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Synthesizing a GPAAS Learning Process Model: Mixed-Methods Evidence from Secondary Education

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Abstract. Employing an explanatory sequential mixed-methods design, this study identified the five components of the gathering, processing, applying, articulating, and self-regulating (GPAAS) learning process among Thai Grade 12 students; examined whether these components represented an overall construct; and explained their practical application through qualitative evidence. The quantitative phase involved two independent samples of students from Thai public and private schools. Questionnaire data from 400 students underwent exploratory factor analysis, followed by confirmatory factor analysis (CFA) with 505 students. The qualitative phase included semi structured interviews with eight high-achieving students and an appraisal by four educational experts, and data were analyzed using directed content analysis with additional inductive subthemes. The findings suggested that the participants demonstrated the five related components. Domain-level

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CFA showed that composite indicators were significantly associated with the overall GPAAS construct. The model also showed good fit with the empirical data. Student and expert evidence highlighted self-regulation as both the fifth component and a process that supported the other steps. Experts also emphasized curriculum design, teacher development, interdisciplinary learning, responsible technology use, and school-level support for GPAAS implementation.

Keywords: GPAAS learning process; self-regulated learning; exploratory factor analysis; confirmatory factor analysis; mixed methods

1. Introduction

From the rapid development of digitalization, automation, and artificial intelligence (AI), new challenges for education have emerged. Expectations have increased for education systems to move beyond knowledge transmission and prepare learners to address complex and changing situations (UNESCO, 2021). Lifelong learning and the four pillars of education – learning to know, learning to do, learning to live together, and learning to be – remain important principles for educational development (Delors et al., 1996). In addition, constructivist perspectives posit that learners do not passively acquire knowledge but actively construct it through experience, interpretation, and social interaction (Piaget, 1972; Vygotsky, 1978; Bruner, 2020). This view is also supported by findings showing that active learning can improve learning outcomes, particularly higher-order thinking and knowledge application (Freeman et al., 2014).

In the twenty-first century, critical thinking, communication, collaboration, and creativity are widely recognized as important learner competencies (Battelle for Kids, 2019). Therefore, educational institutions must design learning processes that allow these competencies to be observed and assessed in classroom practice. Similarly, evidence from the Thai school context has highlighted critical thinking, communication, collaboration, creativity and innovation, and information technology skills as important learning competencies alongside the development of responsible digital citizenship (Jatuporn, 2025). Innovation pedagogy has also emphasized learners' abilities to use knowledge, solve problems, and create new ideas (Keinänen & Kairisto-Mertanen, 2019). However, lecture-dominated teaching, limited assessment methods, and insufficient support for creativity and innovation have continued to impede many education systems (Nordin & Malik, 2015). In Thailand, the development of learner-centered education also requires a role shift among teachers from information providers to learning facilitators (Thayati et al., 2025).

Stakeholders have focused on active learning, backward design, and constructivist teaching approaches as they support learners' active engagement, higher-order thinking, and knowledge transfer to real situations (Wiggins & McTighe, 2005; Freeman et al., 2014). Effective learning involves discovery, interaction, practice, and reflection rather than participation in activities without cognitive engagement (Vygotsky, 1978; Bruner, 2020; Chi & Wylie, 2014). Classroom interaction quality can also facilitate communication and problem-

solving skills (English & Sriraman, 2009). Collaborative professional learning approaches can also enhance teachers' confidence and readiness to implement learner-centered instruction (Sonsupap et al., 2025). These learning concepts are vital for equipping learners with the necessary competencies and skills.

Meanwhile, the characteristics of the national Thai curriculum and its learners emphasize the development of foundational skills as a pathway toward deeper understanding and creativity. Consequently, the alignment between the adoption or adaptation of learning theories and models and Thai students' learning styles is often less effective (Wedding & Chin, 2013). Recognizing this, some Thai educational units or stakeholders developed the gathering, processing, applying, articulating, and self-regulating (GPAAS) instructional model to support student learning in accordance with the core curriculum (The Institute of Academic Development, 2017). Therefore, a crucial goal involves explaining how the implementation of GPAAS, as an instructional process, shapes and constructs students' internal learning processes. Such an understanding will allow educators to better design instructional plans, create learning materials, and cultivate a learning ecosystem that is highly responsive to learners' needs.

Internal learning processes are equally crucial for understanding how students achieve successful learning. Metacognition and self-regulated learning describe how learners set goals, monitor their understanding, control their behavior, and adjust their learning strategies (Flavell, 1979; Zimmerman, 2000; Pintrich, 2000; Panadero, 2017), demonstrating that effective learning is not limited to achievement scores. This viewpoint also highlights how learners gather information, process and construct knowledge, apply what they have learned, articulate their understanding, and regulate themselves. Studies examining transfer, knowledge building, and self-regulated learning further suggest that learning may develop through repeated cycles of inquiry, action, reflection, and improvement rather than through a completely linear process (Perkins & Salomon, 1992; Scardamalia & Bereiter, 2006; Winne & Hadwin, 1998).

Thailand has promoted the GPAAS framework as an active learning approach for learner-centered and competency-based education. Its five processes trace a learner's journey from information collection and knowledge construction to application, articulation, and self-regulation. Because the framework is linked to constructivism, metacognition, and self-regulated learning, it may be considered both an instructional approach and a model of learners' internal learning processes. Previous studies have demonstrated that GPAAS-oriented and active-learning practices can support higher-order thinking, communication, and teachers' instructional competence (Institute of Academic Development, 2017; Tayraukham et al., 2022). However, research has yet to explain learners' internal learning processes at each stage, which is key to understanding the underlying mechanisms of individual GPAAS components and their interactions with one another.

This gap must be addressed because modern learners require processes that connect knowledge, action, communication, and value creation (Paavola & Hakkarainen, 2005; Tan et al., 2021). While Thai studies have examined teacher development and readiness to implement active learning (Thayati et al., 2025; Sonsupap et al., 2025), fewer studies have examined how learners organize their internal learning processes. Evidence is also limited as to whether GPAAS components form a coherent overall process and how self-regulation contributes to such process. Therefore, focusing on Thai Grade 12 students, this study sought to synthesize and empirically examine the GPAAS learning process model by integrating quantitative evidence from exploratory and confirmatory factor analyses with qualitative findings from student interviews and expert appraisal. The results are expected to inform instructional design, assessment, and competency-based curriculum development in the Thai educational context.

