RELATIONSHIPS BETWEEN METACOGNITION, LEARNING STRATEGIES AND EMOTIONS IN UNIVERSITY STUDENTS

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October 05, 2022

Abstract

The purpose of this article is to analyze the relationship between metacognition, learning strategies and academic emotions in 1096 university students belonging to different academic programs from a Colombian higher education institution. To this end, a principal component factor analysis was performed to reduce the dimensions represented in the items of the instruments used and structural equation modeling (SEM) was applied to explain the existing interrelationships among the three variables studied. The findings show that there is a positive relationship between metacognition and learning strategies and these, in turn, with positive academic emotions; on the contrary, negative academic emotions have a negative relationship with learning strategies and metacognition, which leads us to conclude that metacognition fosters learning strategies and negative academic emotions discourage it.

Introduction

Metacognition is considered by Versteeg et al. (2021) as the action of thinking about one's own thinking. It refers to the knowledge of both one's own cognition and awareness to exercise control (self-regulation) of cognitive processes (Flavell, 1976). Some authors define it as the set of skills that enable a student to monitor their cognition (the latter comprises judgments, perceptions, memory and reasoning) (Rhodes, 2019; Schraw & Moshman, 1995). Metacognitive skills are recognized as planning, monitoring, and actions that students can take to achieve better learning outcomes (Pintrich et al., 2000; Roberts, 2021). Assessing and regulating what has been understood from reading an academic text involves monitoring the comprehension of that cognitive process (Bol & Hacker, 2012; Connor et al., 2019).

Learning strategies are also related to how a university student learns (McDaniel & Einstein, 2020). 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 learning that will have an impact throughout their whole life (McDaniel et al., 2021). A student will get better achievements if they know how the teacher will evaluate a topic and more so if they know how to choose the classmates with whom they can study before a test.

In the same vein, studies on positive academic emotions (pride, hope, to mention two) or negative ones (boredom, hopelessness etc.), have found 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 specific situation and positively or negatively influence the outcome of a specific task related to

studying (Chin et al., 2017), for example, if a student feels desperate because they do fail to understand the class topics, they may receive negative outcomes in their grades.

Although for some authors such as (Broadbent, 2017; Magno, 2010; 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 is going to require exercising control over cognitive, metacognitive and emotional processes. The limits of each of the aforementioned research approaches are difficult to define, and although they are closely related to how a student achieves better learning outcomes, in the available literature it is not so simple to establish their differences or correspondences (Ramirez-Arellano et al., 2018). For the latter author, analyzing each of these aspects separately limits the perspective of this type of studies; however, this has been done and, therefore, it is the empirical basis with which most of the publications on the subject are available.

To a lesser extent, there are studies that have managed to relate two of the variables involved in this research, whether by analyzing the influence of emotions on metacognition or by determining what the influence of these two variables is on learning strategies (Acosta-Gonzaga & Ramirez-Arellano, 2021; Artino & Jones, 2012; Wittmann, 2011). To a much lesser extent, as far as the authors have been able to verify, articles have been written that barely confirmed a correspondence between the data collected with different instruments with theoretical proposals that relate three or more variables, including: metacognition, learning strategies and emotions (Acosta-Gonzaga & Ramirez-Arellano, 2021; Efklides, 2011; Ramirez-Arellano et al., 2018, 2019). Regarding the foregoing, it is possible to conclude that the relational analysis between the different approaches mentioned is an emerging line that should be increasingly developed. Therefore, this study adds to the limited research base on the subject.

In this research, we analyze the perceptions of n= 1097 university students, who filled out three instruments, namely: the metacognitive abilities inventory (MAI) (Huertas Bustos et al., 2014; Schraw & Dennison, 1994); the learning strategies instrument by Gargallo et al. (2009) and, finally, the one of emotions oriented solely towards studying or learning by Pekrun et al. (2005), which has been adjusted to the university context by Sánchez-Rosas (2015), by means of which three positive emotions (enjoyment, hope, pride), and five negative emotions (anger, anxiety, shame, hopelessness and boredom) can be evaluated. Three research questions were posed for this study:

1. What are college students' perceptions of metacognition, learning strategies, and emotions?
2. What relationships can be identified between metacognition, learning strategies, and emotions in university students?
3. Can recent theoretical postulates constructed on the theoretical relationships between the approaches to be assessed within the study be confirmed, rejected, or partially accepted?

