Metacognitive skills and emotions in the construction of Personal Learning Environments

Habilidades metacognitivas y emociones en la construcción de los Entornos Personales de Aprendizaje

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Abstract

The metacognitive skills carried out during PLE development are linked to several different aspects, such as emotions and motivation which in turn contribute to students' performance. This research is aimed at exploring the role of emotions in the learning experience of Higher Education students during the construction of their Personal Learning Environments (PLE) in Mexico. The study was carried out by means of a mixed research protocol in which the CAPPLE questionnaire and semi-structured interviews were implemented. Results based on the survey revealed that students' motivation is linked to certain metacognitive skills during the planning phase of the self-regulated learning process. The interviews show that emotions related to happiness and surprise motivate students to develop their PLE, while emotions such as fear or sadness motivate to work harder in order to build up new skills and abilities. Conclusions reflect on the need to support both metacognitive and emotional processes for successful online learning and PLE construction.
Key words: Personal Learning Environment, Self-regulated learning, emotions, Higher Education

Resumen

Las habilidades metacognitivas llevadas a cabo durante el desarrollo del PLE están vinculadas a varios aspectos como las emociones y la motivación que, a su vez, contribuyen al rendimiento del estudiantado. Esta investigación tiene como objetivo explorar el papel de las emociones en la experiencia de aprendizaje del alumnado de Educación Superior durante la construcción de sus Entornos Personales de Aprendizaje (PLE por sus siglas en inglés) en México. El estudio se llevó a cabo mediante un protocolo mixto de investigación en el que se implementó el cuestionario CAPPLE y entrevistas semiestructuradas. Los resultados cuantitativos revelaron que la motivación está asociada al desarrollo de ciertas habilidades metacognitivas durante la fase de planificación del proceso de aprendizaje autorregulado. Las entrevistas muestran que las emociones relacionadas con la alegría y la sorpresa motivan a desarrollar su PLE, mientras que emociones como el miedo o la tristeza motivan al estudiantado a esforzarse más para desarrollar nuevas habilidades y destrezas. Las conclusiones reflejan la necesidad de apoyar tanto los procesos metacognitivos como los emocionales para el aprendizaje en línea exitoso y la construcción de PLE

Palabras clave: Entornos Personales de Aprendizaje, Aprendizaje Autorregulado, emociones, Educación Superior

1. Introduction

In recent years, the integration of digital technologies into the teaching and learning process has revealed a series of needs that had previously been overlooked, such as for example the motivational aspect and the control over learning itself (Kim et al., 2013). When considering the importance of the integration of digital technologies into the curriculum, the creation of learning environments is important to motivate the learning process, increase learning achievements and develop skills and abilities for lifelong learning. However, according to some authors, the learning process is connected to students' feelings and emotions. For example, during the Covid-19 pandemic, some studies suggest that students' mental well-being had serious emotional consequences generating negative feelings including stress, depression, anger and boredom (Camacho-Zuñiga et al., 2020). In addition, the shift from onsite to online education during the Covid-19 pandemic was commonly associated with negative experiences, since the level of self-control, autonomy and digital skills are higher in students studying totally or partially online in comparison with face-to-face learning (Bird et al., 2022; Curelaru et al., 2022).

In this study, we are looking for evidence that might help us to identify the online students' emotions during the first phase of Self-Regulated Learning (SRL) that could contribute to the development and cultivation of the Personal Learning Environment (PLE). In order to do so, we first analyse the metacognitive skills for which students feel greater motivation, look for the correlation with emotions and explore the complexity of the relationship between metacognition and emotions.

2. Personal Learning Environments

Personal Learning Environments (PLE) allows us to understand how people learn through the use of digital tools (Castañeda & Adell, 2013) taking into consideration their skills and capacities. PLE includes technological, pedagogical and human dimensions (Anggun et al., 2022) that require a combination of technological learning resources, a cognitive process, experience and strategies. The discussion in early research as to the importance of the technological or pedagogical aspects led to further conceptualisation in which the metacognitive processes were understood in relation to information access, information management, knowledge creation or reflection, and communication or networking (Adell & Castañeda, 2010; Prendes et al., 2016). The latest review to the PLE concept goes beyond the definition of the different interactions of the learner with tools and platforms for learning and considers the multilayered, complex relationship that emerges from all these elements, thus highlighting its technosocial reality and sociomaterial entanglement (Dabbagh & Castañeda, 2020).