2. Literature Review

2.1 Meaning and the Principles of Constructivism

Constructivism posits that knowledge is not directly transmitted from teachers to learners; instead, learners construct knowledge through experience, interpretation, and sociocultural interaction (Piaget, 1972; Vygotsky, 1978). Piaget conceptualized learning through assimilation and accommodation, while Vygotsky emphasized language, social interaction, and cultural tools. Bruner further developed the concepts of discovery learning and scaffolding to support learners' independence (Bruner, 2020). Similarly, Ausubel explained how meaningful learning takes place when new information is linked to existing knowledge (Ausubel, 1968). Dewey also highlighted direct experience and inquiry as important learning foundations (Dewey, 2007). These perspectives generally emphasize learners' active participation in the construction of their own understanding.

2.2 Constructivist Thinking Processes that Promote Learning Success

The constructivist perspective considers thinking as both a learning process and a learning outcome. Higher-order thinking includes analysis, synthesis, evaluation, and creativity (Anderson & Krathwohl, 2001; NRC, 2000). Metacognition is critical as well because it allows learners to monitor and regulate their thinking (Flavell, 1979). Critical and creative thinking helps learners evaluate evidence, solve problems, and develop new approaches (Halpern, 1998). Deep understanding also facilitates the transfer of learning to new contexts (Perkins & Salomon, 1992). Knowledge building in real-world contexts and learning communities can further develop higher-order thinking by requiring learners to discuss, examine, and improve shared ideas (Brown et al., 1989; Scardamalia & Bereiter, 2006).

2.3 Teaching and Learning Models in International and Thai Contexts

Several learning models have applied constructivism. Cognitive apprenticeship allows learners to observe and practice thinking in authentic situations, while knowledge building advances shared knowledge in a learning community (Collins et al., 1989; Scardamalia & Bereiter, 2006). Both approaches facilitate active participation, intellectual development, and real-world knowledge use.

In Thailand, the GPAAS framework links constructivist principles and active learning. According to the Institute of Academic Development (2017), GPAAS-based instruction can support deep learning, innovation, and important twenty-first-century competencies. Tayraukham et al. (2022) also observed that GPAAS-integrated constructivist instruction enhanced learners' higher-order thinking, communication, and teamwork while also improving teachers' active learning design skills. More recently, Yaboonthong et al. (2025) developed an integrated active learning model in Thai schools that connected learning activities with intended learning outcomes, local contexts, and the application of learning to everyday life.

2.4 GPAAS

Thailand's Ministry of Education created GPAS while developing the 2008 Core Curriculum for Basic Education; afterward, the model was further developed as GPAAS by the Institute of Academic Development (Ministry of Education, 2008; Institute of Academic Development, 2007). The framework aligns with the curriculum's focus on higher-order thinking, communication, problem-solving, life skills, technology use, and knowledge application in the real world. GPAAS is also related to UNESCO's four pillars of education: learning to know, learning to do, learning to live together, and learning to be (Delors et al., 1996).

In the GPAAS framework, which is based on learner-centered education and constructivism, learners are expected to construct knowledge through direct experience, action, and reflection rather than only acquire information from their teachers (Piaget, 1972; Vygotsky, 1978). The model is also linked to brain-based learning, which emphasizes cognitive processes and deep understanding and backward design, which begins with desired outcomes and then proceeds with learning activity and assessment design (Wiggins & McTighe, 2005). Hence, GPAAS connects learning goals, learning processes, assessment, and problem-solving within classroom and real-life contexts.

2.5 GPAAS Structure

The GPAAS framework consists of five steps:

- 1) *Gathering (G)* involves observing, exploring, identifying problems, and collecting relevant information. Learners build a foundation for further learning by selecting useful and reliable information.
- 2) *Processing (P)* involves classifying, comparing, connecting, reasoning, and examining information to develop structured understanding (Anderson & Krathwohl, 2001).
- 3) *Applying or constructing (A1)* involves planning, testing ideas, and constructing knowledge or products to solve problems.
- 4) *Applying for communication (A2)* involves communicating processes, ideas, and results through speaking, writing, technology, or different presentation formats. Communication also helps learners examine and improve their own understanding.
- 5) *Self-regulating (S)* involves reflection, self-assessment, peer assessment, monitoring progress, and setting new goals for further development (Zimmerman, 2000).

These steps can be summarized as inquiry, conclusion, action, communication, and reflection, respectively. While this framework presents a sequence, the learning process may not always be completely linear; learners may return to previous steps, revise their understanding, and adjust their actions based on reflection and feedback.

2.6 Success Factors and Implementation Limitations

Thai studies have found that GPAAS can help teachers transition from a teacher-centered, lecture-based instruction to an active learning or student-centered approach. Through this approach, learners may also improve analytical thinking, communication, and self-regulation (Tayraukham et al., 2022). Supporting factors include instructional coaches, appropriate learning materials, sufficient time for professional learning communities, and administrative support (Institute of Academic Development, 2017).

Meanwhile, time, budget, teacher workload, and differences among school contexts may limit GPAAS implementation. Hence, flexible support systems, such as coaching combined with professional learning communities and online supervision, may help schools apply the framework more effectively.

2.7 Theoretical Frameworks and Practical Research

GPAAS is linked to Kolb's experiential learning cycle, which includes concrete experience, reflective observation, abstract conceptualization, and active experimentation (Kolb, 1984). Both frameworks emphasize learning development through experience, reflection, conceptual understanding, and further action. GPAAS also shares some characteristics with Rogers's innovation process as learners develop awareness, interest, experimentation, and acceptance of new ideas. Therefore, GPAAS offers a common structure for connecting learning goals, activities, evidence, communication, and reflection. However, the proposed components should also be empirically investigated. To this end, exploratory factor analysis (EFA) can be used to clarify the component structure, while confirmatory factor analysis (CFA) can examine whether the identified components represent an overall GPAAS learning process model (Institute of Academic Development, 2017).