Relationships between metacognition, learning strategies, and emotions.

Metacognition and learning strategies are of considerable interest to the academic community because both have been found to influence students' school performance and learning outcomes (Chang et al., 2021; Ebomoyi, 2020). Despite this, it is unclear how either can positively impact the other (Zhao et al., 2019). For some authors(Erbas & Okur, 2012; Sáiz-Manzanares & Montero-García, 2015), knowing how to choose the most appropriate metacognitive skills (such as planning or evaluating) will favor "problem solving" (learning strategy). The overall idea underlying this approach is that if the student evaluates each step that can lead them to understand the problem statement, they will be able to decide which is the best strategy to solve it. Other authors have asserted that learning strategies are an intermediary between metacognition and academic performance (Vrugt & Oort, 2008). If knowing how to choose what is required to pass a test (learning strategy) well, it will be possible to plan and control how to take the best actions to achieve

it (metacognitive ability). The debate continues with which variable affects the other and has even been extended by introducing others such as emotions.

With respect to the latter, research that has studied the relationships between metacognition and emotions (González et al., 2017; Trigueros et al., 2020) has found that the latter exert either a positive or negative effect on learning outcomes. The former idea, by far the one that garners the greatest consensus in the current literature on the subject, asserts that students in whom positive emotions predominate may be more aware of their metacognitive abilities (Hayat et al., 2020); in other words, they are better at recognizing their abilities to reflect, evaluate and take control of their learning (Hertel & Karlen, 2021). This has also been confirmed in articles that have studied the influence of positive emotions on the most appropriate choice that students make about their learning strategies (Karlen et al., 2021). If they learn to identify which strategies are the most effective in improving academic performance, they will consequently not only experience more positive emotions, but will also learn to make higher quality evaluative judgments about their academic processes (Cervin-Ellqvist et al., 2021). Conversely, negative emotions have been found to affect the metacognitive process and correctly choosing the best strategies for learning (Price et al., 2018).

On the other hand, there are a few articles that have analyzed more than three variables in a single study and have developed theoretical proposals to see whether the data they obtain from students correspond to these conceptual approaches. These models have, of course, fed many constructs developed in the aforementioned studies, among many others. Efklides (2011) creates a model on regulated learning and explains the relationship between cognition, metacognition and emotions. For this author, the strategies chosen by students are determined by their metacognitive abilities, motivation and the emotions they feel when completing academic activities (Acosta-Gonzaga & Ramirez-Arellano, 2021),

Another hypothetical model (Ramirez-Arellano et al., 2018), confirms that the relationship between emotions, metacognition and learning strategies impacts either positively or negatively on learning outcomes (Fig 1), among other aspects such as motivation and cognitive strategies, which are not within this research's scope. Ramirez-Arellano et al. (2018)in a context of blended learning where they evaluate a pedagogical intervention, barely corroborate that theoretical relationship with the data obtained from their research. They find that there is a relationship between metacognition and learning strategies, but not significantly between the latter variable and positive emotions. The foregoing is explained by the fact that the negative emotions experienced by students are greater. This did not occur in the research of Acosta-Gonzaga & Ramirez-Arellano (2021) whose findings showed an influence of positive emotions on strategies and metacognition.

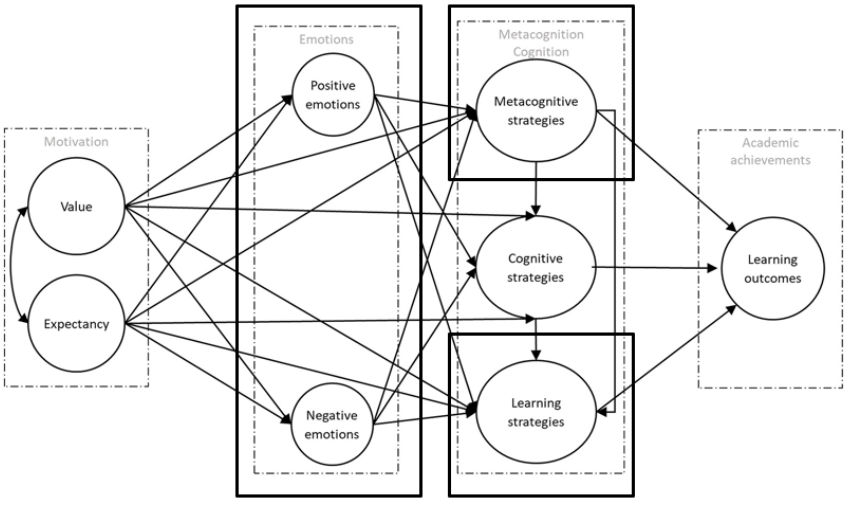

Fig. 1. Hypothetical causal model: Factors affecting student-learning performance (Ramirez-Arellano et al., 2018).

