018	−0.49	0.628	[−0.094, 0.056]
Professional development goal setting	0.007	0.039	0.007	0.19	0.852	[−0.070, 0.084]
Initiation of professional development activities	0.069	0.034	0.079	2.03	0.043	[0.002, 0.136]

Notes. B = unstandardised coefficient; SE = standard error; β = standardised coefficient; CI = confidence interval. Across the two models, tolerance values ranged from 0.352 to 0.977 and VIF values from 1.023 to 2.842. The Durbin–Watson statistic for the final model was 1.772, and the maximum Cook’s distance was 0.048.

LCA Test Results

A latent class analysis (LCA) identified subgroups based on the following three binary indicators of professional development: voluntary major choice, professional development goal setting, and initiation of professional development activities. One- to three-class models were estimated using maximum likelihood with robust standard errors. Extensive random starts, followed by re-estimation with twice as many starts, were used to reduce concerns about local maxima (see Table 4).

Table 4

Latent Classes

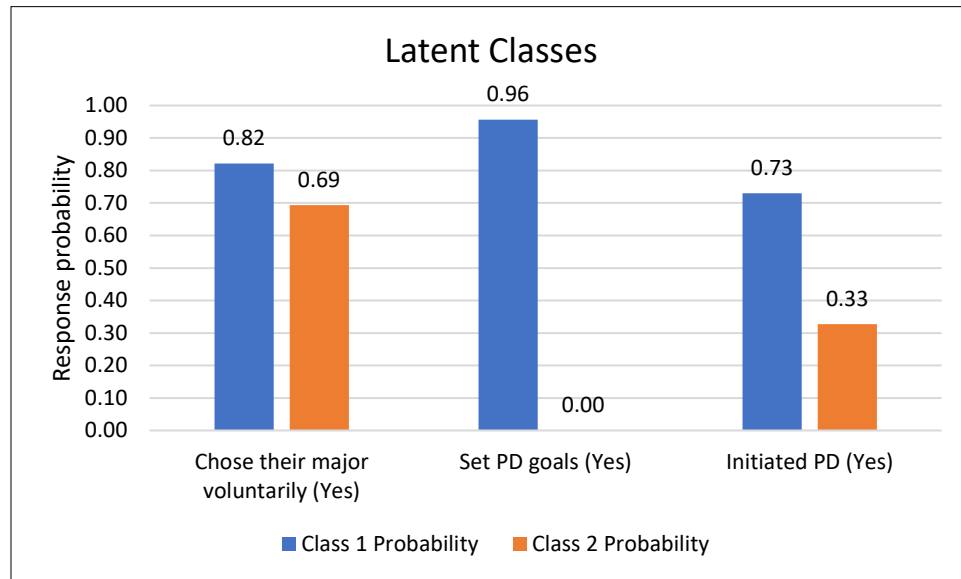
K	LL	AIC	BIC	SABIC	Entropy	Smallest class %	LMR <i>p</i>	BLRT <i>p</i>
1	-781.508	1569.016	1581.435	1571.914	—	100%	—	—
2	-758.883	1531.766	1560.745	1538.528	0.874	19.1%	< .001	< .001
3	-758.879	1539.757	1585.296	1550.385	0.642	6.5%	.930	.975

Notes. K = number of classes; LL = log-likelihood; AIC = Akaike information criterion; BIC = Bayesian information criterion; SABIC = sample-size-adjusted Bayesian information criterion; entropy = classification quality; LMR = Lo–Mendell–Rubin likelihood-ratio test; BLRT = bootstrap likelihood-ratio test

The two-class model showed high classification quality (entropy = 0.874), acceptable class proportions, and coherent response patterns. Re-estimation produced the same log-likelihood and solution. The three-class model showed poorer classification and interpretability, including higher information criteria, lower entropy (0.642), nonsignificant likelihood-ratio tests, and indications of non-identification. Therefore, the two-class solution was retained. Class 1 was labelled “Self-directed and development-oriented” ($n = 376$, 80.9%), and Class 2 “Passively oriented” ($n = 88$, 19.1%) (see Figure 2).

Figure 2

Class-specific Response Probabilities



BCH comparisons accounted for classification uncertainty (see Table 5). The classes did not differ significantly in the GPA, $\chi^2(1) = 2.94$, $p = 0.087$. Class 1 scored higher on perceived 21st-century skills, $\chi^2(1) = 11.54$, $p = 0.001$, and on all four strategy dimensions, with all $ps < 0.001$. Thus, class differences were evident in perceived skills and reported strategy use but not in the GPA.

Table 5

BCH Analysis for the Latent Classes

Outcome	Class 1 Mean (SE)	Class 2 Mean (SE)	$\chi^2(1)$	<i>p</i>
GPA	3.119 (0.022)	3.019 (0.053)	2.94	0.087
Perceived 21st-century skills	3.828 (0.021)	3.640 (0.049)	11.54	0.001
Study habits	3.952 (0.023)	3.674 (0.053)	21.81	< 0.001
Elaboration and monitoring Strategies	3.986 (0.028)	3.685 (0.064)	17.58	< 0.001
Organisation strategies	3.896 (0.036)	3.406 (0.089)	24.88	< 0.001
Motivation strategies	3.830 (0.036)	3.478 (0.077)	16.12	< 0.001

Notes. BCH = Bolck–Croon–Hagenaars method.

LPA Test Results

An LPA compared one- to four-profile solutions. Re-estimation replicated the best log-likelihood across models. Although statistical fit continued to improve through four profiles, entropy declined from 0.825 for three profiles to 0.781 for four profiles, and the additional profile did not divide the moderate group while yielding a substantively distinct pattern (see Table 6). Considering fit, classification quality, parsimony, and interpretability, the three-profile solution was retained.

