Publicaciones. Facultad de Educación y Humanidades del Campus de Melilla
Depósito legal: GR-94-2001 · eISSN: 2530-9269 · pISSN: 1577-4147
Editor: Facultad de Ciencias de la Educación y del Deporte de Melilla (Universidad de Granada)

Relationships between Metacognition, Learning Strategies, and Emotions in Colombian University Students

Relaciones entre la metacognición, las estrategias de aprendizaje y las emociones en estudiantes universitarios colombianos

Взаимосвязь между метапознанием, стратегиями обучения и эмоциями у студентов университета

大学生元认知、学习策略与情绪的关系

John Jairo Briceño-Martínez
Antonio Nariño University (Colombia)
decano.educacion@uan.edu.co
https://orcid.org/00000-0002-2285-8396

Fernando Barrios-Aguirre
Business School, Konrad Lorenz University Foundation (Colombia)
fernando.barriosa@konradlorenz.edu.co
https://orcid.org/0000-0001-9577-3329

Martha Patricia Castellanos Saavedra
University Foundation of the Andean Area (Colombia)
mpcastellanos@areandina.edu.co
https://orcid.org/0000-0002-4233-2762

Dates · Fechas

Received: 2024-02-10
Accepted: 2024-06-15
Published: 2024-07-01

How to Cite this Paper · Cómo citar este trabajo

Briceño-Martínez, J. J., Barrios-Aguirre, F., & Castellanos, M. P. (2024). Relationships between Metacognition, Learning Strategies, and Emotions in Colombian University Students. *Publicaciones, 54*(1), 259–280. https://doi.org/10.30827/publicaciones.v54i1.27736

Abstract

The study of the relationships between metacognition, learning strategies, and positive and negative emotions is an emerging line of research that has been scarcely explored. This article aims to discuss the relationship among these variables in 1,096 university students from different academic programs at a Colombian university. We conducted a principal component analysis to reduce the dimensions represented in the items of the instruments administered and applied structural equation modeling to elucidate the existing interrelationships among the three variables under investigation. The results demonstrate a positive relationship between metacognition and learning strategies and between learning strategies and positive academic emotions. In contrast, negative academic emotions negatively correlate with learning strategies and metacognition. In brief, metacognition promotes learning strategies, while negative academic emotions discourage them.

Keywords: metacognition, learning strategies, academic emotions, learning perspective, student perceptions, higher education.

Resumen

El estudio de las relaciones entre la metacognición, las estrategias de aprendizaje y las emociones tanto positivas como negativas es una línea emergente de investigación que ha sido escasamente explorada. En consecuencia, el objetivo de este trabajo es el de analizar la relación entre estas variables mencionadas, en 1096 estudiantes universitarios pertenecientes a diferentes programas académicos de una institución de educación superior colombiana. Para lo anterior, se realizó un análisis factorial por componentes principales para la reducción de dimensiones representados en los ítems de los instrumentos usados y se aplicó el modelado de ecuaciones estructurales (SEM) para explicar las interrelaciones existentes entre las tres variables indagadas. Los resultados demuestran que hay una relación positiva entre la metacognición con las estrategias de aprendizaje y estas a su vez con las emociones académicas positivas. Por el contrario, las emociones académicas negativas tienen una relación negativa con las estrategias de aprendizaje y la metacognición, lo que nos lleva a concluir que la metacognición fomenta las estrategias de aprendizajes y las emociones académicas negativas lo desalientan.

Palabras clave: metacognición, estrategias de aprendizaje, emociones académicas, perspectiva de aprendizaje, percepciones de los estudiantes, educación universitaria.

Аннотация

Цель данной статьи - проанализировать взаимосвязь между метапознанием, стратегиями обучения и академическими эмоциями 1096 студентов, обучающихся по различным академическим программам в одном из вузов Колумбии. Для этого был проведен факторный анализ главных компонентов, чтобы сократить количество измерений, представленных в пунктах используемых инструментов, и было применено моделирование структурных уравнений (SEM) для объяснения взаимосвязей между тремя исследуемыми переменными. Результаты показывают, что существует положительная связь между метапознанием и стратегиями обучения, а те, в свою очередь, с положительными академическими эмоциями; напротив, отрицательные академические эмоции имеют отрицательную связь со стратегиями обучения и метапознанием, что позволяет сделать вывод о том, что метапознание поощряет стратегии обучения, а отрицательные академические эмоции препятствуют этому.

Ключевые слова: метакогниция, стратегии обучения, академические эмоции, перспектива обучения, представления студентов, университетское образование.

概要

本文的目的是分析哥伦比亚高等教育机构不同学术项目的 1096 名大学生的元认知、学习策略和学术情绪之间的关系。对于上述情况，研究进行了主成分因子分析，以减少所用仪器项目所表示的维度，并应用结构方程模型（SEM）来解释所研究的三个变量之间的相互关系。结果表明，元认知与学习策略之间存在正相关关系，而学习策略又与积极的学业情绪之间存在正相关关系；相反，负学习情绪与学习策略和元认知之间存在负相关关系，这使我们得出元认知促进学习策略的结论。负面的学术情绪会阻碍它。

关键词：元认知、学习策略、学术情绪、学习视角、学生感知、大学教育。

Introduction

Interest in understanding how university students learn has increased considerably (Guterman & Neuman, 2022). Universities have begun promoting critical reflection and awareness (metacognitive skills) among teachers regarding students' progress and setbacks in their learning processes (Ochoa-Sierra & Moya-Pardo, 2019). Other authors recommend that to improve academic performance, students, on the one hand, know and choose the learning strategies that work best for them when preparing, for example, for an exam (Brady et al., 2021), and, on the other, recognize the importance of their emotions to improve their understanding of the contents of a subject (Pekrun, 2021).

For some researchers, such as Broadbent (2017), Magno (2010), and Wilson (2021), the development of metacognitive skills means being aware of learning strategies and emotions. For others (Aizpurua et al., 2018; Bjork et al., 2013; Samuelowicz & Bain, 2001), using the most appropriate learning strategies to learn better will require exercising control over cognitive, metacognitive, and emotional processes. The limits of these investigations' approaches are difficult to define. Although they are closely related in how the student achieves better learning outcomes, it is difficult to establish the differences or correspondences between these terms (metacognition, learning strategies, and emotions) in the available literature (Ramirez-Arellano et al., 2018). For these authors, discussing each aspect separately limits the scope of this type of study; however, it has been done this way, and thus, it is the empirical basis of most publications.