Materials and Methods

To complete this research, there was a set of questions contained in three instruments: a) metacognitive skills with 52 items (Huertas Bustos et al., 2014; Schraw & Dennison, 1994); b) learning strategies of university students with 88 items (Gargallo et al., 2009), and c) academic emotions both positive and negative towards studying or learning with 75 items (Pekrun et al., 2005; Sánchez-Rosas, 2015).

We worked with a convenience sample composed of 1097 students from Fundación Universitaria del Área Andina (Bogotá-Colombia), a high-quality, accredited higher education institution in the Colombian context, which offers professional programs, specializations and master's degrees remotely, virtually and face-to-face. This sample corresponds to a universe of 34141 students, with a confidence level of 95% and an allowed sampling error of 2.9%. The average age of the participants was 29 years, with a dispersion of 9 years, and a range between 4 and 63 years.

Descriptive statistics were used to characterize the participants and to analyze the results for each variable under study: metacognition, learning strategies and emotions. Subsequently, this article uses factor analysis by principal components as a dimension reduction technique and structural equation models to find the direct and indirect effects of the latent variables that are formed from the three aforementioned variables under study in this research.

Instruments

The instruments correspond to simple questionnaires where there were neither correct nor incorrect answers, which generated honest answers about what truly represents students' perceptions. For each statement for the three variables under study, the student only chose one option, with a degree of perception that was categorized in all questions as: completely disagree 1; disagree 2; indecisive 3; agree 4; completely agree 5.

The first questionnaire contains aspects related to metacognitive skills Table 1; in other words, cognition knowledge (declarative knowledge, procedural knowledge and conditional knowledge) and cognition regulation (planning, organizing, monitoring, debugging and evaluation). On the other hand, Cronbach's Alpha is calculated for the data set of 52 items that comprise the instrument, which is 0.959, confirming its reliability.

Table 1

Scale, subscale and definitions (Huertas Bustos et al., 2014)

Scale	Subscale	Definition
Cognition Knowledge	Declarative knowledge	Knowledge a subject has of their learning, their abilities and the use of the
	Procedural knowledge	Knowledge a subject has about the use of their learning strategies.
	Conditional knowledge	Knowledge a subject has of when and why to use learning strategies.
Cognition Regulation	Planning	Planning, performed by the subject, of study times, setting of learning goa
	Organizing	Process carried out by the subject that allows them to organize the activit
	Monitoring	Supervision the subject exercises over the learning process during task con
	Debugging	Process carried out by the subject that allows them to identify weaknesses

The second instrument contains the evaluation of learning strategies. It relates university students' perceptions to two major categories: emotional, supportive and control strategies and strategies related to information processing, which, in turn, are subdivided into subcategories that are shown in Table 2. Cronbach's Alpha of this instrument is 0.934, which makes it quite reliable for this study.

Table 2

Scale, subscale, learning strategies and items (López Paz et al., 2018).

Scale	Subscale
Emotional, supportive and control strategies	Motivational strategies
	Emotional components
	Metacognitive strategies MS
	Strategies of context control, social interaction and ECO resource manageme
Strategies related to information processing	Strategies for information search and selection EEB
	Strategies for information processing and use

Finally, the third instrument (Table 3) contains academic emotions towards studying or learning, in other words, positive perceptions (enjoyment, hope, pride), and negative ones (anger, anxiety, shame, hopelessness and boredom). The instrument is quite reliable, Cronbach's Alpha is 0.955.