3. Methodology

This study adopted an explanatory sequential mixed-methods design (QUAN → QUAL) consisting of a quantitative phase, which aimed to identify and examine the GPAAS learning process model, and qualitative interviews, which sought to explain the quantitative findings and examine the framework's practical meaning (Creswell & Plano Clark, 2018; Dawadi et al., 2021). This study obtained ethical approval from the Human Research Ethics Committee of Mahasarakham University (Approval No. 806-798/2025).

3.1 Participants and Sampling

The first phase involved EFA model development. The first sample consisted of 400 Grade 12 students enrolled in public and private schools in Thailand during the second semester of the 2025 academic year. This sample size was considered

sufficient for EFA (Hair et al., 2019). Two-stage sampling was conducted by using the Northern, Central, Northeastern, and Southern regions as strata and then selecting schools through simple random sampling. The final sample included 100 students from each region.

The second phase involved CFA model confirmation. The second sample, which was independent of that in phase 1, consisted of 505 Grade 12 students from public and private schools. Sample-size adequacy was considered using a priori structural equation modelling sample-size calculation. The researchers used stratified sampling by region, followed by school selection and voluntary student participation. The analysis only included complete responses.

The third phase involved qualitative validation. Purposive sampling was performed to select eight high-achieving students representing four regions in Thailand with a cumulative grade point average of at least 3.50 (87.5%) and with outstanding learning activity profiles. This phase also included four educational experts with experience in curriculum, teaching, or student development in basic education; held professorial-level academic positions; and had at least 10 years of relevant research experience. These experts provided detailed explanations of the learning processes and the possible application of the model in school contexts (Patton, 2022).

3.2 Instruments and Quality Assurance

3.2.1 Questionnaire

The questionnaire contained two sections: participants' background information and 25 items that measure the five GPAAS elements using a five-point Likert scale.

Five experts reviewed the questionnaire to examine its content validity. Index of item-objective congruence values ranged from .80 to 1.00, suggesting acceptable content validity (Rovinelli & Hambleton, 1977). The questionnaire was then pilot tested with 44 students outside the main study. Corrected item-total correlations ranged from .876 to .946. Cronbach's alpha coefficients were .970-.976 for the five dimensions and .993 for the total questionnaire, suggesting high internal consistency.

The questionnaire's factorial structure was examined via EFA using the first sample and via CFA using the independent second sample.

3.2.2 Interview Protocols

Two semistructured interview guides were used. The first was used to interview the eight students regarding their learning processes and experiences, while the second was used to obtain opinions from the four educational experts on the meaning, appropriateness, and application of the GPAAS model. Before data collection, the experts reviewed the interview questions for clarity and relevance. These questions were developed around the five GPAAS components and included issues related to goal setting, monitoring, reflection, and strategy adjustment during learning (Zimmerman, 2000; Panadero, 2017).

3.3 Data Collection

Data was collected in three steps. The first involved requesting permission from the participating schools. In this step, the purpose and procedures of the study were explained to the participants, and data was collected only from students who agreed to participate. The questionnaire was administered to the first sample for EFA.

The second step involved administering the questionnaire to a completely different group of students for model confirmation. Electronic and paper questionnaires were used depending on the school context. Before data analysis, the researchers reviewed the responses for completeness and excluded incomplete questionnaires.

In the third step, the selected students and experts underwent semistructured interviews. The student interviews sought to clarify how the participants applied the five learning processes in actual situations, while the experts examined the model's appropriateness and practical meaning. The interviews were audio-recorded or documented through detailed notes. The data were transcribed, and pertinent information that required clarification was checked with the participants.

3.4 Data Analysis

3.4.1 Quantitative Analysis

Frequencies and percentages were used to describe participants' background information, while means and standard deviations described the levels of the five learning process components.

One-way analysis of variance (ANOVA) was used to examine differences in the background variables. The Shapiro-Wilk test was performed to assess data distribution, while Levene's test was used to examine the homogeneity of variance assumption. Welch's ANOVA was used when the homogeneity assumption was not met.

EFA was conducted using data from the first sample of 400 students. Data suitability was determined using the Kaiser-Meyer-Olkin measure (Kaiser, 1974) and Bartlett's test of sphericity (Bartlett, 1954). Factors were extracted using the maximum likelihood method with oblimin rotation because the learning process components were expected to be related. Factors count and meaning were examined using the scree plot, factor loadings, and theoretical interpretation.

CFA was then performed using data from the independent sample of 505 students to determine whether the five domain-level indicators represented an overall GPAAS learning process construct. Maximum likelihood estimation was used. Model fit was evaluated using the chi-square statistic (χ^2), comparative fit index (CFI), Tucker-Lewis's index (TLI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR) (Brown, 2015; Hu & Bentler, 1999; Kline, 2023). Quantitative analyses were conducted using jamovi and the lavaan package in R.

3.4.2 Qualitative Analysis

Qualitative data were examined using direct qualitative content analysis with additional inductive subthemes. The five GPAAS components were used as the initial coding categories as the interview questions were developed from the quantitative findings and the GPAAS framework.

The researchers repeatedly read the transcripts to understand the overall meaning and then coded relevant statements under gathering, processing, applying, articulating, and self-regulating. Information that did not clearly fit the initial categories was coded as additional subthemes. Similarities and differences among participants were extracted, and the quantitative findings were explained using representative statements. Coding and interpretation were reviewed by more than one researcher. Areas of agreement, extension, or difference were examined by comparing student findings and expert opinions. Member checking was performed when additional confirmation from the participants was required (Lincoln & Guba, 1985).

3.5 Trustworthiness and Research Ethics

To ensure the quality of the study, the questionnaire was reviewed by experts, pilot-tested, and examined using independent samples for EFA and CFA, and the qualitative findings were supported through member checking, researcher review, and comparison between student and expert information.

The participants were informed about the study's objectives and procedures as well as the voluntary nature of participation before giving consent. They could also withdraw from the study without negative consequences, and their identities and personal information were kept confidential. This study was conducted after obtaining ethical approval from the Human Research Ethics Committee of Mahasarakham University.