Table 6

Latent Profiles

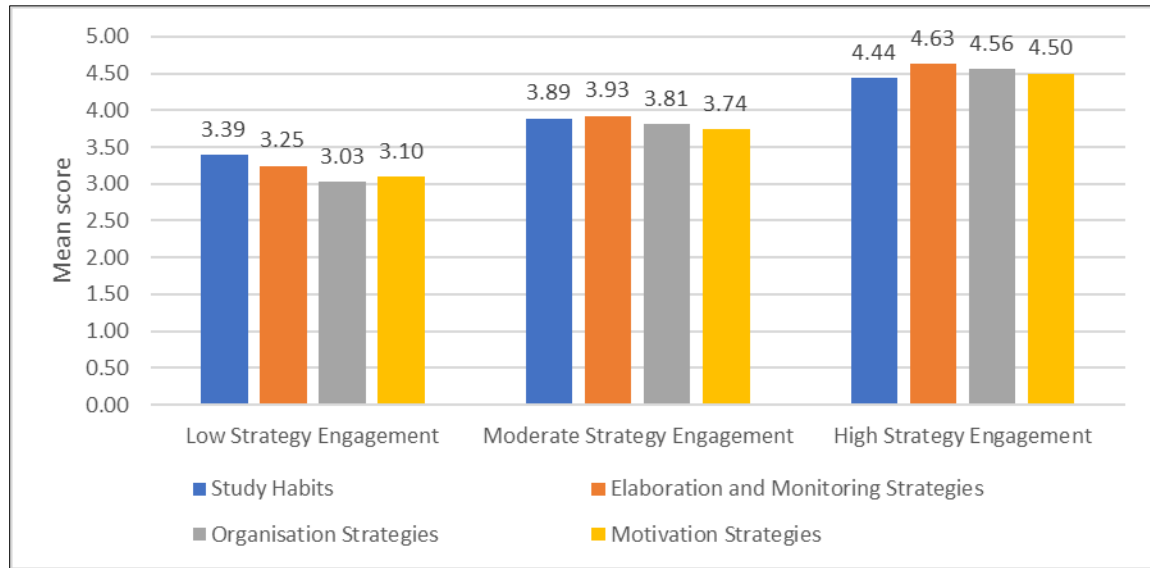
K	LL	AIC	BIC	SABIC	Entropy	Smallest profile %	LMR <i>p</i>	BLRT <i>p</i>
1	-1665.504	3347.008	3380.127	3354.737	—	100.0%	—	—
2	-1421.386	2868.772	2922.591	2881.332	0.720	49.2%	0.004	< 0.001
3	-1293.160	2622.320	2696.838	2639.710	0.825	21.0%	< 0.001	< 0.001
4	-1264.166	2574.333	2669.550	2596.554	0.781	11.2%	0.001	< 0.001

Notes. K = number of profiles; LL = log-likelihood; AIC = Akaike information criterion; BIC = Bayesian information criterion; SABIC = sample-size-adjusted Bayesian information criterion; entropy = classification quality; LMR = Lo–Mendell–Rubin likelihood-ratio test; BLRT = bootstrap likelihood-ratio test

The retained solution comprised Low strategy engagement (*n* = 95, 20.5%), Moderate strategy engagement (*n* = 274, 59.0%), and High strategy engagement (*n* = 95, 20.5%) (see Figure 3).

Figure 3

Latent Profiles Based on Strategy Engagement



BCH comparisons showed differences in perceived 21st-century skills, $\chi^2(2) = 159.07$, $p < 0.001$, with Profile 1 < Profile 2 < Profile 3. The GPA also differed overall, $\chi^2(2) = 14.81$, $p = 0.001$. Profile 1 had a lower mean GPA than Profiles 2 and 3, whereas Profiles 2 and 3 were not significantly different, $p = 0.368$ (see Table 7).

Table 7

BCH Analysis for the Latent Profiles

Distal outcome	Profile 1 Mean (SE)	Profile 2 Mean (SE)	Profile 3 Mean (SE)	Overall BCH $\chi^2(2)$	p	Pairwise BCH tests (χ^2 , p)
GPA	2.931 (0.053)	3.133 (0.027)	3.179 (0.040)	14.81	0.001	1 vs 2: 10.32, 0.001 ; 1 vs 3: 14.09, < 0.001 ; 2 vs 3: 0.81, 0.368
Perceived 21st-century skills	3.499 (0.046)	3.753 (0.023)	4.195 (0.037)	159.07	<0.001	1 vs 2: 21.75, < 0.001 ; 1 vs 3: 138.47, < 0.001 ; 2 vs 3: 93.62, < 0.001

Notes. BCH = Bolck–Croon–Hagenaars method.

The profiles differentiated perceived 21st-century skills more consistently than the GPA. Because they were derived from self-reported learning strategies rather than from observed learning activities, they were not classified as passive, active, constructive, or interactive ICAP modes.

Qualitative Findings

The thematic analysis generated the following five interrelated themes: (1) instructional fit and meaning-making, (2) strategic repertoire, calibration and assessment fit, (3) regulation breakdowns under load, (4) identity, professional growth and success criteria, and (5) 21st-century-skill talk as perceived transfer. All 12 participants contributed coded material to each theme, although emphasis and enactment varied across classes and profiles. The themes were examined alongside latent memberships to explain and qualify quantitative tendencies and within-group variation. Class 1 denotes the self-directed, development-oriented class, and Class 2 the passively oriented class. Profiles 1–3 denote low, moderate, and high strategy engagement, respectively.

Theme 1: Instructional Fit and Meaning-Making

The first theme concerned participants' accounts of how instructional conditions were linked to efforts to connect, explain, and apply what they learned. Meaning-making was described more readily when instruction was perceived as supportive and relevant, whereas stress, perceived threat, and poor instructional fit were described as constraints. These variations occurred across latent memberships, indicating that class or profile membership did not determine engagement in every context.

P1 (Class 1/Profile 3) described connecting knowledge to possible application: "I connect what I learn ... I transfer it to daily life ... 'I learned this method, but how can I put it into practice?' ... because I build its scenario in my mind." This account was consistent with constructive processing, as it involved generating an application beyond the information provided.