Table 3

Scale, subscale, and items of emotions

Scale	Subscale	Some examples of items
Positive emotions	Enjoyment	I am look forward to studying (1); I enjoy the challenge of learning the subject matter (2
	Hope	I have an optimistic view of studying (11); I am confident that I will be able to master th
	Pride	I am proud of my ability (17); because I want to be proud of my accomplishments, I feel
Negative emotions	Anger	I get angry when I have to study (23); I get upset when I have to study so much (24).
	Anxiety	When I see the books that I still have to read, I get anxious (32); I get so nervous that I
	Shame	I feel ashamed of constantly procrastinating (43); I feel ashamed (44).
	Despair	I feel hopeless when I think about studying (54); My lack of confidence exhausts me even
	Boredom	Because I am bored, I don't feel like studying (65); I prefer to put this boring work off un

Structural Equation Modeling (SEM)

SEM as a multivariate technique was used to test and evaluate multivariate causal relationships stemming from emotions, metacognition and learning. To this end, a structural model was proposed in which hypotheses about causal relationships between several interacting variables were represented. SEM is used in this research because of its strength of combining confirmatory factor analysis and path analysis, and to define a theoretical causal model in which by defining a set of forecasted covariances between variables tests whether the model is feasible in comparison with the observed data (Jöreskog, 1970; Wright, 1934). A major advantage of using SEM in this research is the evidence of direct and indirect effects on causal relationships assumed based on theory and the state-of-the-art literature.

SEM, compared to other multivariate techniques, allows an explicit evaluation of measurement error and the estimation of error variance parameters for both independent and dependent variables (Byrne, 2013); SEM also allows estimating latent variables using the variables that were obtained during data collection and allows applying a structure and evaluation of data fit. In sum, the advantage of SEM is that the directionality in the influence of one variable on another can be identified. In addition, SEM allows the researcher to test the validity of a theoretical model with respect to the network interactions between the variables that support the hypothesis design under study.

Finally, the main idea of SEM is that the system of equations acquires a specific causal order, which can be used to generate an implied covariance matrix, minimizing the difference between the observed and the implied covariance structure in the structural model (McArdle & McDonald, 1984). The identified best-fit path coefficient has a meaning similar to a semipartial correlation in that it reflects the influence of one variable on another with the influences of all other variables on the second variable held constant (McIntosh & Mišić, 2013).

Data analysis plan

Stata 17 principal component analysis and SEM were used to validate the multivariate causal relationship between metacognition, learning and emotions. Based on this research's sample, an exploratory factorial analysis was performed using the principal components extraction method and varimax rotation. This allowed reducing the dimensions of the items into four latent variables or indexes that describe positive and negative emotions, learning, and metacognition. Finally, with these indexes, the structural equation model was built, with which, based on the covariances and their statistical significance, the relationship between these indexes was established.

Results

Metacognition

In Table 4, the means for the aspects related to metacognition are identified and what stands out the most is that the item with the highest value is 46: *I learn more when I am interested in the topic* (M=4.399) and slightly followed by 52: *I stop and reread when I am confused* (M=52). The commonality in the results for all items is that they were valued above M=3.397, which indicates that this is an aspect (metacognition) highly valued by students. Item 48 stands out:*I pay more attention to the global meaning than to the specific one* , since students perceive that they pay more attention to general or global aspects than to in-depth class topics. Another item worth highlighting is item 19: *when I complete a task, I ask myself if there was an easier way to do it* (M=3.525), possibly, students require more assistance to learn the best study routes to achieve better outcomes.

Table 4

Descriptive Statistics per Metacognition Item

Item	Mean	Std. Dev.	Item	Mean	Std. Dev.
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

Source: Authors' calculation based on primary information.

Learning Strategies in University Students

In Table 5, the results of the means for learning strategies are organized. The learning indicator most valued by the sample is related to the need of studying with an interest in learning (item 3; M=4.678). Before analyzing the worst valued items, we note that items 12, 13, 20, 34 and 78 can be considered as distracters that should have values below M=3 (completely disagree and disagree), which indeed happened: item 12:*my academic performance depends on luck* (M=1. 723); item 13:*my academic performance depends on the teachers* (M=2.811); item 20: *intelligence, you either have it or you don't, and it cannot be improved* (M=2.063); item 34: *I only study before tests*(M=2.466) and, item 78: *to learn things, I merely repeat them over and over again* (M=2.457).

Not considering the foregoing items, the worst valued items were item 5: I need other people –parents, friends, teachers, etc.- to encourage me to study (M= 2.355) and item 56: I know how to use the newspaper library and find the articles I need (M= 2.954). Item 37: when I see that my initial plans do not achieve the expected success, when studying, I change them for more adequate ones (M=3.672), its wording and structure is similar to item 19 of the metacognition instrument (3.525), and both were valued without statistically significant differences, which, undoubtedly, is a clear generalized student perception about their need to be trained to cope with difficulties in learning specific content seen in the classroom, this may indicate that when they are performing poorly in their studies, they do not know how to deal with the situation.