4. Results and Findings

4.1 Phase 1: Exploratory Factor Analysis of Learning-Process Components (n = 400)

Data suitability was examined before EFA. Bartlett's test of sphericity was statistically significant, $\chi^2(300) = 7,389$, $p < .001$, indicating that the correlation matrix was appropriate for factor analysis. The overall Kaiser-Meyer-Olkin value was .976, while item-level values ranged from .964 to .986. The five-factor model, extracted using the minimum residual method with oblimin rotation, showed excellent data fit. Although the chi-square test was not statistically significant, $\chi^2(185) = 220$, $p = .39$, the remaining indices suggested excellent fit: RMSEA = 0.0217 and TLI = 0.992. These results confirmed that the sample and the relations among the items were appropriate for EFA.

Factors were extracted using the maximum likelihood method with oblimin rotation. The scree plot, factor loadings, theoretical meaning, and interpretability of the factors were considered. The theoretical framework specified a five-factor structure, with initial eigenvalues above 1.0. The results supported five learning process components: gathering, processing, applying, articulating, and self-regulating. Table 1 presents each component's meaning and loading range.

Table 1: Definitions of the gathering, processing, applying, articulating, and self-regulating (GPAAS) learning process components

Component	Operational meaning	Item	Factor loading	Eigen Value	communalities
Gathering	Focusing attention, setting learning goals, observing different senses, recording information, and selecting important information for further learning	G1 - G5	.596-.764	6.8912	.318 - .471
Processing	Classifying, grouping, comparing, connecting, and evaluating information to develop a clear conclusion or knowledge that can be applied	P1- P5	.456-.802	2.4137	.321 - .401
Applying	Planning and taking action to test, extend, and apply knowledge in learning activities, other subjects, or real-life situations	AP1- AP5	.521-.758	2.7052	.420 - .506
Articulating	Using self-explanation and communication through listening, speaking, reading, writing, or presenting to examine and improve understanding	AR1- AR5	.363-.469	2.3550	.459 - .506
Self-regulating	Monitoring and controlling one's thinking and actions to use knowledge for the benefit of oneself and society and to prevent misuse of knowledge	SR1- SR5	.403-.827	2.2851	.310 - .464

The five factors represented different but related aspects of the GPAAS learning process, with self-regulating showing the widest factor loading range and articulating showing lower loadings than those of the other components. Although some caution is warranted when interpreting the articulating component, it remained theoretically relevant to the GPAAS framework and was further examined through the CFA and qualitative phases.

4.2 Phase 2: Descriptive Results and CFA Model Confirmation (n = 505)

4.2.1 Descriptive Results

Results showed high mean scores for all five GPAAS components, ranging from 4.00 to 4.14, with the highest mean score for applying followed by gathering, self-regulating, processing, and articulating. The overall mean score was 4.06. Table 2 shows these results.

4.2.2 Confirmatory factor analysis of the GPAAS Learning Process Model

Positive and statistically significant correlations were obtained among the five domain scores, ranging from .561 to .711 ($p < .001$), showing that the components were related but represented different parts of the learning process.

Table 2: Descriptive results for the gathering, processing, applying, articulating, and self-regulating (GPAAS) learning process components (n = 505)

Items	M	SD	Interpret the results	
1. Observation for data gathering (Gathering: G)	4.08	0.52	High	
2. Cognitive thinking for knowledge summarization (Processing: P)	4.02	0.66	High	
3. Action for self-directed knowledge construction (Applying: A1)	4.14	0.63	High	
4. Communicating effectively and meaningfully (Articulating: A2)	4.00	0.67	High	
5. Self-regulation for value creation (Self-regulating: S)	4.06	0.69	High	
Total average	4.06	0.83	High	
Background variables	F	df1	df2	p
School location (North=132, Middle=147, Northeast=114, South=112)	22.00*	3.00	429.00	<.001
Type of school (Private School=90, Public School=415)	0.347	2.00	41.10	0.714
Program of study (Sci & math=245, Language=131, Special=129)	1.301	4.00	48.30	0.278
Shapiro-Wilk = .9260, $p = .542$, Levene's = 3.14, $p = .0015$				

Note: * $p < .05$, Welch's analysis of variance was applied for all background variable comparisons because the homogeneity of variance assumption was violated (Levene's test = 3.14, $p = .0015$).

Table 3: Correlation Matrix and Sampling Adequacy Diagnostics (KMO and Bartlett's Test) for the GPAAS Model

variable	G	P	A1	A2	S	KMO	Shapiro-Wilk	p-value
G	—					0.888	8.730	0.521
P	0.622***	—				0.861	9.450	0.656
A1	0.573***	0.682***	—			0.858	9.240	0.627
A2	0.633***	0.608***	0.691***	—		0.852	9.400	0.670
S	0.561***	0.565***	0.664***	0.711***	—	0.871	9.420	0.691
Bartlett's Test of Sphericity $\chi^2 = 1440$, $df = 10$, $p = .001$								

All five indicators had statistically significant standardized loadings, ranging from .540 to .782, with self-regulating showing the highest loading ($\beta = .782$) followed by gathering, articulating, processing, and self-regulating. The model also showed good fit with the empirical data, $\chi^2(256) = 550$, $p = 0.211$, CFI = .952, TLI = .962, SRMR = 0.0378, RMSEA = 0.0476, AIC = 27669, BIC = 28066. Comparison of goodness-of-fit indices revealed that the five-factor model provided the optimal fit to the empirical data over the four- and six-factor models. Although the six-factor model yielded perfect fit indices (CFI = 1.00, TLI = 1.00), this condition represents an overfit resulting from excess parameterization rather than true structural improvement.