In the literature, some works have managed to relate two of the variables involved in this research, either analyzing the influence of emotions on metacognition or determining the influence of these two variables on learning strategies (Acosta-Gonzaga & Ramirez-Arellano, 2021; Artino & Jones, 2012). To a lesser extent, as far as the authors have been able to verify, some articles have barely confirmed correspondence between the data collected using various instruments with the theoretical proposals relating three or more variables, including metacognition, learning strategies, and emotions (Acosta-Gonzaga & Ramirez-Arellano, 2021; Efklides, 2011; Ekatushabe et al., 2021; Ramirez-Arellano et al., 2018, 2019). In summary, the relational analysis between the approaches mentioned is an emerging line that must be increasingly developed. This study adds to the limited research base on the topic.

Specifically, three instruments were administered to 1,097 university students: the metacognitive awareness inventory (MAI) (Huertas et al., 2014; Schraw & Dennison, 1994), the learning strategies instrument by Gargallo et al. (2009), and the achievement emotions questionnaire oriented solely toward study or learning (Pekrun et al., 2005), as adapted to the university context by Sánchez-Rosas (2015), which assesses three positive (enjoyment, hope, pride), and five negative (anger, anxiety, shame, hopelessness, and boredom) emotions. Descriptive statistics were employed to analyze the students' perceptions of each instrument, and structural equation modeling (SEM) was used as a multivariate technique to test and evaluate multivariate causal relationships (Byrne, 2011) involving emotions, metacognition, and learning.

Relationships between metacognition, learning strategies, and emotions

Metacognition means thinking about one's thoughts (Versteeg et al., 2021). It is the knowledge of one's cognition and consciousness to exercise control (self-regulation) of cognitive processes (Flavell, 1976). Some authors define it as the skills that allow students to monitor their cognition, including judgments, perceptions, memory, and reasoning (Rhodes, 2019; Schraw & Moshman, 1995). The planning, monitoring, and execution of actions students can perform to achieve better learning outcomes are known as metacognitive skills (Pintrich et al., 2000; Roberts, 2021). Evaluating and regulating what has been understood from reading an academic text is monitoring the understanding of that cognitive process (Bol & Hacker, 2012; Connor et al., 2019).

Learning strategies also affect university students' learning (McDaniel & Einstein, 2020). The academic interest in what strategies university students use lies in the fact that if they learn to use the most effective ones, they will be able to develop lifelong learning (McDaniel et al., 2021). For example, students will achieve better if they know how the teacher will evaluate a topic.

From the same perspective, studies on positive (pride, hope, etc.) or negative (boredom, hopelessness, etc.) academic emotions have determined that these become catalysts or inhibitors of outcomes in school performance (Pekrun et al., 2011). Learning, therefore, depends on the emotions that students are experiencing in each particular situation and positively or adversely influence the outcome of a specific task (Chin et al., 2017); for instance, if a student feels desperate because they do not understand the class topics, they may get low grades.

Focusing on studies that address the relationship between metacognition and learning strategies, it has been found that both variables influence students' school performance and learning outcomes (Chang et al., 2021; Ebomoyi, 2020). However, it is not very clear how either of the two can positively impact the other (Zhao et al., 2019). For some authors (Erbas, 2012; Sáiz-Manzanares & Montero-García, 2015), knowing how to choose the most appropriate metacognitive skills (how to plan or evaluate) will favor "problem-solving" (learning strategy). The idea underlying this approach is that if the student evaluates each step that can lead to understanding the problematic statement, they can decide the best strategy to solve it. Other authors have argued that learning strategies are an intermediary between metacognition and academic performance (Vrugt & Oort, 2008). If the student knows how to choose what is required to pass an exam (learning strategy), they can plan and control how to take the best actions to achieve it (metacognitive skill). The debate about which variable affects the other has even been expanded by introducing others, such as emotions.

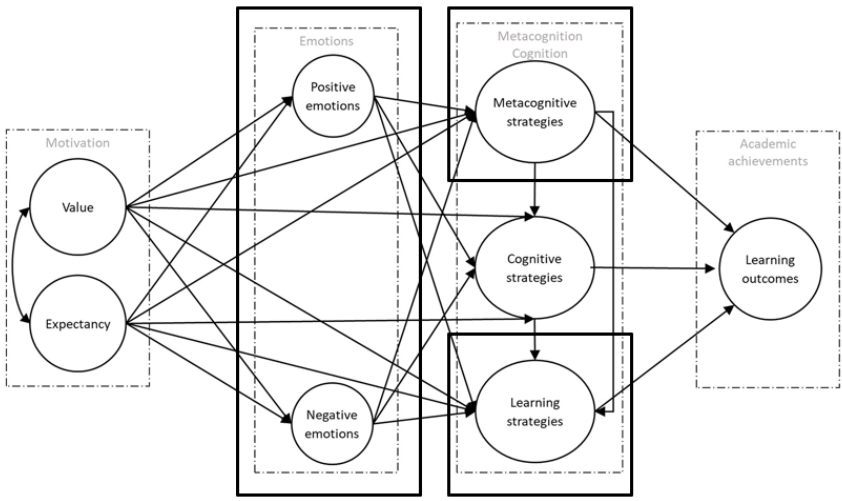
Accordingly, research on the relationships between metacognition and emotions (González et al., 2017) has found that the latter have either a positive or negative effect

on learning outcomes. The first proposal, which also has the greatest consensus in the current literature on the subject, maintains that students in whom positive emotions predominate may be more aware of their metacognitive abilities (Hayat et al., 2020); that is, they better recognize their abilities to reflect, evaluate, and take control of their learning (Hertel & Karlen, 2021). This has also been confirmed by articles about the influence of positive emotions on students' most appropriate choices regarding their learning strategies (Karlen et al., 2021). If they learn to identify which strategies are the most effective for improving academic performance, they will experience more positive emotions and learn to make higher-quality assessment judgments about their academic processes (Cervin-Ellqvist et al., 2021). On the contrary, negative emotions have been found to adversely affect the metacognitive process and the right selection of the best strategies for learning (Price et al., 2018).

Moreover, few studies have analyzed more than three variables in a study and developed theoretical proposals to see whether student data matches these conceptual approaches. These models have been fed, of course, by many of the constructs established in the works described above, among many others. Efklides (2011) advanced a regulated learning model and explained the linkage between cognition, metacognition, and emotions. For this author, students' strategies are determined by their metacognitive skills, motivation, and emotions when carrying out academic activities (Acosta-Gonzaga & Ramirez-Arellano, 2021).

Figure 1

Hypothetical causal model: Factors affecting student learning performance



Note. Taken from ¨ Factors affecting student learning performance: A causal model in higher blended education ¨ by A. Ramirez-Arellano, E. Acosta-Gonzaga, J. Bory-Reyes, L. M., & Hernández-Simón, 2018, Journal of Computer Assisted Learning, 34(6).