By contrast, P10 (Class 1/Profile 2) described an instructor's questioning as threatening: "Under stress I can't even say my name ... I never want to go to that class." Thus, membership of the more development-oriented class did not ensure sustained engagement across contexts. Conversely, low-profile membership did not preclude meaning-making. P4 (Class 2/Profile 1) described selecting different approaches across courses and evaluating their effectiveness. Together, these cases suggest that profiles differed more in the consistency and breadth of strategy use than in the presence or absence of meaningful engagement.

Theme 2: Strategic Repertoire, Calibration and Assessment Fit

All participants described adapting strategies to course difficulty, available time, assessment format, or instructor expectations. Their repertoires included planning, writing, explaining, repeated reading, peer consultation, audio recording, video, and GenAI-supported summarisation or questioning. These accounts provided contextual evidence for interpreting the significant association between elaboration and monitoring and the GPA. Students calibrated effort and processing to perceived demands. Within an ICAP interpretation, manipulating provided information was consistent with active engagement, whereas generating explanations, summaries, or examples indicated constructive engagement. The relevant ICAP interpretation therefore depended on the cognitive product rather than the strategy label alone.

P6 (Class 1/Profile 2) described excessive attention to detail as counterproductive: "I used to study too much detail ... it stressed me ... I was getting a lower grade ... so I shifted towards understanding the

essence of the topic.” P12 (Class 2/Profile 2) similarly described adapting strategies across courses: “It changes by course: notes plus highlighted PDFs; near exams I summarise; easier courses need less effort.” These accounts suggest that participants perceived task and assessment fit as relevant to strategy effectiveness. However, they did not establish that such calibration caused differences in academic performance.

Assessment fit was not always positive. P1 distinguished between preparing to explain material and recognising a multiple-choice answer, while P10 described instances when greater preparation coincided with poorer results under stress. These accounts contextualise the modest GPA model, but do not establish that assessment design caused individual grades.

P11 (Class 1/Profile 1) provided a disconfirming low-profile case. She described rehearsing information while walking, simplifying difficult material with GenAI, and reorganising it in a note-taking application, but used these strategies irregularly amid procrastination, health problems, and course failure. Her account shows that a low aggregate strategy score can coexist with specialised strategies used inconsistently or under restricted conditions.

Theme 3: Regulation Breakdowns under Load

The third theme concerned difficulty initiating or sustaining learning in accounts involving anxiety, uncertainty, low mood, health problems, or competing responsibilities. Participants distinguished between knowing or possessing a strategy and being able to enact it consistently under particular conditions.

P10 (Class 1/Profile 2) described delaying the start of studying through preparatory activities by saying, “Because exams are approaching, I even tidied my closet ... I organised my desk ... when I start, it must be spotless.” P7 (Class 2/Profile 2) described the effect of low mood on studying, with these remarks, “If my mood is down that day ... if I can’t listen [to the lesson] that day, it’s over for me ... a slide that takes 15 minutes becomes 45 minutes.” P11 (Class 1/Profile 1) similarly linked difficulty and procrastination to examination performance with this reflection, “When I struggle ... I procrastinate ... then exam week comes, and I get 20 [out of 100].”

High-profile participants described more stable external structures for managing load. P1 (Class 1/Profile 3) arranged her environment and used lists because “uncertainty tires me a lot”, while P8 (Class 1/Profile 3) relied on summaries, explanations, and repeated reconstruction. However, effective regulation also appeared in moderate- and low-profile accounts, and high-profile participants still reported distraction and overload.

Therefore, the term “regulation breakdown” denotes a contextual process rather than a stable personal deficit. The data did not establish “somatic regulation” as a distinct construct. Bodily discomfort, anxiety, health, workload, and environmental conditions were instead described as influencing the enactment of strategy. Within ICAP, regulation under load was treated as a contextual condition rather than as a separate engagement mode.

Theme 4: Identity, Professional Growth and Success Criteria

Participants' accounts of major choice, professional goals, and success criteria contextualised the LCA findings. Several Class 1 participants described relatively coherent development pathways, including academic and career planning, conference participation, volunteering, and practical experience. Some Class 2 accounts reflected uncertainty or weaker alignment between studies and professional plans.

P4 (Class 2/Profile 1) stated, "Teaching wasn't my own choice ... at first I was unwilling [to study in this department]," and linked her interest in a course to her willingness to study. This pattern was consistent with the quantitative finding that Class 1 had higher strategy and perceived-skill scores, but not a significantly higher GPA.

The accounts also resisted deterministic class labels. Respondents P3 and P12 were assigned to Class 2, but described professional aspirations and meaningful engagement. P12 (Class 2/Profile 2) said, "I don't study just to pass ... I study harder to gain qualities and become a better teacher." Conversely, Class 1 included participants with uncertain professional direction or limited formal development activity. Class membership, therefore reflected the three survey indicators at a single point in time rather than a complete or fixed professional identity.

Definitions of success extended beyond the GPA. Eleven participants described success in terms of learning, experience, or professional growth rather than grades alone. P12 stated, "What matters is self-development ... a 4.0 [over 4.0 GPA] 'robot' isn't success; but a 2.0 who gained qualities is." At the same time, several participants required specific grades for postgraduate study or evaluated strategies by examination results. GPA and professional growth, therefore served as overlapping but sometimes competing criteria.

Theme 5: 21st-Century-Skill Talk as Perceived Transfer

All participants linked aspects of their learning practices to at least one self-perceived 21st-century skill, including communication, collaboration, adaptability, digital literacy, critical thinking, responsibility, or independent learning. These accounts contextualised the stronger statistical association between learning strategies and perceived 21st-century skills than between learning strategies and the GPA. They reflected participants' perceptions of transfer rather than independent evidence of skill attainment or competence.