Table 4: Relationship Between Quantitative CFA Results (n = 505) and Qualitative In-Depth Interview Findings (n = 8)

GPAAS learning process Factor	Quantitative Analysis					Qualitative Analysis
	Item	b	β	SE	Z	Evidence based behaviors from In-depth interview
Gathering (G) b = .355, β = .683, SE = .022, Z = 15.80***	G-1	0.587	0.691	0.038	10.240***	The intentional and systematic process of observing, selecting relevant information sources, identifying key evidence, and recording information is facilitated by attention control, the effective application of a note-taking strategy, and credibility checks to ensure the completeness and trustworthiness of the collected information, all of which are regulated through an individual's awareness.
	G-2	0.633	0.692	0.040	10.720***	
	G-3	0.542	0.550	0.035	9.940***	
	G-4	0.536	0.541	0.045	7.470***	
	G-5	0.631	0.687	0.042	10.380***	
Processing (P) b = .505, β = .771, SE = .026, Z = 19.00***	P-1	0.514	0.566	0.040	12.710***	The application of metacognitive strategies enables individuals to evaluate, analyses, integrate, and synthesize information into new knowledge. This process involves establishing comprehension goals, planning information-processing procedures, monitoring progress, and adapting strategies when necessary.
	P-2	0.532	0.595	0.039	13.640***	
	P-3	0.579	0.649	0.039	14.860***	
	P-4	0.533	0.636	0.036	14.790***	
	P-5	0.558	0.637	0.038	14.780***	
Applying (A1) b = .545, β = .869, SE = .024, Z = 17.80***	AP-1	0.548	0.642	0.036	15.250***	The translation of intention and planning into purposeful action through deliberate practice enables individuals to construct experiences that can be transformed into new knowledge. This cyclical process comprises four stages: engaging in concrete experience, observing and reflecting on that experience, developing abstract conceptualizations, and repeatedly applying the newly formed concepts to test and validate them.
	AP-2	0.541	0.657	0.034	15.710***	
	AP-3	0.571	0.674	0.035	16.230***	
	AP-4	0.623	0.731	0.035	18.070***	
	AP-5	0.524	0.636	0.035	15.090***	
Articulating (A2) b = .532, β = .797, SE = .029, Z = 17.80**	AR-1	0.500	0.540	0.040	12.380***	The intentional use of communication strategies enables individuals to convey knowledge clearly through spoken language, written language, and symbolic representations in ways appropriate to the intended audience. In addition, self-explanation/articulation serves as a cognitive tool for monitoring and refining one's understanding. By consciously explaining concepts to oneself, individuals can identify gaps or misconceptions in their understanding and thereby enhance their learning.
	AR-2	0.525	0.592	0.038	13.810***	
	AR-3	0.608	0.698	0.036	17.040***	
	AR-4	0.645	0.694	0.038	16.980***	
	AR-5	0.626	0.654	0.040	15.640***	
Self-regulating (S) b = .527, β = .763, SE = .027, Z = 18.90***	SR-1	0.577	0.669	0.037	15.640***	The establishment of value-oriented goals, together with self-monitoring, self-evaluation, and self-adaptation, enables individuals to regulate their learning and work toward outcomes that generate value for both themselves and others. This process also entails the capacity to inhibit and regulate actions that may lead to the unethical or inappropriate application of acquired knowledge
	SR-2	0.653	0.736	0.036	18.220***	
	SR-3	0.665	0.782	0.034	19.850***	
	SR-4	0.647	0.754	0.035	18.760***	
	SR-5	0.615	0.734	0.034	18.040***	

$\chi^2(256) = 550$, $p=0.211$, CFI=.952, TLI=.962, SRMR=0.0378, RMSEA=0.0476, AIC=27669, BIC=28066

*** $p < .001$

Table 5: Confirmatory factor analysis (CFA) results for the gathering, processing, applying, articulating, and self-regulating (GPAAS) learning process model (n = 505)

Model	χ^2	p-value	CFI	TLI	AIC	BIC
4 Indicators	632	Underdefined	.901	.890	28964	30494
5 Indicators	550	.211	.952	.962	27669	28066
6 Indicators	479	.535	1.00	1.00	25210	26548

In the CFA, the five domain-level composite scores were used as indicators of the overall GPAAS construct. Therefore, the results supported the relation between the five components and the overall learning process model at the domain level.