Another hypothetical model (Ramirez-Arellano et al., 2018) confirms that the relationship between emotions, metacognition, and learning strategies affects learning outcomes positively or adversely (Figure 1), among other elements such as motivation and cognitive strategies, which are not considered in this research. Ramirez-Arellano et al. (2018), who evaluate a pedagogical intervention in a blended learning context,

barely verified this theoretical relationship with the data they obtained in their research. They found a relationship between metacognition and learning strategies, but there is no significant relationship between the latter and positive emotions because the negative emotions that students experience are more significant. This did not occur in the research by Acosta-Gonzaga and Ramirez-Arellano (2021), whose results showed an impact of positive emotions on strategies and metacognition.

Study objectives

To analyze university students' perceptions of metacognition, learning strategies, and emotions.

To study the relationships between university students' metacognition, learning strategies, and positive and negative emotions.

Research questions

1. What are college students' perceptions of metacognition, learning strategies, and emotions?
2. What relationships can be determined between university students' metacognition, learning strategies, and positive and negative emotions?

Hypothesis

Alternative hypothesis (H1): There is a positive and significant relationship between university students' level of metacognition, use of effective learning strategies, and positive emotions.

Null hypothesis (H0): There is no significant relationship between university students' level of metacognition, use of effective learning strategies, and negative emotions.

Materials and Methods

This research has a non-experimental cross-sectional design where quantitative data are collected simultaneously. Specifically, there was a battery of questions contained in three instruments: a) metacognitive skills, with 52 items (Huertas et al., 2014; Schraw & Dennison, 1994); b) learning strategies of university students, with 88 items (Gargallo et al., 2009), and c) positive and negative academic emotions toward studying or learning, with 75 items (Pekrun et al., 2005, as adapted by Sánchez-Rosas, 2015).

Participants

We worked with a convenience sample of 1,097 students from the Fundación Universitaria del Área Andina (Bogotá-Colombia), an accredited, high-quality university in the Colombian context that offers undergraduate programs, specializations, and

master's degrees in distance, virtual and in-person modes. The sample (1,097) corresponds to the universe of 34,141 students, with a confidence level of 95 % and an allowable sampling error of 2.9 %. The average age of the participants was 29 years, with a dispersion of nine years and a range of 4–63 years. The respondents belonged to the following disciplines: management (41.02 %; 450), health, including nursing and medicine (21.42 %; 235), education (14.31 %; 157), psychology (13.49 %; 148), engineering and design (5.93 %; 65), and law (3.83 %; 42). The participants were from all semesters (1 to 10).

Instruments

The three instruments used in this study are of a Likert scale type, with the following response options: 1—strongly disagree; 2—disagree; 3—neither agree nor disagree; 4—agree; strongly agree. They are described below.

The first questionnaire found in the publications by Huertas et al. (2014) and Schraw and Dennison (1994) contain aspects related to metacognitive skills. It involves two scales distributed in 52 items. The knowledge of cognition scale is composed of declarative knowledge (items 5, 10,12, 16, 17, 20, 32, 46), procedural knowledge (items 3,14, 27, 33), and conditional knowledge (items 15, 18, 26, 29, 35). The second scale is the regulation of cognition comprising planning (items 4, 6, 8, 22, 23, 42, 45), information management (items 9, 13, 30, 31, 37, 39, 41, 43, 47, 48), monitoring (items 1, 2, 11, 21, 28, 34, 49), debugging (items 25, 40, 44, 51, 52), and evaluation (items 7, 19, 24, 36, 38, 50). Cronbach's alpha was calculated for scale 1 (.898), scale 2 (.939), and the total data (.848), confirming its reliability.

The second instrument, published by Gargallo et al. (2009), assesses learning strategies in 88 items distributed in two scales. The first is about affective strategies of support and control, including motivational strategies (items 1 to 20), affective strategies (items 21 to 28), metacognitive strategies (items 29 to 43), and context control, social interaction, and resource management strategies (items 44 to 53). The second comprises strategies related to information processing, including information search and selection (items 54 to 61) and information processing and use (items 62 to 88). Cronbach's alpha was .903 for the first scale and .9194 for the second. Compared to the total results, the alpha was .934, which makes the instrument reliable for this study.

Finally, the third instrument (Pekrun et al., 2005), translated into Spanish by Sánchez-Rosas (2015), covers academic emotions toward studying or learning, that is, positive perceptions: enjoyment (items 1 to 10), hope (items 11 to 16), and pride (items 17 to 22), and negative perceptions: anger (items 23 to 31), anxiety (items 32 to 42), shame (items 43 to 53), hopelessness (items 54 to 64), and boredom (items 64 to 75). The instrument is reasonably reliable; Cronbach's alpha was .940 for positive emotions, .9772 for negative emotions, and .955 for the total data.

Procedure

The three instruments were uploaded to a Google form, adding questions about the semester, program, and age. The link was sent to the students' institutional emails, specifying that their anonymity was guaranteed. They had the permission of lecturers to answer the battery of items during or after class, as the participants decided best.

Since the researcher was authorized by the institution's research office and supported by the Academic Vice-President's Office, we could guarantee that the participants had the necessary time (approximately one to two hours) to answer the questions of the mentioned instruments calmly and assertively. The research naturally meets the ethical requirements for this study.

Data analysis

Descriptive statistics were employed to characterize the participants and analyze the results in each variable investigated: metacognition, learning strategies, and emotions with the SPSS 26 software (statistical package for social sciences). Subsequently, Stata 17 principal component analysis and SEM were used to validate the multivariate causal relationship between metacognition, learning strategies, and emotions. Based on the results obtained after administering the three instruments to 1097 students, exploratory factor analysis was performed using the principal component extraction method and varimax rotation to narrow down the dimensions of the items to four latent variables or indices that describe metacognitive skills, learning strategies, and positive and negative emotions. Finally, the SEM was built with these indices to establish the relationship between the variables based on covariances and their statistical significance. Likewise, confirmatory factor analysis (CFA) was conducted with four latent variables available, examining their relationships with the components resulting from the exploratory analysis. The CFA allows assessing the measurement model, which refers to the external part of the model; that is, it evaluates the relationship between the latent variables and their indicators. Assessing the measurement model means measuring how well the latent variable reflects its indicators. Ultimately, we considered SEM in Stata with the maximum likelihood estimation because it is the most used method in the literature to find predicted relationships. We included the support of the SEM model in the covariance analysis, residual normality, and relationship linearity.