Strongly related to the pedagogical research strand, PLE has been associated with self-regulation, autonomy, self-control, ownership, and learner agency (Pedro & Santos, 2021; Marín et al., 2014; Ramírez & Tur, 2021). Some other authors suggest that PLE should be an educational effort for adult learners and for lifelong learning to model their learning environments (Fielder & Väljataga, 2013; Yen et al., 2019) while exploring the digital

realm and in particular the use of Web 2.0 and social media (Casquero et al., 2013; Dabbagh & Kitsantas, 2012).

Since PLEs are centred on the student with the learning process being the learners' personal responsibility and educational institutions give freedom to learners for the creation of their own learning paths (Kop & Fournier, 2013). Thus, PLEs empower individuals to apply digital technologies as an enabler while they assemble a flexible and adaptive learning path so as to become successful lifelong learners, which aligns with formal, non-formal and informal learning (Anggun et al., 2022). In this research strand, the model by Dabbagh and Kitsantas (2012), an influential reference for research and practice (Castañeda et al., 2022), offers a framework for PLEs under the metacognitive cycle described by Zimmerman (2002), which addresses learning in three stages, for planning (forethought phase), developing (performance phase) and self-assessing (self-reflection phase). In this cycle, motivational aspects are considered key factors by which students can set their aims and carry out learning (Zimmerman, 2002). Thus, subjective cognitive processes such as intrinsic motivation are key drivers for PLE learning and the learning experience.

Although the PLE idea is not new and has undergone more than a decade of research development (Castañeda et al., 2022), in the wake of the Covid19 pandemic, a great opportunity for the promotion of pedagogical and technological approaches emerged (Pedro & Santos, 2021). Since the early years, educational practice was aimed at including PLE beyond the LMS, and great efforts were made to recognise the importance of the interoperability of a PLE offering access to a variety of learning resources and learning interactions (Fiedler & Väljataga, 2011). Even when PLE is enhanced in any of the diverse educational modalities, whether online, onsite or a combination of the two, some evidence shows that PLE growth depends on students' learning environments, and thus, both face-to-face or online learning might have a strong influence on PLE development (Ramírez et al., 2022).

In recent research and especially related to the analysis of education during the COVID-19 pandemic, emotions have been addressed as a key factor for learning, and although they have had relevant roles in the psychological approach to self-regulated learning, in particular through Pintrich's work (Panadero, 2017), we posit that there exists a research gap when addressing students' processes in PLEs, in alignment with Castañeda et al. (2022).

3. Learning Experience in the performance phase and emotions

The learning experience is of considerable importance since it is closely related to the learners' individual interaction with the learning environment, where they respond to diverse stimuli (Anwar & Wardhono, 2019). Thus, stimuli such as learning resources, interactions, environments, and networks are vital for the creation of learning experiences and can strongly influence expected outcomes. Diverse authors (e.g Dewey, 1938; Lewin, 1946) have developed learning experience models which assume that knowledge is transformed from experience in a repetitive and continuous process. The learning model begins with a concrete experience or impulse that students live, followed by observation and reflection on such experiences. Then knowledge emerges while students form abstract concepts and generalisations and finally students test the implications of these

abstract concepts in new situations, thus validating the knowledge created during the learning process (Kolb, 1984).

The learning experience and performance are unique to each individual and, consequently, the tools and strategies will vary depending on the student's characteristics (Kim at al., 2012; Kop & Fournier, 2013). In addition, the educational process should emphasise and promote a way of looking at education from the perspective of the person who lives and experiences (Kim et al., 2014; Trujillo, 2014), and therefore, the teaching and learning process is aligned to each individual's goals and achievements.

Although experience is subjective (Larrosa, 2006), there are some impulses and concrete situations that may motivate or demotivate the learning performance process. One of the most important elements contributing to success during this process is the combination of motivation and emotions closely related to the students' learning goal with a direct effect on behaviour (Kim & Pekrun, 2013). Some authors (e.g., Mega et al., 2014) link motivation and emotions in a bidirectional sense, meaning that one cannot exist without the other, in coexistence with academic achievements aligned with the cyclic conception of Zimmerman's SRL model (Nota et al., 2004).