P3 (Class 2/Profile 2) described using GenAI to summarise course material, generate questions, and test herself, while also comparing notes with peers. P2 (Class 1/Profile 2) linked conference participation and shared resources to communication, collaboration, and digital literacy. P11 (Class 1/Profile 1) described using GenAI to simplify difficult material and support critical reflection, despite belonging to the low-strategy profile.

GenAI was therefore one element of a broader repertoire rather than an independent theme. Participants described it as scaffolding for comprehension, questioning, and organisation, while others raised concerns about ready-made outputs, laziness, and ethical use. These practices are cautiously described as GenAI-

supported scaffolding. The accounts do not establish that human–AI interaction constitutes ICAP’s interactive mode, which involves responsive co-construction of understanding.

Low-profile cases further complicated a linear interpretation. P11’s digital and reflective practices showed that rich 21st-century-skill talk could coexist with a low aggregate strategy profile, while some participants claimed skill development without describing transfer beyond the activity. The outcome should therefore be interpreted as perceived 21st-century skills with possible shared-method effects.

Integrated Interpretation

Across themes, latent memberships were interpreted as tendencies rather than homogeneous learner types. High-profile interviewees generally described more stable planning, explanation, and transfer; low-profile interviewees described specialised but less consistent strategies; and moderate-profile interviewees varied in calibration, regulation, and professional direction. Counterexamples to these tendencies occurred in both latent classes and across the strategy profiles.

Overall, the qualitative findings contextualised and qualified the quantitative patterns by accounting for variation in enactment and context. Strategy engagement was more strongly reflected in perceived 21st-century skills than in the GPA, and participants highlighted assessment calibration, instructional fit, and regulation under load as plausible contextual influences. These interpretations are not causal tests and do not imply that latent groups define fixed forms of engagement.

Table 8 integrates the quantitative findings with the five qualitative themes, including convergent patterns, within-group variation, and disconfirming cases.

Table 8

Joint Display of Quantitative and Qualitative Findings by Research Question

Research question	Quantitative finding and key statistics	Qualitative theme(s)	Meta-Inference
RQ1 – GPA prediction	Elaboration and monitoring strategies ($\beta = 0.221$) and voluntary major choice ($\beta = 0.131$) predicted GPA; final $R^2 = 0.051$.	Strategic repertoire, calibration and assessment fit; Identity, professional growth and success criteria; Regulation breakdowns under load	Elaboration and monitoring and voluntary major choice were associated with the GPA, while participants’ accounts highlighted variation in assessment fit and regulation across contexts. These accounts provide plausible contextual interpretations of the modest model rather than evidence of causal mechanisms.

(continued)

Research question	Quantitative finding and key statistics	Qualitative theme(s)	Meta-Inference
RQ1 – Perceived 21st-century skills prediction	Final $R^2 = 0.385$. Study habits ($\beta = 0.341$), elaboration and monitoring strategies ($\beta = 0.166$), motivation ($\beta = 0.232$), and initiating PD ($\beta = 0.079$) were significant; the PD block did not add significant variance ($\Delta R^2 = 0.007$, $p = 0.185$).	Instructional fit and meaning-making; Strategic repertoire; Regulation breakdowns; 21st-century-skill talk as perceived transfer	Learning strategies were more strongly associated with perceived 21st-century skills than with the GPA. Participants' accounts linked these perceived skills with communication, digital practices, adaptation, and self-regulation, while also revealing within-profile variation. These accounts support an interpretation of perceived transfer, but do not independently verify skill attainment or competence.
RQ2 – Latent class analysis	Class 1 had higher perceived skills and strategy scores than Class 2, but GPA did not differ; skills $\chi^2(1) = 11.54$, $p = 0.001$; GPA $\chi^2(1) = 2.94$, $p = 0.087$; entropy = 0.874.	Identity, professional growth and success criteria; Regulation breakdowns under load	Participant accounts suggested greater coherence in several Class 1 professional development pathways, while counterexamples occurred in both classes. Class membership should, therefore be interpreted as a probabilistic configuration of the three survey indicators rather than as a fixed professional identity.
RQ2 – Latent profile analysis	Perceived skills increased from Profile 1 to Profile 3, $\chi^2(2) = 159.07$, $p < 0.001$. Profile 1 had lower GPA than Profiles 2 and 3; Profiles 2 and 3 did not differ, $p = 0.368$.	Strategic repertoire, calibration and assessment fit; Regulation breakdowns under load; 21st-century-skill talk as perceived transfer	Profiles differed mainly in the consistency and breadth of reported strategy enactment. Low-profile participants still described specialised strategies, providing disconfirming evidence against equating profiles directly with ICAP modes (Chi & Wylie, 2014).

(continued)

Research question	Quantitative finding and key statistics	Qualitative theme(s)	Meta-Inference
RQ3 – Mixed-methods integration	The final regression models explained substantially more variance in perceived skills ($R^2 = .385$) than in the GPA ($R^2 = .051$). The moderate- and high-strategy profiles did not differ significantly in the GPA.	All five themes	The meaning of engagement varied depending on the outcome examined. Latent profiles clearly differentiated perceived 21st-century skills, but only partially differentiated the GPA. At the same time, participant-linked interviews identified within-profile variation associated in participants' accounts with instructional fit, assessment calibration, regulation under load, and professional criteria. Engagement profiles should, therefore be interpreted as outcome- and context-dependent tendencies rather than general indicators of student capability.

Notes. RQ = Research Question; β = standardised regression coefficient; R^2 = variance explained; $\chi^2(df)$ = BCH chi-square statistic; LCA = latent class analysis; LPA = latent profile analysis; PD = professional development. Meta-inferences are interpretive explanations that connect quantitative tendencies to participants' accounts and should not be read as causal conclusions.

DISCUSSION

Cognitive Engagement, Academic Achievement, and Perceived 21st-Century Skills

This study examined whether learning strategies and professional development orientations related differently to the GPA and perceived 21st-century skills, and how person-centred patterns and interviews qualified these relationships. The predictors explained 38.5% of the variance in perceived skills but 5.1% in the GPA, providing the central interpretive contrast. Reported engagement was more strongly reflected in perceived skills, while participants' accounts showed that its enactment varied across instructional, assessment, regulatory, and professional conditions. Thus, the quantitative and qualitative strands are interpreted as complementary evidence.