Results

Metacognition

Table 1 identifies the means for the aspects related to metacognition, highlighting that the item with the highest rating is 46: "I learn more when I am interested in the topic" (M = 4.399), closely followed by 52: "I stop and reread when I get confused" (M = 4.335). The generality of the results in all the items is that they were rated above M = 3.397, which indicates that the students highly value metacognition. Item 48: "I focus on overall meaning rather than specifics" is striking, as students perceive that they pay more attention to general or global aspects than the depth of topics. Another item worth emphasizing is 19: "I ask myself if there was an easier way to do things after I finish a task" (M = 3.525). Students may need more assistance knowing the best study paths to achieve better results.

Table 1

Descriptive statistics by item of metacognition

Item	Mean	*SD*	Item	Mean	*SD*
1	4.133	.82	27	4.111	.726
2	4.231	.631	28	3.889	.807
3	4.192	.68	29	4.093	.733
4	4.07	.775	30	4.104	.648
5	4.222	.7	31	4.007	.829
6	4.008	.834	32	4.285	.61
7	3.742	.831	33	3.967	.772
8	3.995	.758	34	4.107	.737
9	4.219	.625	35	3.81	.816
10	4.057	.748	36	3.881	.828
11	3.98	.754	37	3.618	1.082
12	3.993	.752	38	3.861	.848
13	4.06	.69	39	4.197	.664
14	3.989	.704	40	3.974	.752
15	4.262	.721	41	4.018	.743
16	3.778	.922	42	4.212	.632
17	3.76	.878	43	4.078	.704
18	4.049	.733	44	4.003	.723
19	3.525	1.029	45	4.036	.806
20	4.262	.649	46	4.399	.738
21	3.866	.844	47	3.926	.816
22	3.732	.935	48	3.397	.942
23	4.053	.717	49	4.06	.701
24	3.682	1.002	50	3.992	.753
25	4.242	.747	51	4.202	.66
26	4.222	.685	52	4.335	.655

Note. SD: standard deviation.

Learning strategies in university students

Table 2 organizes the results of the means for learning strategies. The learning indicator best valued by the sample is related to the need to study with an interest in learning (item 3; *M* = 4.678). Before analyzing the worst rated, it should be noted that

items 12: "My academic performance depends on luck" (*M* = 1.723), 13: "My academic performance depends on teachers" (*M* = 2.811); 20: "You are either intelligent or not, and intelligence cannot be improved" (*M* = 2.063), 34: "I only study before exams" (*M* = 2.466), and 78: "To learn things, I limit myself to repeating them over and over again" (*M* = 2.457) can be considered distractors that should have ratings below *M* = 3 (totally disagree and disagree), which happened.

Discarding the previous items, the worst rated were items 5: "I need other people—parents, friends, teachers, etc.—to encourage me to study" (*M* = 2.355) and 56: "I know how to use the newspaper archive and find the articles I need" (*M* = 2.954). Item 37: "When I see that my initial plans do not succeed as expected in my studies, I change them for others more appropriate" (*M* = 3.672), is similar in its wording and structure to item 19 of the metacognition instrument (*M* = 3.525), and both were assessed without statistically significant differences. Undoubtedly, it is a clear generalized perception of the students about their need to be trained to face difficulties in learning specific contents they study in class, which could suggest that when they do poorly in their studies, they do not know how to face the situation.

Table 2

Descriptive statistics by item of learning strategies

Item	Mean	SD	Item	Mean	SD
1	4.444	.739	45	3.93	.928
2	4.642	.681	46	4.062	.793
3	4.678	.633	47	4.075	.762
4	3.134	1.347	48	3.686	1.007
5	2.355	1.239	49	3.914	.882
6	4.606	.625	50	3.977	.968
7	4.467	.691	51	4.22	.762
8	4.362	.727	52	3.855	1.021
9	4.63	.557	53	4.005	.911
10	4.591	.64	54	3.997	.826
11	4.163	.864	55	3.418	1.066
12	1.723	.864	56	2.954	1.162
13	2.811	1.145	57	4.027	.831
14	4.356	.694	58	4.088	.711
15	4.013	.849	59	3.28	1.072
16	4.29	.607	60	3.908	.762
17	4.464	.612	61	4.085	.712
18	4.3	.645	62	4.17	.636
19	4.388	.643	63	4.228	.671

Item	Mean	SD	Item	Mean	SD
20	2.063	1.097	64	4.356	.617
21	4.1	.823	65	4.276	.688
22	3.301	1.118	66	4.215	.703
23	3.911	.874	67	3.987	.854
24	4.084	.74	68	4.104	.684
25	3.302	1.133	69	3.775	.976
26	3.134	1.261	70	4.06	.867
27	3.117	1.255	71	3.758	.988
28	3.49	1.006	72	4.013	.73
29	4.161	.655	73	4.094	.678
30	4.006	.819	74	4.074	.701
31	4.17	.686	75	3.919	.764
32	4.077	.779	76	4.028	.669
33	4.083	.737	77	3.163	1.178
34	2.466	1.048	78	2.457	1.056
35	3.645	1.01	79	3.643	1.008
36	3.961	.763	80	3.669	1.001
37	3.672	.98	81	4.093	.756
38	4.004	.751	82	3.346	1.123
39	3.681	.766	83	3.984	.788
40	3.992	.863	84	4.129	.689
41	4.149	.744	85	3.758	.901
42	4.402	.628	86	4.25	.692
43	4.343	.657	87	4.237	.609
44	3.992	.929	88	4.263	.607

Emotions

Table 3 shows the means and standard deviations of positive (enjoyment, hope, and pride) and negative (anger, anxiety, shame, hopelessness, and boredom) academic emotions toward studying or learning. We found that the mean values for positive emotions are above 4, except item 4: "I study more than necessary because I enjoy it a lot" (M = 3.65), which obtained a lower mean, showing that studying is not entirely enjoyable for some students. For negative emotions, the perceptions are primarily "totally disagree" and "disagree" (as they should be). However, attention is paid to the items that obtained means higher than 3 (Likert scale: agree and totally agree); for example,

item 41: "I worry if I have understood the material well" and item 42: "When I cannot keep up with my studies, I feel afraid." The values above 2.9, such as item 39: "As the study time runs out, my heart begins to accelerate," are also interesting. Overall, the data reveal positive emotions have better values and, therefore, a favorable impact on learning, while negative emotions worry students more and can affect their academic performance. The SEM will later evaluate and corroborate these aspects.