Table 5

Descriptive Statistics per Learning Strategies Item

Item	Mean	Std. Dev.	Item	Mean	Std. Dev.
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
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

Source: Authors' calculation based on primary information.

Emotions

Table 6 shows the means and standard deviations of the academic emotions towards studying or learning, both positive (enjoyment, hope and pride) and negative (anger, anxiety, shame, hopelessness and boredom). We found that the mean values for positive emotions are above 4 except for item 4 (M=3.65), which obtained a lower mean: "*I study more than what is needed because I enjoy it a lot* , indicating that studying is not totally enjoyable for some students. For negative emotions, perceptions are mostly located in completely disagree and disagree (as they should be); however, we draw attention to the items that obtained means higher than 3 (Likert scale: agree and completely agree), for example, item 41:*the student worries whether they have understood the class material well* and item 42: *when they are unable to keep up with their studies, they feel scared* . Values above 2.9 are also noteworthy, such as item 39: *as study time runs out, my heart starts to race* . Commonalities found in the data were that positive emotions have better values and therefore a favorable influence on learning, and that negative emotions are more concerning to students and may possibly affect their academic performance. Aspects that will be assessed and corroborated below with SEM.

Table 6

Descriptive Statistics per Academic Emotions Towards Studying or Learning Item

Item	Emotion	Mean	Std. Dev.	Item	Emotion	Mean	Std. Dev.
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
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

Item	Emotion	Mean	Std. Dev.	Item	Emotion	Mean	Std. Dev.
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				

Source: Authors' calculation based on primary information.

Theoretical Measurement Model

Subsequently, to verify the construct validity (factorial structure) of the proposed instrument, an exploratory factor analysis (Table 7) was performed using the principal component extraction method and varimax rotation. The result of the principal component dimension reduction defined 10 components of learning, 4 of metacognition, 3 of positive emotions and 4 of negative emotions. This allowed us to define positive emotions indexes (PCEP), negative emotions index (PCEN), learning strategies index (PCA) and metacognition index (PCM). The descriptive data are shown below.

Table 7

Results of the Exploratory Factor Analysis

Variable	Obs.	Mean	Std. Dev.	Min	Max
Main components	Main components	Main components	Main components	Main components	Main 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
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
Indexes	Indexes	Indexes	Indexes	Indexes	Indexes
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

Source: Authors' calculation based on primary information.

Based on the results of the foregoing exploratory analysis, the theoretical measurement model was formulated, which kept the structure of four first-order factors and consisted of 21 items (see Fig 2 and Appendix A). The results of the SEM covariances in (Fig 2) substantiate the positive relationships between positive emotions and metacognition, positive emotions and learning strategies, and between metacognitions and learning. These results are consistent with the proposal of Hayat et al. (2020), in which students in whom positive emotions predominate may be more aware of their metacognitive skills, and with Pintrich et al. (2000) and Roberts (2021), which recognize that metacognitive skills, planning, monitoring and actions that students can perform are generated with the aim of achieving better learning outcomes. Negative emotions have a negative relationship with learning and metacognition. In sum, metacognition fosters learning strategies and negative emotions discourage it.

Table 8

Relationships between Emotions, Learning and Metacognition

Relationships between variables according to SEM	Relationships between variables according to SEM	Type of relationsl
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

Source: Authors' calculations based on survey and SEM model

Hosted file

`image2.emf` available at https://authorea.com/users/719125/articles/704177-relationships-between-metacognition-learning-strategies-and-emotions-in-university-students

Fig. 2. Structural Equation Model (SEM)

PCEP: Positive Emotions Index; PCEN: Negative Emotions Index; PCA: Learning Strategies index; PCM: Metacognition index.

Source: Authors' calculations based on surv**ey**

Final Discussion

According to the theoretical frameworks used for this study, emotions and metacognition, are important factors influencing students' learning. In this research, students' emotions and metacognition predicted on the same path the learning outcome. For educational environment, students with more positive emotions had a better disposition toward learning and metacognition. These effects may also reflect the importance of the use of metacognitive skills and emotions in fostering learning. In fact, this may be a reflection of the sample chosen for this study. For example, it is possible that students attend the courses taught with a generally more positive attitude and emotion toward the classes, it may be reflected in higher levels of knowledge and, consequently, learning.