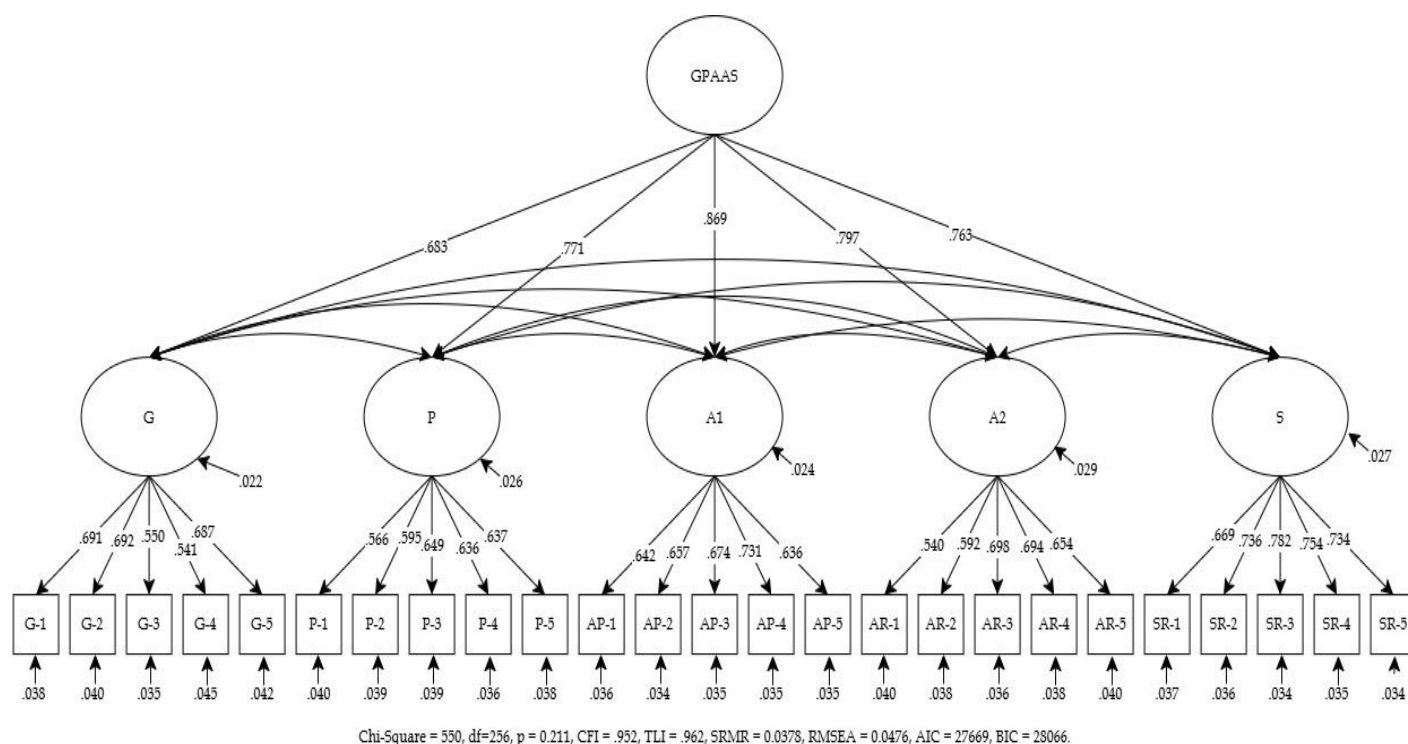


Figure 1: The confirmed gathering, processing, applying, articulating, and self-regulating (GPAAS) learning process model, including the five correlated elements (G, P, A1, A2, S)

After the quantitative analysis, in-depth interviews were conducted with eight high-achieving students. The goal of the qualitative phase was to explain the students' application of each GPAAS component in actual learning situations and the role of self-regulation across the learning process. The interview results confirmed that all eight students exhibited behaviors consistent with each component of the GPAAS learning process, as detailed in the Evidence based on In-depth interview column of Table 4.

4.3 Phase 3: Expert Appraisal of the GPAAS Learning Process

After reviewing the findings from phase 2, four educational experts confirmed that the five-step structure aligns with secondary education students' learning characteristics and could be applied to classroom practice. They also suggested that self-regulation extends beyond the final step and supports learners

throughout the process. Table 6 presents the main functions, observable behaviors, and levels of agreement for each step.

Table 6: Expert appraisal of the five-step gathering, processing, applying, articulating, and self-regulating (GPAAS) learning process

Step	Main function of the learning process	Students' Observable behaviors	Expert agreement
Step1 G ^s 	Learners consciously observe, select information sources, identify important evidence, and organize information while monitoring what they are observing and why.	Asking questions before collecting information, separating important information from unimportant information, recording information systematically, and examining source reliability	4/4 (100%)
Step2 P ^s 	Learners use metacognitive strategies to analyze, connect, evaluate, and synthesize information. They monitor their understanding and adjust their thinking when necessary.	Summarizing important information, providing reasons for conclusions, identifying conditions or limitations, and selecting suitable methods of analysis	4/4 (100%)
Step3 A ^s ₁ 	Learners transform plans and intentions into action to develop knowledge, skills, values, and personal characteristics. They monitor results and improve their methods through practice.	Designing or arranging activities, setting up success indicators, recording results, and modifying methods based on evidence or feedback	4/4 (100%)
Step4 A ^s ₂ 	Learners communicate knowledge clearly through speaking, writing, visual presentation, or self-explanation. Communication is also used to check and improve understanding.	Explaining complex ideas step by step, using examples or illustrations, adjusting explanations for the audience, and using feedback to correct misunderstandings	3/4 (75%)
Step5 S ^s 	Learners set value-oriented goals, monitor and evaluate their progress, and adjust their behavior to ensure that knowledge is used for the benefit of themselves and others.	Setting short- and long-term goals, monitoring progress, identifying expected outcomes, and adjusting actions or resources when results do not meet goals	3/4 (75%)

All four experts showed full agreement regarding the functions and observable behaviors of gathering, processing, and applying. Three agreed with the definitions of articulating and self-regulating, explaining that the former requires regular practice and sufficient time, while the latter requires learner motivation and commitment.

Figure 2 shows the five-step cycle illustrating the GPAAS learning process based on the quantitative findings, student interviews, and expert appraisal.

The integrated findings show that the GPAAS learning process begins when learners observe and collect information, which then undergoes analysis and synthesis. Learners then apply their knowledge through action and communicate their understanding for further examination. Finally, they monitor their learning, consider the value of their actions, and set new goals.

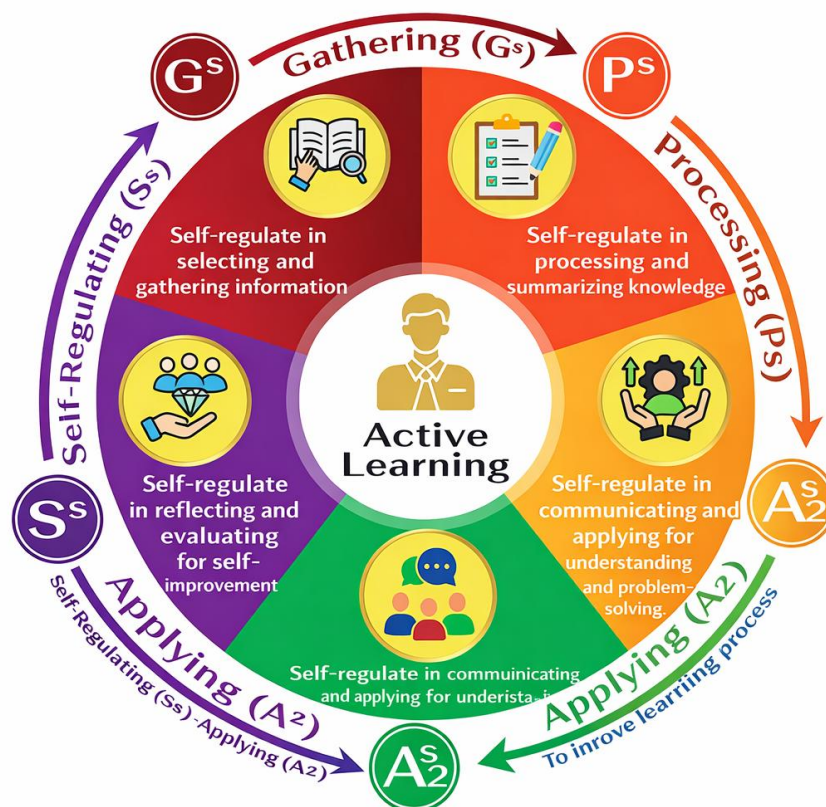


Figure 2: The gathering, processing, applying, articulating, and self-regulating (GPAAS) learning process for secondary education students

The experts suggested that the process may operate as a cycle rather than as a fixed linear sequence. Feedback from action and communication may encourage learners to review information, revise their understanding, or adjust their learning strategies. Hence, self-regulation may function both as the fifth component and as a mechanism that supports the other steps. Such interpretation is associated with self-regulated learning and experiential learning, which emphasizes monitoring, reflection, adjustment, and repeated learning experiences (Kolb, 1984; Zimmerman, 2000).