Table 3

Descriptive statistics by item of academic emotions toward studying or learning

Item	Emotion	Mean	SD	Item	Emotion	Mean	SD
1	Enjoyment	4.239	.822	39	Anxiety	2.935	1.3
2	Enjoyment	4.309	.653	40	Anxiety	2.578	1.25
3	Enjoyment	4.534	.584	41	Anxiety	3.311	1.181
4	Enjoyment	3.65	.96	42	Anxiety	3.485	1.215
5	Enjoyment	4.119	.749	43	Shame	2.934	1.286
6	Enjoyment	4.711	.528	44	Shame	1.91	1.014
7	Enjoyment	4.733	.519	45	Shame	2.477	1.236
8	Enjoyment	4.549	.657	46	Shame	2.405	1.254
9	Enjoyment	4.253	.815	47	Shame	2.458	1.234
10	Enjoyment	4.364	.678	48	Shame	2.568	1.27
11	Hope	4.286	.71	49	Shame	2.349	1.186
12	Hope	4.123	.746	50	Shame	2.808	1.284
13	Hope	4.277	.679	51	Shame	2.29	1.133
14	Hope	4.243	.734	52	Shame	2.222	1.103
15	Hope	4.295	.728	53	Shame	2.358	1.226
16	Hope	4.447	.672	54	Hopelessness	1.902	.959
17	Pride	4.336	.718	55	Hopelessness	2.039	1.096
18	Pride	4.352	.702	56	Hopelessness	2.148	1.156
19	Pride	4.457	.703	57	Hopelessness	1.909	.99
20	Pride	4.536	.671	58	Hopelessness	2.146	1.162
21	Pride	4.432	.712	59	Hopelessness	1.638	.923
22	Pride	4.415	.714	60	Hopelessness	1.929	1.089
23	Anger	1.909	.999	61	Hopelessness	1.873	.958
24	Anger	1.943	1.003	62	Hopelessness	1.756	.945
25	Anger	2.008	1.047	63	Hopelessness	1.784	.949
26	Anger	1.718	.88	64	Hopelessness	2.399	1.321

Item	Emotion	Mean	SD	Item	Emotion	Mean	SD
27	Anger	1.795	.931	65	Boredom	2.049	1.084
28	Anger	1.665	.843	66	Boredom	2.083	1.066
29	Anger	1.634	.898	67	Boredom	1.925	.933
30	Anger	2.098	1.127	68	Boredom	1.637	.809
31	Anger	1.874	.981	69	Boredom	1.637	.833
32	Anxiety	2.718	1.162	70	Boredom	1.858	.977
33	Anxiety	1.995	1.001	71	Boredom	1.803	.945
34	Anxiety	1.773	.897	72	Boredom	2.464	1.245
35	Anxiety	2.002	1.04	73	Boredom	1.984	1.045
36	Anxiety	2.838	1.272	74	Boredom	1.879	.958
37	Anxiety	2.707	1.214	75	Boredom	1.964	1.049
38	Anxiety	2.692	1.238				

Theoretical measurement model

Subsequently, to verify the instruments' construct validity (factorial structure), an exploratory factor analysis (Table 4) was performed using principal component extraction and varimax rotation. Reducing dimensions by principal component resulted in ten learning components: four for metacognition, 3 for positive emotions, and four for negative emotions. This allowed us to define positive emotions (PCEP), negative emotions (PCEN), learning strategies (PCA), and metacognition (PCM) indices. The descriptions are shown below.

Table 4

Exploratory factor analysis results

Variable	Obs	Mean	SD	Min	Max
Principal components					
pca1	1097	0	2.705	-14.045	5.766
pca2	1097	0	2.563	-18.845	5.953
pca3	1097	0	2.348	-14.09	5.851
pca4	1097	0	2.067	-7.186	4.266
pca5	1097	0	1.843	-7.757	3.697
pca6	1097	0	1.753	-15.235	3.084
pca7	1097	0	1.743	-8.529	4.287
pca8	1097	0	1.722	-4.661	6.876
pca9	1097	0	1.616	-4.674	4.955

Variable	Obs	Mean	SD	Min	Max
pca10	1097	0	1.574	-6.232	4.017
pcm1	1097	0	2.924	-12.612	6.911
pcm2	1097	0	2.528	-15.285	6.433
pcm3	1097	0	2.486	-14.073	5.335
pcm4	1097	0	1.587	-6.933	4.138
pcepos1	1084	0	2.358	-13.635	3.394
pcepos2	1084	0	2.029	-13.277	5.307
pcepos3	1084	0	1.899	-14.55	3.176
pceneg1	1092	0	3.484	-5.281	11.679
pceneg2	1092	0	2.984	-4.239	12.155
pceneg3	1092	0	2.883	-4.407	11.028
pceneg4	1092	0	2.226	-5.913	7.126
Indices					
PCA	1097	0	1.136	-4.82	3.573
PCM	1097	0	2.015	-10.742	4.449
PCEP	1084	0	1.818	-10.787	2.376
PCEN	1092	0	2.439	-3.862	9.532

Building on the previous exploratory analysis results, the theoretical measurement model was formulated, maintaining the structure of four first-order factors and comprising 21 items (Figure 2 and Appendix 1). The results of the SEM covariances in Figure 2 support the positive relationships between positive emotions and metacognition, positive emotions and learning strategies, and metacognitions and learning. For their part, negative emotions adversely affect learning and metacognition. Hence, it can be stated that metacognition promotes learning strategies, and negative emotions discourage it (Table 5).

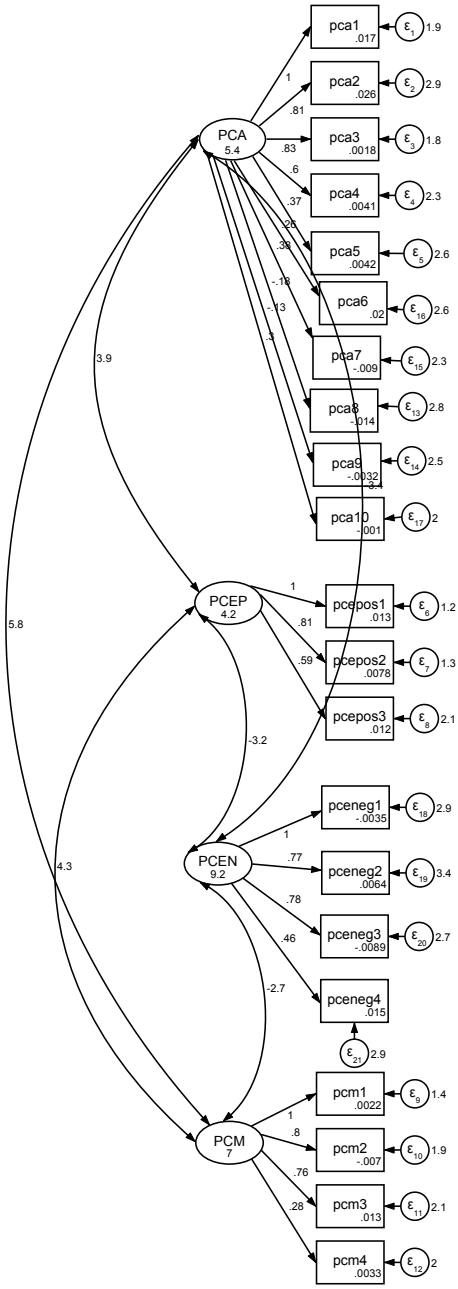
Table 5

Relationships between emotions, learning, and metacognition

Relationships between variables according to SEM		Relationship type
Positive emotions index	Metacognition index	Positive
Positive emotions index	Learning strategies index	Positive
Negative emotions index	Metacognition index	Negative
Negative emotions index	Learning strategies index	Negative
Metacognition index	Learning strategies index	Positive

Figure 2

Structural equation modeling (SEM)



Note. PCEP: positive emotions index; PCEN: negative emotions index; PCA: learning strategies index; PCM: metacognition index.