The elaboration and monitoring dimension and voluntary major choice were the only significant predictors of the GPA. This is broadly consistent with evidence linking specific metacognitive and self-regulatory strategies to performance (Cosma et al., 2025). However, other studies have reported weak strategy–grade relationships (Bernabé Lillo et al., 2022) or stronger associations with more proximal achievement outcomes (Freeman et al., 2014; Gargallo López et al., 2023; Liu et al., 2014). Cumulative GPA aggregates performance across subjects, instructors, assessment formats, and time. Qualitative findings further suggest that the strategy effectiveness depended in part on calibration to course and assessment demands. Thus,

assessment fit should be interpreted as a plausible contextual influence on the observed association rather than a demonstrated cause of grades (Fischer et al., 2024).

The findings also qualify the assumption that recognising effective strategies ensures consistent use. Rea et al. (2022) similarly found that students may recognise effective practices without consistently implementing them. Participants' accounts distinguished between possessing strategies and enacting them, showing that anxiety, health, workload, environmental constraints, and procrastination could disrupt otherwise appropriate strategies. This distinction may help explain why broad study-habit and organisational indicators were not uniquely associated with the GPA.

Perceived 21st-century skills were more strongly associated with study habits, motivation, and elaboration and monitoring. Participants described these learning processes in terms of communication, collaboration, digital practice, independent learning, and adaptation, rather than assessment performance alone. This conceptual alignment may partly explain the stronger association between strategy use and perceived skills. Related teacher education research has also linked learning skills, metacognitive awareness, teacher identity, and perceived 21st-century competencies (Cengelci & Egmir, 2022; Yenel & Selçuk, 2024).

However, the outcome captured self-reported perceptions of 21st-century skills rather than externally assessed competence. Ratings may reflect capability, but also confidence, familiarity with the language of competence, or shared response tendencies. Because learning strategies and perceived skills were measured in the same survey, common method variance may also have strengthened their association. The qualitative evidence therefore supports perceived transfer rather than independent verification of competence. Within-profile counterexamples further caution against interpreting higher profile membership as evidence of greater demonstrated competence.

Person-Centred Variation and Contextual Enactment

The LCA distinguished a self-directed, development-oriented class from a passively oriented class. Class 1 reported stronger strategies and perceived skills, but the classes did not differ in the GPA. Participant accounts suggested that this distinction reflected differences in the coherence of professional orientation rather than academic performance, consistent with research linking professional identity and engagement and identifying heterogeneous career and professional-goal patterns (Chen et al., 2025; Levin et al., 2022; Wolter et al., 2019). However, counterexamples in both classes showed that aspirations, meaningful engagement, uncertainty, and difficulties with regulation did not align uniformly with membership. The classes should be interpreted as probabilistic configurations of the three professional development indicators rather than fixed professional types.

The absence of a class difference in the GPA also cautions against explanations based solely on professional motivation or commitment. Floris et al. (2024) found that identified motivation was linked to achievement through career-planning confidence and effort regulation. In the present study, any relationship between professional orientation and grades may similarly have depended on regulation and assessment-relevant action, although mediation and temporal ordering were not tested.

The LPA identified low-, moderate-, and high-strategy profiles. Perceived skills increased across all three profiles, whereas the GPA was lower only in the low profile and did not differ significantly between the moderate and high profiles. Therefore, the findings do not support a strictly linear relationship between reported strategy use and the GPA. Participant accounts further suggested that profiles differed more in the breadth and consistency of strategy enactment than in the presence or absence of sophisticated strategies. This qualifies previous findings linking higher-strategy profiles to stronger academic outcomes (Gargallo López et al., 2023; Han et al., 2018; Liu et al., 2014), and complements person-centred evidence that 21st-century skill-related characteristics can form distinct latent configurations among university students (Uras et al., 2025). Together, these studies indicate that the meaning of a latent profile depends on the indicators from which it is derived and the outcome against which it is evaluated. Assessment calibration, instructional fit, and regulation under load provide plausible contextual interpretations of the weaker differentiation in the GPA. In contrast, participants' accounts of communication, adaptation, digital practice, and independent learning were more closely aligned with perceived skills. These explanations remain interpretive rather than causal.

The nonsignificant GPA difference between the moderate and high profiles should not be interpreted as a performance ceiling, threshold, or diminishing return. The cross-sectional design establishes only that their mean GPAs were not statistically distinguishable in this sample. Longitudinal or experimental evidence would be required to infer a plateau or a change in the effect of additional strategy use.

Taken together, these participant-linked patterns caution against treating latent profiles as fixed learner types or assigning them directly to the passive, active, constructive, or interactive ICAP categories (Chi & Wylie, 2014). Instead, the profiles represent probabilistic tendencies whose expression varies across instructional, assessment, regulatory, and professional conditions.

ICAP as an Interpretive Lens

The findings are consistent with ICAP's distinction among receiving information, acting on material, generating understanding, and constructing meaning through interaction (Chi & Wylie, 2014). However, processes aligned with these modes varied within, rather than between fixed latent categories. Participants reported more or less generative processing depending on instructional fit, assessment demands, and regulation under load. The contribution is, therefore not to assign latent groups to ICAP modes but to identify contextual variation in reported cognitive engagement.

This interpretation remains constrained by the study's measures. ICAP modes were not directly assessed, and the learning-strategy scale captured self-reported tendencies rather than observed engagement in a common task. Thus, qualitative accounts were used to interpret reported cognitive processes, not to validate ICAP hierarchy or classify profiles into ICAP modes. This limitation aligns with calls for student-perception measures of cognitive activation to be complemented by direct observation (Theelen et al., 2025). The GPA and perceived 21st-century skills also differ from the task-level outcomes commonly used to test ICAP predictions (Chi & Wylie, 2014). As a result, the findings should be understood as an ICAP-informed interpretation rather than validation of ICAP as a measurement or causal model.