4.4 Phase 4: Synthesis of Guidelines for Developing Learners through GPAAS

The final phase synthesized the practical guidelines from the expert interviews. The guidelines covered six areas: teaching materials and AI, interdisciplinary teaching, curriculum design, teacher development, the school learning

environment, and school policy. Table 7 shows the main recommendations and the number of experts who supported each area.

Table 7: Guidelines for developing learners through the gathering, processing, applying, articulating, and self-regulating (GPAAS) learning process

Guideline	Main recommendation	Expert Interview (EI)	
		Expert agreement	Representative expert statement
1. Teaching materials and AI	Develop varied learning materials and use AI to support critical learning. Technology should be used as a learning tool rather than a substitute for thinking.	2/4	EI3: <i>"Intelligence must go beyond simply knowing how to use AI."</i>
2. Interdisciplinary teaching	Develop continuous learning processes that connect subjects and support collaboration. Learning should also relate to important changes in society and the world.	3/4	EI4: <i>"A continuous and coordinated teaching process between subjects and within subjects is crucial."</i>
3. Curriculum design	Develop or adapt the school curriculum to support interdisciplinary learning and metacognition. The curriculum should help teachers understand clearly the expected learning processes and outcomes.	4/4	EI4: <i>"Teachers should have a clear picture of what they need to do with the children."</i>
4. Teacher development	Develop teachers' abilities to support advanced literacy, critical thinking, and suitable use of AI. Teacher development should also support a culture of thinking in schools.	4/4	EI2: <i>"We must cultivate a culture of thinking within schools and classrooms."</i>
5. School learning environment	Create a school learning environment that involves teachers, students, parents, administrators, and the community. A learning innovation center may also support continuous learning.	3/4	EI1: <i>"Creation of a school ecosystem that engages teachers, students, parents, administrators, and the community."</i>
6. School policy and administration	Develop academic strategies and school policies that support the learning process from classroom practice to the school level. Administrators should support teaching materials, instructional methods, curriculum development, and teacher development.	3/4	EI1: <i>"School administrators must be involved."</i>

Curriculum design and teacher development received the strongest agreement, with all four experts supporting these areas, emphasizing that the GPAAS learning process should relate to an interdisciplinary curriculum, metacognition, critical thinking, and changes in teachers' roles.

Three experts supported interdisciplinary teaching, the development of a school learning environment, and school-level policy, indicating that GPAAS implementation requires support beyond individual classroom activities. Cooperation among teachers, administrators, parents, and communities may allow for a more continuous operation of the learning process. Two experts specifically mentioned teaching materials and AI, but this lower level of agreement does not suggest that technology is unimportant; instead, the experts viewed technology as a supporting tool. The focus should remain on learners' thinking, self-regulation, communication, and ability to apply knowledge.

Overall, the guidelines suggest that GPAAS development should integrate curriculum, teaching, teacher development, the school setting, and administrative policy. While technology can support this process, it should not replace the main learning processes of observation, thinking, action, communication, and self-regulation.

5. Discussion

The EFA results should not be interpreted as demonstrating that all components were equally strong. The lower loadings for the items under the articulating component than for those under the other components may suggest that communication is a more complex process or that some items did not fully represent the intended component. Nevertheless, articulating remained theoretically important because explaining and exchanging ideas can help learners examine and refine their understanding. Further research may review or improve the items used to measure this component.

The CFA results also showed a significant association between the five domain-level indicators and the overall GPAAS learning process construct. Standardized loading ranged from .540 to .782, and the model showed a good fit with the empirical data. These findings support the view that gathering, processing, applying, articulating, and self-regulating are related parts of a broader learning process rather than separate learning skills.

The CFA results also support the domain-level coherence of the GPAAS model. However, this should not be construed as complete confirmation of the 25-item measurement structure. Future studies may conduct item-level CFA and examine whether the model operates similarly across regions, school types, or other learner groups. Among the five components, self-regulation carried the greatest statistical weight speaks to its foundational role in learning performance. Rather than acting as a static trait, self-regulation functions as the primary psychological engine through which learners plan, execute, and sustain their own intellectual growth (Zimmerman and Schunk, 2013). This aligns neatly with broader empirical evidence. In their meta-analysis, Hemmler and Ifenthaler (2024) demonstrated

that self-regulated learning strategies consistently drive achievement and efficiency across multiple metrics. Notably, they found moderate-to-strong positive links with engagement ($r = .39$), performance ($r = .36$), achievement motivation ($r = .30$), and overall satisfaction ($r = .30$), alongside a slight inverse relationship with task avoidance ($r = -.14$). Together, these insights underscore that self-regulation is an active, trainable competence that directly governs how effectively students navigate academic demands.

However, the loading results for applying neither elevates its importance over the other components nor suggests that it alone produces successful learning. Applying depends on the information collected during gathering and the understanding developed during processing and may also be improved through articulating and self-regulating. Therefore, the five components should be viewed as connected processes that support one another.

The qualitative findings and expert appraisal further suggest that in the GPAAS model, self-regulation may play two roles. Quantitatively, it was examined as the fifth component, linked to value creation and responsible knowledge use. Qualitatively, students and experts described monitoring, goal setting, reflection, and strategy adjustment within the other steps. This indicates that self-regulation may also support the other four components. This interpretation is consistent with self-regulated learning theory, which posits that learning is a repeated process of planning, monitoring, evaluating, and adjusting actions (Zimmerman, 2002).