Confirmatory factor analysis

The CFA was conducted, and the fit, consistency, and convergent and discriminant validity were verified. To do this, the instruction was provided to Stata like this: sem (PCA -> pca1 pca2 pca3 pca4 pca5 pca6 pca7 pca8 pca9 pca10) (PCM -> pcm1 pcm2 pcm3 pcm4) (PCEP-> pcepos1 pcepos2 pcepos3) (PCEN -> pceneg1 pceneg2 pceneg3 pceneg4); "sem, standardized". From the maximum likelihood estimation, this confirms that all the variables associated with each latent variable were significant in both the SEM and the normalized SEM. The instructions were stat gof, stat(all), stat mindices, and condisc.

Concerning the model's fit to the data, the comparative fit index (CFI) is .777, and the Tucker-Lewis index is .744, indicating that the model is 77.7–74.4 % better than the null model, which assumes no correlation between the indicators. Although the root mean square error of approximation (RMSEA) is .125 and the standardized root mean square residual (SRMR) is .108, the coefficient of determination is .998. In brief, there are reasons to consider that the model fits.

Discussion and Conclusions

The first descriptive analysis of the student's perceptions of the three variables investigated in the questionnaires determined that some items demonstrate the need for students to be assisted and trained to face negative emotions, such as fear of not being able to complete their tasks or their concerns toward understanding the topics covered in classes, which will, of course, require learning to manage their learning strategies better (McDaniel et al., 2021). It is vital that students can respond, for instance, to a change in plans when those initially proposed do not work to obtain good learning outcomes, for which teachers must be prepared.

Few studies in the research literature examine the role of metacognition, learning strategies, and academic emotions in higher education settings. Furthermore, little research has yet explored the temporal relationships between the variables investigated in this study involving university students (Acosta-Gonzaga & Ramirez-Arellano, 2021; Efklides, 2011; Ramirez-Arellano et al., 2018; 2019).

Therefore, the second analysis in the present study aimed to explore whether there is a relationship between learning strategies, metacognitive skills to face their learning, and academic emotions toward studying. The model and instruments proposed by Efklides (2011), Pekrun et al. (2011), Ramirez et al. (2018), and Ramirez-Arellano et al. (2019) were used as a theoretical basis. Based on the SEM results, we can affirm that positive relationships exist between positive emotions and metacognition, positive emotions and learning strategies, and metacognition and learning. Meanwhile, negative emotions adversely affect learning and metacognition. In conclusion, metacognition promotes learning strategies, and negative emotions discourage or disfavor it.

The internal consistency measured with Cronbach's alpha is greater than .8 for the three instruments used, which shows that they are pretty reliable in supporting the results of this study. Regarding convergent validity, the factor loadings are significant and greater than .5. In terms of discriminant validity, the compared correlations, except for PCA, between latent variables with the square root of the AVE are lower. This means that the factor analyzes and validates the structural model where the hypotheses about the relationships between the variables in this research were represented.

These results may reflect the importance of using metacognitive skills, learning strategies, and positive emotions to promote learning (Celik, 2022). For example, students who enter the courses taught with a generally more positive attitude and emotion toward the classes can achieve better learning, although the latter has not been proven in this study. Still, other works (Ekatushabe et al., 2021) have shown that effects can be achieved on learning outcomes when the relationships are positive between the mentioned variables.

Thus, these findings can practically suggest that the emotional states that students bring with them to their classes have a high or low impact on their learning, which can translate into efforts that the teacher will need to make in the classroom to encourage the most appropriate emotions (positive) for the student to face their learning processes with greater confidence (Pekrun, 2021). Therefore, students—with appropriate support from a tutor/teacher—can adopt more adaptive coping strategies to dissipate negative emotions.

Lastly, understanding this process is the first in a series of steps to discovering training and support strategies to meet students' educational needs more adequately. In investigating the relationships between these factors, we hope to discover ways to cope with negative emotions and maintain students' positive affect. The present study's findings imply that this can be achieved through teaching methodologies that give greater relevance to metacognition and learning strategies and establish more concrete connections between emotions and personal and professional goals.

Acknowledgments

To Fundación Universitaria del Areandina for financing the research project from which this article arises: Building Future Scenarios for Higher Education, code: CV2023-ET-B-12988.

Conflict of interests

This research has no conflicts of interest.

References

Acosta-Gonzaga, E., & Ramirez-Arellano, A. (2021). The Influence of Motivation, Emotions, Cognition, and Metacognition on Students' Learning Performance: A Comparative Study in Higher Education in Blended and Traditional Contexts. *SAGE Open*, *11*(2). https://doi.org/10.1177/21582440211027561

Aizpurua, A., Lizaso, I., & Iturbe, I. (2018). Estrategias de aprendizaje y habilidades de razonamiento de estudiantes universitarios. *Revista de Psicodidáctica*, *23*(2), 110–116. https://doi.org/https://doi.org/10.1016/j.psicod.2018.01.001

Artino, A. R., & Jones, K. D. (2012). Exploring the complex relations between achievement emotions and self-regulated learning behaviors in online learning. Internet and Higher Education, *15*(3), 170–175. https://doi.org/10.1016/j.iheduc.2012.01.006.

Bjork, R. A., Dunlosky, J., & Kornell, N. (2013). Self-Regulated Learning: Beliefs, Techniques, and Illusions. *Annual Review of Psychology*, *64*(1), 417–444. https://doi.org/10.1146/annurev-psych-113011-143823

Brady, A. C., Kim, Y. E., & Cutshall, J. (2021). The what, why, and how of distractions from a self-regulated learning perspective. Journal of college reading and learning, *51*(2), 153–172. https://doi-org.ezproxy.uan.edu.co/10.1080/10790195.2020.1867671

Bol, L., & Hacker, D. (2012). Calibration Research: Where Do We Go from Here? *Frontiers in Psychology*, *3*. https://doi.org/10.3389/fpsyg.2012.00229

Broadbent, J. (2017). Comparing online and blended learner's self-regulated learning strategies and academic performance. *The Internet and Higher Education*, *33*, 24–32. https://doi.org/https://doi.org/10.1016/j.iheduc.2017.01.004

Byrne, B. M. (2013). Structural Equation Modeling with Mplus: Basic Concepts, Applications, and Programming. *Structural Equation Modeling with Mplus*. https://doi.org/10.4324/9780203807644

Celik, B. (2022). The Effect of Metacognitive Strategies on Self-Efficacy, Motivation and Academic Achievement of University Students. *Canadian Journal of Educational and Social Studies*, *2*(4), 37–55.