These findings may suggest that the emotional states that students bring with them to their classes have a greater or lesser impact on their learning, which may translate into efforts that the teacher will need to

make in the classroom to foster the most appropriate (positive) emotions so that the student manages to cope with their learning processes with greater confidence. Therefore, students –with adequate assistance from a tutor-teacher– can adopt more adaptive coping strategies to dissipate negative emotions.

Conclusions

In the first descriptive analysis of students' perceptions for the three variables studied in the questionnaires, it was possible to determine that there are items that demonstrate students' need of assistance and training to cope, above all, with negative emotions such as fear of not completing their assignments or their concerns about understanding the topics worked on in class, which will require, of course, learning to better manage their learning strategies (McDaniel et al., 2021). It is important for students to be able to respond, for example, to changes in plans when those initially proposed do not work to obtain good learning outcomes, for which teachers must be prepared.

On the other hand, there have been few studies in the research literature that examine the role between metacognition, learning strategies, and academic emotions in higher education settings. In addition, very few research has explored the temporal relationships among the variables studied in this research involving university students. It is essential to understand how students' perceptions of the value of learning and the relevance of metacognition interact with positive and negative emotions within different types of learning environments.

Therefore, the second analysis conducted in this study sought to inquire into whether there is a relationship between learning strategies, metacognitive skills to cope with their learning and their academic emotions towards studying. As a theoretical basis, the model and instruments proposed by Efklides (2011), Pekrun et al. (2011), Ramirez-Arellano et al. (2018) were used. Based on the results with structural equation modeling, it is possible to assert that there are positive relationships between positive emotions and metacognition, positive emotions and learning strategies, and between metacognition and learning. On the other hand, negative emotions have a negative relationship with learning and metacognition. In sum, metacognition fosters learning strategies and negative emotions discourage or disfavor it.

Understanding this process is the first in a series of steps to discover educational and assisting strategies to better meet students' educational needs. By investigating the relationships among these factors, we hope to discover ways to cope with negative emotions and maintain students' positive affect. The findings of this study imply that this can be achieved through teaching methodologies that give greater relevance to metacognition, and more concrete connections are established between personal and professional goals.

Appendix A. Supplementary data

All procedures performed in this research involving human participants were in accordance with the ethical standards at Fundación Universitaria del Area Andina in the frame of the 1964 Helsinki declaration.

Informed consent was obtained from all individual participants involved in the study.

Data availability statements

The authors confirms that all data generated or analysed during this study are included in this published article.

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Appendix A

Table 9. Results of the Structural Equation Model

	1	2	3	4	5	6	7	8	9	10
VARIABLES	pca1	pca2	pca3	pca4	pca5	pca8	pca9	pca7	pca6	pca1

	1	2	3	4	5	6	7	8	9	10
PCA	1	0.809***	0.827***	0.599***	0.368***	-0.177***	-0.133***	0.376***	0.256***	0.29
	0	(0.0281)	(0.0244)	(0.0238)	(0.0231)	(0.0230)	(0.0217)	(0.0217)	(0.0227)	(0.0
PCEP										
PCEN										
PCM										
Constant	0.0169	0.0265	0.00181	0.00410	0.00423	-0.0137	-0.00319	-0.00896	0.0203	-0.0
	(0.0824)	(0.0771)	(0.0715)	(0.0630)	(0.0559)	(0.0521)	(0.0491)	(0.0531)	(0.0527)	(0.0
Observations	1,079	1,079	1,079	1,079	1,079	1,079	1,079	1,079	1,079	1,07
	12	13	14	15	16	17	18	19	20	21
VARIABLES	pcepos2	pcepos3	pceneg1	pceneg2	pceneg3	pceneg4	pcm1	pcm2	pcm3	pcm
PCA										
PCEP	0.811***	0.587***								
	(0.0263)	(0.0253)								
PCEN			1	0.775***	0.776***	0.462***				
			0	(0.0283)	(0.0265)	(0.0201)				
PCM							1	0.797***	0.757***	0.28
							0	(0.0207)	(0.0208)	(0.0
Constant	0.00784	0.0116	-0.00354	0.00642	-0.00887	0.0146	0.00216	-0.00696	0.0125	0.00
	(0.0615)	(0.0573)	(0.106)	(0.0910)	(0.0873)	(0.0674)	(0.0879)	(0.0769)	(0.0751)	(0.0
Observations	1,079	1,079	1,079	1,079	1,079	1,079	1,079	1,079	1,079	1,07