These findings generally confirm that the GPAAS learning process is an integrated structure that explains how Grade 12 students gather information, construct understanding, apply knowledge, articulate meaning, and regulate their learning. This process may not always follow a fixed linear sequence as feedback from action and communication can cause learners to reconsider information, revise their understanding, and modify their learning strategies. The model's cyclical nature was mainly supported by the qualitative findings and expert interpretation rather than directly tested through cross-sectional factor analyses.

6. Conclusion

Overall, the findings provide empirical support for the utility of GPAAS as an original conceptual framework for understanding and designing learning processes that integrate information gathering, thinking, action, communication, and the responsible application of knowledge. Quantitative evidence from exploratory and confirmatory factor analyses (EFA and CFA) supports the proposed five-component structure, while qualitative evidence from in-depth interviews illustrates how these statistically identified dimensions are manifested in learners' observable behaviors in authentic learning situations. Furthermore, expert validation supports the accuracy, conceptual soundness, and practical relevance of the framework. Taken together, these complementary sources of evidence strengthen the interpretation of GPAAS as a theoretically grounded and empirically supported framework for examining and promoting comprehensive learning processes.

The originality of GPAAS lies in its representation of learning as a dynamic and recursive process rather than a fixed linear sequence. Learners may revisit earlier stages, reconsider their interpretations, and modify their actions in response to experience and feedback. Although self-regulation was identified as the fifth component, the qualitative findings indicate that its underlying processes—including goal setting, monitoring, reflection, and strategy adjustment—may function across and support the other four components. This cross-component role offers an important direction for further theoretical examination and empirical testing. In addition, the experts identified six priority areas for extending the framework's practical application: learning materials and artificial intelligence, interdisciplinary instruction, curriculum design, teacher professional development, school learning environments, and educational administration and policy.

6.1 Implications

6.1.1 Practical Recommendations

The five GPAAS components may serve as a guide for designing learning activities and assessment. Learning activities should encourage students to collect and examine information, construct knowledge through action, communicate their understanding, and reflect on their learning.

In addition, self-regulation should not be included only at the end of a lesson. Throughout the learning process, teachers may incorporate goal setting, progress monitoring, self-assessment, peer feedback, and revision. Simple teaching guides or lesson templates may help them connect learning objectives, activities, assessment, and the five GPAAS components. Professional development should also focus on how teachers design and facilitate the learning process and not only on how teaching techniques or digital tools are used. Coaching, lesson study, and professional learning communities may help teachers review and improve GPAAS-based lessons.

6.1.2 Policy Recommendations

For schools, GPAAS may be used as a common framework for integrating curriculum, classroom teaching, assessment, and student development. To this end, school administrators should provide time, materials, professional support, and collaboration opportunities for teachers.

The use of AI and other technologies should facilitate critical thinking and self-directed learning rather than replace students' thinking. Hence, school policies should emphasize responsible technology use, information evaluation, communication, and knowledge application for personal and social benefit. At the policy level, self-regulation and metacognition may be considered important competencies within curriculum and assessment guidelines, but the framework should be adapted to different school contexts rather than applied as a universal teaching approach.

6.1.3. Suggestions for further research

Future studies should perform item-level CFA to further examine the measurement structure of the 25-item questionnaire. Research should also

investigate reliability, convergent validity, discriminant validity, and measurement invariance across regions, school types, and student groups. Research may also benefit students with different achievement levels and from different educational levels. Longitudinal, experimental, or classroom-based studies may help explain how the five components develop and influence learning outcomes over time. Researchers may also use data from learning logs, student work, classroom observations, digital learning records, and performance-based tasks, which could provide a clearer understanding of how students transition between GPAAS components and engage in self-regulation during actual learning.

6.2 Limitations

This study has several limitations. First, it collected quantitative data through self-report questionnaires, which may have been influenced by participants' perceptions and socially desirable responses. Second, the qualitative phase included only eight high-achieving Grade 12 students, whose experiences may not represent learners from different academic backgrounds or school contexts. Fourth, the study used cross-sectional data; changes in the learning process over time or cyclical relations among the five components could not be directly examined. Finally, this study did not examine measurement invariance across regions, school types, and other groups. These issues should be considered when applying the findings to other learners and educational settings.

Conflict of Interest

The authors declare no conflicts of interest.

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Appendix 1

The questionnaire

1. Students stayed focused and attentive to gather key points while reading, listening, and learning in class.
2. Students set learning goals or activity objectives during classroom instruction.
3. Students utilized multiple senses—such as reading and listening—during classroom learning.
4. Students gathered data through notetaking, highlighting, using symbols, or employing tools to emphasize key information during class.
5. Students reflected on and carefully selected essential information during classroom learning.
6. Students categorized searches or collected data into distinct groups to simplify analysis and application.
7. Students organized information into categories for easier analysis and application.
8. Students compared and ordered information for easier analysis and application.
9. Students identified relationships and synthesized connections within the data for easier analysis and application.
10. Students critically evaluated, examined, and logically reflected on data before drawing conclusions for application.
11. Students evaluated their available options before making decisions and taking action.
12. Students applied knowledge synthesized from collected data to act creatively.
13. Students engaged in hands-on practice to deepen their understanding and master concepts.
14. Students employed critical thinking during hands-on activities to acquire new knowledge.
15. Students applied knowledge gained from practical tasks to other projects, subjects, or daily life.
16. Students communicated with themselves through self-listening, self-talk, reviewing notes, and writing summaries in their own words to maximize task outcomes.
17. Students communicated with others through listening, speaking, reading, and writing to maximize work efficiency.
18. Students interpreted, translated, expanded upon, and summarized knowledge they constructed individually or collaboratively.
19. Students presented or discussed results to synthesize ideas from practical experience into core concepts or best practices for themselves and others.
20. Students are engaged in social communication by exchanging information and opinions with individuals and organizations to foster mutual understanding of knowledge, ideas, attitudes, and behaviors leading to positive change.
21. Students monitored and controlled their thoughts to prevent actions that misused their knowledge.
22. Students monitored and controlled their thoughts to share knowledge with society and those around them.

23. Students monitored and controlled their thoughts to direct themselves toward using knowledge for the benefit of society and others.
24. Students monitored and controlled their thoughts to cultivate values centered on using knowledge to benefit society and others.
25. Students monitored and controlled their thoughts to build habits of using knowledge for the benefit of society and others.