Cervin-Ellqvist, M., Larsson, D., Adawi, T., Stöhr, C., & Negretti, R. (2021). Metacognitive illusion or self-regulated learning? Assessing engineering students' learning strategies against the backdrop of recent advances in cognitive science. *Higher Education*, *82*(3), 477–498. https://doi.org/10.1007/s10734-020-00635-x

Chang, C., Colón-Berlingeri, M., Mavis, B., Laird-Fick, H. S., Parker, C., & Solomon, D. (2021). Medical student progress examination performance and its relationship with metacognition, critical thinking, and self-regulated learning strategies. *Academic Medicine*, *96*(2), 278–284.

Chin, E. C. H., Williams, M. W., Taylor, J. E., & Harvey, S. T. (2017). The influence of negative affect on test anxiety and academic performance: An examination of the tripartite model of emotions. *Learning and Individual Differences, 54*, 1–8. https://doi.org/https://doi.org/10.1016/j.lindif.2017.01.002

Connor, C. M., Day, S. L., Zargar, E., Wood, T. S., Taylor, K. S., Jones, M. R., & Hwang, J. K. (2019). Building word knowledge, learning strategies, and metacognition with the Word-Knowledge e-Book. *Computers & Education*, *128*, 284–311. https://doi.org/https://doi.org/10.1016/j.compedu.2018.09.016

Ebomoyi, J. I. (2020). Metacognition and Peer Learning Strategies as Predictors in Problem-Solving Performance in Microbiology. *Journal of Microbiology \& Biology Education, 21*(1), 10. https://doi.org/10.1128/jmbe.v21i1.1715

Efklides, A. (2011). Interactions of Metacognition With Motivation and Affect in Self-Regulated Learning: The MASRL Model. *Educational Psychologist*, *46*(1), 6–25. https://doi.org/10.1080/00461520.2011.538645

Ekatushabe, M., Nsanganwimana, F., Muwonge, C. M., & Ssenyonga, J. (2021). The relationship between cognitive activation, self-efficacy, achievement emotions and (meta) cognitive learning strategies among Ugandan biology learners. *African journal of research in mathematics, science and technology education, 25*(3), 247-258. https://doi-org.ezproxy.uan.edu.co/10.1080/18117295.2021.2018867

Erbas, A. K., & Okur, S. (2012). Researching students? strategies, episodes, and metacognitions in mathematical problem solving. *Quality \& Quantity*, *46*(1), 89–102.

Flavell, J. H. (1976). Metacognitive aspects of problem solving. *The Nature of Intelligence*, 231–235. https://doi.org/10.12691/education-4-2-5

Gargallo, B., Jesús, S.-R., & Pérez-Pérez, C. (2009). El cuestionario CEVEAPEU. Un instrumento para la evaluación de las estrategias de aprendizaje de los estudiantes universitarios. *RELIEVE. Revista Electrónica de Investigación y Evaluación Educativa*, *15*(2), 1–31.

González, A., Fernández, M.-V. C., & Paoloni, P.-V. (2017). Hope and anxiety in physics class: Exploring their motivational antecedents and influence on metacognition and performance. *Journal of Research in Science Teaching*, *54*(5), 558–585. https://doi.org/https://doi.org/10.1002/tea.21377

Guterman, O., & Neuman, A. (2022). Not all paths lead to success: learning strategies and achievement among undergraduate students. J*ournal of Further and Higher Education, 46*(1), 115-127. https://doi-org.ezproxy.uan.edu.co/10.1080/0309877X.2021.1890701

Hayat, A. A., Shateri, K., Amini, M., & Shokrpour, N. (2020). Relationships between academic self-efficacy, learning-related emotions, and metacognitive learning strategies with academic performance in medical students: a structural equation model. *BMC Medical Education, 20*(1), 76. https://doi.org/10.1186/s12909-020-01995-9

Hertel, S., & Karlen, Y. (2021). Implicit theories of self-regulated learning: Interplay with students' achievement goals, learning strategies, and metacognition. *British Journal of Educational Psychology, 91*(3), 972–996. https://doi.org/10.1111/bjep.12402

Huertas Bustos, A. P., Vesga Bravo, G. J., & Galindo León, M. (2014). Validación del instrumento'Inventario de habilidades metacognitivas (mai)'con estudiantes colombianos. *Praxis \& Saber, 5*(10), 56–74.

Karlen, Y., Hirt, C. N., Liska, A., & Stebner, F. (2021). Mindsets and Self-Concepts About Self-Regulated Learning: Their Relationships With Emotions, Strategy Knowledge, and Academic Achievement. *Frontiers in Psychology, 12*. https://doi.org/10.3389/fpsyg.2021.661142

Magno, C. (2010). The role of metacognitive skills in developing critical thinking. *Metacognition and Learning, 5*(2), 137–156.

McDaniel, M. A., & Einstein, G. O. (2020). Training Learning Strategies to Promote Self-Regulation and Transfer: The Knowledge, Belief, Commitment, and Planning Framework. *Perspectives on Psychological Science, 15*(6), 1363–1381. https://doi.org/10.1177/1745691620920723

McDaniel, M. A., Einstein, G. O., & Een, E. (2021). Training College Students to Use Learning Strategies: A Framework and Pilot Course. *Psychology Learning \& Teaching, 20*(3), 364–382. https://doi.org/10.1177/1475725721989489

Ochoa Sierra, L., & Moya Pardo, C. (2019). La evaluación docente universitaria: retos y posibilidades. *Folios,* (49), 41-60. https://doi.org/10.17227/folios.49-9390

Pekrun, R. (2021). Teachers need more than knowledge: Why motivation, emotion, and self-regulation are indispensable. *Educational Psychologist, 56*(4), 312–322. https://doi-org.ezproxy.uan.edu.co/10.1080/00461520.2021.1991356

Pekrun, R., Goetz, T., Frenzel, A. C., Barchfeld, P., & Perry, R. P. (2011). Measuring emotions in students' learning and performance: The Achievement Emotions Ques-

tionnaire (AEQ). *Contemporary Educational Psychology, 36*(1), 36–48. https://doi.org/https://doi.org/10.1016/j.cedpsych.2010.10.002

Pekrun, R., Goetz, T., & Perry, R. P. (2005). *Achievement emotions questionnaire (AEQ). User's manual*. Unpublished Manuscript, University of Munich.