Participants' GenAI use should be interpreted within the same boundary. They described using GenAI for explanation, question generation, note organisation, and alternative representations, supporting a cautious interpretation of GenAI-supported scaffolding. These accounts do not establish that human–AI exchanges constitute ICAP's interactive mode. Whether such exchanges involve co-construction associated with interactive engagement requires direct observation, process data, and performance measures.

Taken together, the findings link ICAP-informed research on cognitive engagement in designed tasks with person-centred research on heterogeneity in self-regulated learning and professional identity (Chen et al., 2025; Lawson et al., 2023; Schel & Drechsel, 2025; Wekerle & Kollar, 2022). The present study shows that engagement-related configurations can carry different meanings, depending on the outcome used to evaluate them, and that participant-linked accounts reveal contextual and within-group variation concealed by aggregate classifications. This supports interpreting latent classes and profiles as probabilistic summaries rather than fixed learner types and illustrates a boundary-aware use of the ICAP framework without equating profiles with their modes.

These findings support a testable proposition for future research in teacher education. Engagement profiles may carry different meanings across outcomes and across the instructional, assessment, and regulatory conditions in which engagement is enacted. This proposition requires testing across institutions, disciplines, and cultural contexts, using observed engagement and performance-based measures alongside self-report.

CONCLUSION

This sequential explanatory mixed-methods study found that learning strategies and professional development orientations were more strongly associated with perceived 21st-century skills than with self-reported GPA among teacher education students in Türkiye. The final models explained 38.5% of the variance in perceived skills and 5.1% in the GPA, indicating that the measured engagement-related variables related differently to the two outcomes, rather than reflecting a single general relationship with educational success. These findings are only concerned with self-reported GPA and perceived 21st-century skills and do not establish objectively assessed competence.

Person-centred analyses further showed that perceived skills increased across the low-, moderate-, and high-strategy profiles, whereas the GPA was lower only in the low profile. The latent classes also differed in strategy use and perceived skills, but not in the GPA. Participant-linked interviews showed that these aggregate patterns varied across instructional, assessment, regulatory, and professional contexts, supporting the interpretation of classes and profiles as probabilistic tendencies rather than fixed learner types.

The study offers an outcome- and context-dependent account of reported engagement by linking person-centred patterns to participant accounts and interpreting them through the ICAP framework without treating its modes as directly measured. Thus, engagement-related configurations should not be read as a fixed high-to-low hierarchy of learner capability or as evidence of a validated extension of ICAP.

Implications

For teacher educators in similar contexts, engagement profiles may be most useful as starting points for inquiry rather than as fixed learner labels. Support may need to distinguish among limited knowledge of strategies, inconsistent enactment, poor assessment calibration, and regulatory breakdowns linked to anxiety, workload, or environmental constraints. Thus, strategy-development initiatives could help students compare approaches across tasks, justify their appropriateness, evaluate their effectiveness, and adapt them to different instructional and assessment contexts.

For programme evaluation, cumulative GPA and perceived 21st-century skills may provide complementary, non-equivalent information. When broader learning or professional development is of interest, self-reported indicators could be considered alongside authentic tasks, portfolios, observed teaching, collaborative problem-solving, and opportunities to make and justify evaluative judgements. Such evidence should supplement, rather than replace established academic assessment and be validated within the programme context.

Limitations

Several limitations, however, constrain interpretation. The cross-sectional design precludes causal or temporal conclusions. Learning strategies and perceived 21st-century skills were self-reported in the same survey, increasing the risk of common method variance, while the GPA was self-reported rather than drawn from institutional records. Excluding incomplete submissions and multivariate outliers may also have affected the sample used for analysis.

The latent classes and profiles are sample-dependent statistical summaries that require replication. Their labels should not be interpreted as complete descriptions of individual students or as direct measures of ICAP modes. The single-faculty setting also limits transferability across disciplines, institutions, assessment systems, and cultural contexts.

The qualitative phase included all 12 students who responded to the invitation to volunteer participation in the study, rather than drawn from a purposive or maximum-variation sample. Although both classes and all three profiles were represented, the low and high profiles each included only two interviewees. Recruitment, therefore, did not ensure balanced representation of latent groups or saturation, and self-selection may have favoured students willing to discuss their learning. Prior contact between the researchers and some participants may also have increased the risk of social desirability, despite the neutral interview stance.

Finally, the qualitative findings were based on participants' accounts rather than on observed learning or independently assessed competence. Translating Turkish quotations into English also involved interpretive decisions, although the researchers checked the translations against the originals. Future studies could combine longitudinal designs, institutional GPA records, observed engagement, process data, and externally assessed 21st-century-skill performance tasks.

DECLARATION OF CONFLICTING INTERESTS

No potential conflicts of interest with respect to the research, authorship, and/or publication of this article are declared.

ETHICS STATEMENT

We declare that this study is original, has not been published before, and is not being considered for publication anywhere, in print or electronic form. All procedures complied with institutional and national ethical standards for research involving human participants. Participation was voluntary, and written informed consent was obtained from all participants before data collection.

During manuscript preparation, the authors used Grammarly and Claude only to improve language and readability, and DeepL solely to check translation accuracy. These tools were not used for coding, data analysis or interpretation. The authors reviewed and edited all outputs and take full responsibility for the final content.

PARTICIPANT CONSENT STATEMENT

Written informed consent was obtained from all participants, who took part voluntarily.