Pintrich, P. R., Wolters, C. A., & Baxter, G. P. (2000). assessing metacognition and self-regulated learning. In G. Gregory & C. James (Ed.), *Issues in the Measurement of Metacognition (pp.* 43–97). Buros Institute of Mental Measurements.

Price, M. J., Mudrick, N. V, Taub, M., & Azevedo, R. (2018). The Role of Negative Emotions and Emotion Regulation on Self-Regulated Learning with MetaTutor. In R. Nkambou, R. Azevedo, & J. Vassileva (Eds.), *Intelligent Tutoring Systems* (pp. 170–179). Springer International Publishing.

Ramirez-Arellano, A., Acosta-Gonzaga, E., Bory-Reyes, J., & Hernández-Simón, L. M. (2018). Factors affecting student learning performance: A causal model in higher blended education. *Journal of Computer Assisted Learning, 34*(6), 807–815. https://doi.org/10.1111/jcal.12289

Ramirez-Arellano, A., Bory-Reyes, J., & Hernández-Simón, L. M. (2019). Emotions, Motivation, Cognitive–Metacognitive Strategies, and Behavior as Predictors of Learning Performance in Blended Learning. *Journal of Educational Computing Research, 57*(2), 491–512. https://doi.org/10.1177/0735633117753935

Rhodes, M. G. (2019). Metacognition. *Teaching of Psychology, 46*(2), 168–175. https://doi.org/10.1177/0098628319834381

Roberts, J. S. (2021). Integrating Metacognitive Regulation into the Online Classroom Using Student-Developed Learning Plans. J*ournal of Microbiology \& Biology Education, 22*(1), ev22i1.2409. https://doi.org/10.1128/jmbe.v22i1.2409

Sáiz-Manzanares, M. C., & Montero-García, E. (2015). Metacognition, Self-regulation and Assessment in Problem-Solving Processes at University. In A. Peña-Ayala (Ed.), *Metacognition: Fundaments, Applications, and Trends: A Profile of the Current State-Of-The-Art* (pp. 107–133). Springer International Publishing. https://doi.org/10.1007/978-3-319-11062-2_5

Samuelowicz, K., & Bain, J. D. (2001). Revisiting academics' beliefs about teaching and learning. *Higher Education, 41*(3), 299–325.

Sánchez-Rosas, J. (2015). The Achievement Emotions Questionnaire-Argentine (AEQ-AR): internal and external validity, reliability, gender differences and norm-referenced interpretation of test scores. *Revista Evaluar, 15*(1 SE-Investigaciones originales). https://doi.org/10.35670/1667-4545.v15.n1.14908

Schraw, G., & Dennison, R. S. (1994). Assessing Metacognitive Awareness. *Contemporary Educational Psychology, 19*(4), 460–475. https://doi.org/https://doi.org/10.1006/ceps.1994.1033

Schraw, G., & Moshman, D. (1995). Metacognitive theories. *Educational Psychology Review, 7*(4), 351–371. https://doi.org/10.1007/BF02212307

Tsai, C. W., Lee, L. Y., Cheng, Y. P., Lin, C. H., Hung, M. L., & Lin, J. W. (2022). Integrating online meta-cognitive learning strategy and team regulation to develop students' programming skills, academic motivation, and refusal self-efficacy of Internet use in a cloud classroom. *Universal Access in the Information Society*, 1-16. https://doi.org/10.1007/s10209-022-00958-9

Versteeg, M., Bressers, G., Wijnen-Meijer, M., Ommering, B. W. C., de Beaufort, A. J., & Steendijk, P. (2021). What Were You Thinking? Medical Students' Metacognition

and Perceptions of Self-Regulated Learning. *Teaching and Learning in Medicine, 33*(5), 473–482. https://doi.org/10.1080/10401334.2021.1889559

Vrugt, A., & Oort, F. J. (2008). Metacognition, achievement goals, study strategies and academic achievement: pathways to achievement. *Metacognition and Learning, 3*(2), 123–146. https://doi.org/10.1007/s11409-008-9022-4

Wilson, A. (2021). Towards an understanding of metacognition(ing) through an agential realism framework. *Educational Philosophy and Theory*, 1–14. https://doi.org/10.1080/00131857.2021.1915763

Wittmann, S. (2011). Learning strategies and learning-related emotions among teacher trainees. *Teaching and Teacher Education, 27*(3), 524–532. https://doi.org/10.1016/j.tate.2010.10.006

Zhao, N., Teng, X., Li, W., Li, Y., Wang, S., Wen, H., & Yi, M. (2019). A path model for metacognition and its relation to problem-solving strategies and achievement for different tasks. *ZDM, 51*(4), 641–653.

Appendix 1. Supplementary data

Table 6

Structural Equation Model Results

	1	2	3	4	5	6	7	8	9	10	11
VARIABLES	pca1	pca2	pca3	pca4	pca5	pca8	pca9	pca7	pca6	pca10	pcepos1
PCA	1	.809***	.827***	.599***	.368***	- .177***	- .133***	.376***	.256***	.297***	
	0	(.0281)	(.0244)	(.0238)	(.0231)	(.0230)	(.0217)	(.0217)	(.0227)	(.0199)	
PCEP											1
											0
PCEN											
PCM											
Constant	.0169	.0265	.00181	.00410	.00423	- .0137	- .00319	- .00896	.0203	- .00102	.0135
	(.0824)	(.0771)	(.0715)	(.0630)	(.0559)	(.0521)	(.0491)	(.0531)	(.0527)	(.0478)	(.0712)
Observations	1.079	1.079	1.079	1.079	1.079	1.079	1.079	1.079	1.079	1.079	1.079
	12	13	14	15	16	17	18	19	20	21	22
VARIABLES	pcepos2	pcepos3	pceneg1	pceneg2	pceneg3	pceneg4	pcm1	pcm2	pcm3	pcm4	/
PCA											
PCEP	.811***	.587***									
	(.0263)	(.0253)									
PCEN			1	.775***	.776***	.462***					
			0	(.0283)	(.0265)	(.0201)					
PCM							1	.797***	.757***	.281***	
							0	(.0207)	(.0208)	(.0173)	
Constant	.00784	.0116	- .00354	.00642	- .00887	.0146	.00216	- .00696	.0125	.00335	
	(.0615)	(.0573)	(.106)	(.0910)	(.0873)	(.0674)	(.0879)	(.0769)	(.0751)	(.0483)	
Observations	1.079	1.079	1.079	1.079	1.079	1.079	1.079	1.079	1.079	1.079	1.079