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REFERENCES

- Bakay, A. (2022). 21st century skills for higher education students in EU countries: Perception of academicians and HR managers. *International Education Studies*, 15(2), 14–24. <https://doi.org/10.5539/ies.v15n2p14>
- Bennett, K., Heritage, B., & Allen, P. (2022). *SPSS statistics: A practical guide*. Cengage.
- Bernabé Lillo, M. D. L. L., Suárez Suri, P. R., Espinoza Ávila, M. E., Armijos Porozo, I. M., & Medina Godoy, A. A. (2022). Learning strategies in Ecuadorian university students: A case study in the province of Esmeraldas. *Revista Andina de Educación*, 5(2), 000529. <https://doi.org/10.32719/26312816.2022.5.2.9>
- Boud, D., & Falchikov, N. (2007). Introduction: Assessment for the longer term. In D. Boud & N. Falchikov (Eds.), *Rethinking assessment in higher education: Learning for the longer term* (pp. 3–13). Routledge.

- Cengelci, S., & Egmir, E. (2022). The effect of 21st century learner skills and metacognitive awareness on early teacher identity. *Shanlax International Journal of Education*, 10(S1-Aug), 270–283. <https://doi.org/10.34293/education.v10iS1-Aug.4873>
- Chen, D. (2023). Toward an understanding of 21st-century skills: From a systematic review. *International Journal for Educational and Vocational Guidance*, 23(2), 275–294. <https://doi.org/10.1007/s10775-021-09511-1>
- Chen, Y., Qi, X., Zhang, J., Ma, M., Yang, X., & Baek, J. (2025). The influence of professional identity on learning engagement among teacher education students: A latent profile analysis. *Frontiers in Education*, 10, 1596827. <https://doi.org/10.3389/educ.2025.1596827>
- Chi, M. T. H., & Wylie, R. (2014). The ICAP framework: Linking cognitive engagement to active learning outcomes. *Educational Psychologist*, 49(4), 219–243. <https://doi.org/10.1080/00461520.2014.965823>
- Chun, T. C., & Abdullah, M. N. L. Y. (2022). The effects of language teachers' attitudes, barriers and enablers in teaching 21st century skills at Chinese vernacular schools. *Malaysian Journal of Learning and Instruction*, 19(1), 115–146. <https://doi.org/10.32890/mjli2022.19.1.5>
- Correia, A.-P. (2014). Creating curriculum within the context of an enterprise. In M. Gosper & D. Ifenthaler (Eds.), *Curriculum models for the 21st century* (pp. 113–134). Springer. https://doi.org/10.1007/978-1-4614-7366-4_7
- Cosma, M. L., Berce, C., Bochiș, L. E., & Clipa, O. (2025). The role of learning strategies and motivation in academic performance: A study of university students. *Revista Romaneasca Pentru Educatie Multidimensionala*, 17(4), 200–222. <https://doi.org/10.18662/rrem/17.4/1054>
- Creswell, J. W., & Creswell, J. D. (2023). *Research design: Qualitative, quantitative, and mixed methods approaches* (6th ed.). SAGE.
- de la Fuente Arias, J., & Justicia Justicia, F. (2003). Abridged ACRA scale of learning strategies for university students. *Electronic Journal of Research in Educational Psychology*, 1(2), 139–158. <https://ojs.ual.es/ojs/index.php/EJREP/article/download/1119/1046/3772>
- Durmuş, A., & Güven, M. (2023). Development of the scale for identifying perceptions of having 21st century skills of pre-service teachers: Validity and reliability study. *Cukurova University Faculty of Education Journal*, 52(1), 99–125. <https://doi.org/10.14812/cuefd.1124952>
- Edwards-Jones, A., Georgeson, J., & Blandon, C. (2016). *Manual of good practice & implementation guidelines*. https://ec.europa.eu/programmes/erasmus-plus/project-result-content/419685e5-bc81-4122-8c1a-5f33010844f7/O5_EN-Manual-of-Good-Practice-and-Implementation-Guidelines_logo.pdf
- Fischer, J., Bearman, M., Boud, D., & Tai, J. (2024). How does assessment drive learning? A focus on students' development of evaluative judgement. *Assessment & Evaluation in Higher Education*, 49(2), 233–245. <https://doi.org/10.1080/02602938.2023.2206986>
- Floris, M., Paganin, G., Guglielmi, D., & Mazzetti, G. (2024). Motivation is not enough: How career planning and effort regulation predict academic achievement. *Current Psychology*, 43(10), 9280–9289. <https://doi.org/10.1007/s12144-023-05070-6>
- Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences*, 111(23), 8410–8415. <https://doi.org/10.1073/pnas.1319030111>

- Gargallo López, B., Almerich Cerveró, G., García García, F.-J., López Francés, I., & Sahuquillo Mateo, P. M. (2023). University student profiles in the learning to learn competence and their relationship with academic achievement. *Revista Española de Pedagogía*, 81(286), 457–487. <https://doi.org/10.22550/REP81-3-2023-02>
- Griffin, P., & Care, E. (Eds.). (2015). *Assessment and teaching of 21st century skills: Methods and approach*. Springer. <https://doi.org/10.1007/978-94-017-9395-7>
- Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2022). *A primer on partial least squares structural equation modeling (PLS-SEM)* (3rd ed.). SAGE.
- Han, C., Farruggia, S. P., & Solomon, B. J. (2018). Latent profiling university students' learning strategies use and effects on academic performance and retention. *Higher Education Research & Development*, 37(7), 1409–1423. <https://doi.org/10.1080/07294360.2018.1498460>
- Hansen, J. M., Jackson, A. P., & Pedersen, T. R. (2017). Career development courses and educational outcomes: Do career courses make a difference? *Journal of Career Development*, 44(3), 209–223. <https://doi.org/10.1177/0894845316644984>
- Hull-Blanks, E., Kurpius, S. E. R., Befort, C., Sollenberger, S., Nicpon, M. F., & Huser, L. (2005). Career goals and retention-related factors among college freshmen. *Journal of Career Development*, 32(1), 16–30. <https://doi.org/10.1177/0894845305277037>
- IBM Corp. (2020). *IBM SPSS Statistics for Windows* (Version 27.0) [Computer software].
- Kemp, R., Snelgar, R., Brace, N., & Harrison, V. (2021). *SPSS for psychologists* (6th ed.). Palgrave Macmillan.
- Küçüker, G. F., Sönmez, B., & Selvi, K. (2014). The adaptation of the ACRA–Higher Education Learning Strategies Scale. *Anadolu University Journal of Social Sciences, Education Special Issue*, 1–14.
- Lawson, M. J., Van Deur, P., Scott, W., Stephenson, H., Kang, S., Wyra, M., Darmawan, I., Vosniadou, S., Murdoch, C., White, E., & Graham, L. (2023). The levels of cognitive engagement of lesson tasks designed by teacher education students and their use of knowledge of self-regulated learning in explanations for task design. *Teaching and Teacher Education*, 125, 104043. <https://doi.org/10.1016/j.tate.2023.104043>
- Levin, N., Lipshits-Braziler, Y., & Gati, I. (2022). The identification and validation of five types of career indecision: A latent profile analysis of career decision-making difficulties. *Journal of Counseling Psychology*, 69(4), 452–462. <https://doi.org/10.1037/cou0000603>
- Liu, W. C., Wang, C. K. J., Kee, Y. H., Koh, C., Lim, B. S. C., & Chua, L. (2014). College students' motivation and learning strategies profiles and academic achievement: A self-determination theory approach. *Educational Psychology*, 34(3), 338–353. <https://doi.org/10.1080/01443410.2013.785067>
- Malkewitz, C. P., Schwall, P., Meesters, C., & Hardt, J. (2023). Estimating reliability: A comparison of Cronbach's α , McDonald's ω and the greatest lower bound. *Social Sciences & Humanities Open*, 7(1), 100368. <https://doi.org/10.1016/j.ssaho.2022.100368>
- Malterud, K., Siersma, V. D., & Guassora, A. D. (2016). Sample size in qualitative interview studies: Guided by information power. *Qualitative Health Research*, 26(13), 1753–1760. <https://doi.org/10.1177/1049732315617444>
- Mistree, F., Panchal, J. H., Schaefer, D., Allen, J. K., Haroon, S., & Siddique, Z. (2014). Personalized engineering education for the twenty-first century. In M. Gosper & D. Ifenthaler (Eds.), *Curriculum models for the 21st century* (pp. 91–111). Springer. https://doi.org/10.1007/978-1-4614-7366-4_6
- Muthén, L. K., & Muthén, B. O. (2017). *Mplus* (Version 8) [Computer software]. Muthén & Muthén.

- Partnership for 21st Century Learning. (2016). *Partnership for 21st century skills core content integration*. Ohio Department of Education. https://www.marietta.edu/sites/default/files/documents/21st_century_skills_standards_book_2.pdf
- Prince, M. (2004). Does active learning work? A review of the research. *Journal of Engineering Education*, 93(3), 223–231. <https://doi.org/10.1002/j.2168-9830.2004.tb00809.x>
- Rea, S. D., Wang, L., Muenks, K., & Yan, V. X. (2022). Students can (mostly) recognize effective learning, so why do they not do it? *Journal of Intelligence*, 10(4), 127. <https://doi.org/10.3390/jintelligence10040127>
- Rust, C. (2007). Towards a scholarship of assessment. *Assessment and Evaluation in Higher Education*, 32(2), 229–237. <https://doi.org/10.1080/02602930600805192>
- Saldaña, J. (2021). *The coding manual for qualitative researchers* (4th ed.). SAGE.
- Schel, J., & Drechsel, B. (2025). A latent profile analysis for teacher education students' learning: An overview of competencies in self-regulated learning. *Frontiers in Psychology*, 16, 1527438. <https://doi.org/10.3389/fpsyg.2025.1527438>
- Theelen, H., Canisius, E., & Lambert, G. (2025). The relationship between instructional strategies and cognitive activation in higher education: A student perspective. *Active Learning in Higher Education*, 26(3), 521–541. <https://doi.org/10.1177/14697874251356242>
- Trilling, B., & Fadel, C. (2009). *21st century skills: Learning for life in our times*. Jossey-Bass.
- UNESCO-UNEVOC. (n.d.). *TVETipedia glossary: 21st century skills*. <https://connect.unevoc.unesco.org/home/TVETipedia+Glossary/lang=e/show=term/lang=e/term=21st+century+skills#start>
- Uras, M. C., Kaya, S., Kaya, A., & Yildirim, M. (2025). Unveiling risk profiles: A latent profile analysis of 21st-century skills, resistance to change, and cognitive flexibility. *Brain and Behavior*, 15, e70167. <https://doi.org/10.1002/brb3.70167>
- Voogt, J., & Roblin, N. P. (2012). A comparative analysis of international frameworks for 21st-century competences: Implications for national curriculum policies. *Journal of Curriculum Studies*, 44(3), 299–321. <https://doi.org/10.1080/00220272.2012.668938>
- Weinstein, C. E., & Mayer, R. E. (1986). The teaching of learning strategies. In M. C. Wittrock (Ed.), *Handbook of research on teaching* (3rd ed., pp. 315–327). Macmillan.
- Wekerle, C., & Kollar, I. (2022). Using technology to promote student learning? An analysis of pre- and in-service teachers' lesson plans. *Technology, Pedagogy and Education*, 31(5), 597–614. <https://doi.org/10.1080/1475939X.2022.2083669>
- Wolter, I., Ehrtmann, L., Seidel, T., & Drechsel, B. (2019). Social or economic goals? The professional goal orientation of students enrolled in STEM and non-STEM majors in university. *Frontiers in Psychology*, 10, 2065. <https://doi.org/10.3389/fpsyg.2019.02065>
- Yenel, K., & Selçuk, G. (2024). Investigation of prospective teachers' 21st century skills competency perceptions based on various variables. *Kastamonu Education Journal*, 32(3), 506–515. <https://doi.org/10.24106/kefdergi.1525403>
- Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory into Practice*, 41(2), 64–70. https://doi.org/10.1207/s15430421tip4102_2