Emotions during the learning performance influence cognitive process and strategies, decision making and motivation (Kim & Pekrun, 2013), so there can be no learning without motivation, positive emotions and attitude (Cheremnykh, 2022). Thus, students' academic performance may consequently improve (Ning & Downing, 2012): for example, online learning may be an unpleasant experience, and students feel a negative attitude toward it (Pedro & Santos, 2021), but at the same time it may contribute to complete outcomes and develop self-regulated learning skills (Aguilera-Hermida, 2021). Based on that, and the limited knowledge gained in research so far, this study will serve to contribute to our knowledge of the role played by emotions in PLE development and the possible impact or mutual relationship between metacognitive processes for planning learning (in the forethought phase) and emotions during students' performance.

3. Method

This research is addressed at answering the following research question: What is the role of emotions in students' PLE development? In order to answer this question, the study's aims are:

- To analyse students' self-motivation for the metacognitive skills in the forethought phase of SRL process during the PLE development.
- To explore the relationship between students' metacognitive skills and emotions.

For this study, participants consisted of a total of 85 students studying an online undergraduate program in Mexico ranging in age from 18 to 58, 23.5% of which are men and 76.5% women.

To achieve these aims, we conducted a mixed research study, since the collection, analysis and crossing of qualitative and quantitative data in the same study allowed us to better understand and explain the research problem (Cohen et al., 2018). Data was collected in two stages, first, by means of a survey and secondly, through in-depth

interviews with key students. The survey is coherent with the pedagogical approach of PLE in which the focus is on students' autonomy in metacognitive processes for information access, information management and communication, as in the CAPPLE project (Prendes et al., 2016). The in-depth interviews answered the need to include the latest sociomaterial approach, whose multilayered conceptualisation requires other data collection that can grasp the complexity of the multiple interactions emerging in the PLE entanglement. For this reason, in-depth interviews allowed exploration in greater depth of the motivational and emotional aspects of PLE.

The CAPPLE questionnaire was applied (Prendes-Espinosa et al., 2016), since its objective is to study how students perceive their learning, which could be translated into identifying the characteristics of their PLE. The CAPPLE questionnaire attempts to describe and analyse the students' PLEs considering that a PLE can be defined as a "set of tools, sources of information, connections and activities that a person uses assiduously in his or her learning" (Adell & Castañeda, 2010, p. 20). So, based on this definition, the CAPPLE questionnaire explores students' experience with digital tools, sources, interactions and activities while learning. The questionnaire was divided into five sections: self-perception, information management, learning process management, communication, and user experience. A construct validation was performed through expert judgement, cognitive interviews, and a pilot test. The CAPPLE questionnaire has been implemented in diverse research projects in varying contexts (e.g., Archundia et al., 2021; Prendes et al., 2018; Serrano et al., 2019), which allows confirmation as to the feasibility of the instrument. It has also been used for previous stages of this study in which the aims were addressed at learning about students' PLE processes in both online and onsite Higher Education programs ((Ramírez & Tur, 2019; Ramírez & Tur, 2021; Ramírez et al., 2022).

In order to gain a deeper insight into the experiences the students had undergone throughout their academic life and taking as a reference the results of the application of the CAPPLE questionnaire, we sought to perform a triangulation of information (Lee et al., 2015), allowing us to avoid any possible biases during the research. Semi-structured interviews were conducted, affording the interviewees the opportunity to express themselves in a natural way, and also enabling the collection of additional data (Cohen et al., 2018) that could grasp the complexity of the PLE development. The questionnaire was based on Author and only the information in relation to the metacognitive process and emotions was considered. The interviews were virtual, and were conducted through video calls on different platforms such as Zoom and Meet. They were subsequently analysed through the Atlas.t 9 program taking in consideration the framework and the results of the CAPPLE questionnaire. This current work shows those results related to the metacognitive processes, and the motivational and emotional aspects of students' PLE entanglement.

4. Results

For the quantitative data analysis, we selected the self-perception section related to intrinsic motivation and self-regulation learning (Prendes et al., 2017; Prendes et al., 2019), and the relationship between students' emotions and metacognitive skills. Subsequently, we have presented the results obtained from the qualitative analysis that

shows in detail the students' emotions in relation to their learning process and metacognitive skills during the forethought phase of SRL learning process in PLEs.

First, we consider intrinsic motivation. The situations motivating students to learn are mainly class attendance (M=4.36, S.D.= 1.194), reading and listening to programs through traditional media (M=3.75, S.D.= 1.194), reading on websites and academic events such as conferences and seminars (M=3.68, S.D.= 1.026). Motivation increases when the learner understands the purpose of the task (M= .84, S.D.= .373), is committed and responsible with its completion (M=.87, S.D.= .339), and has resources for its completion (M=.78, S.D.= .419).

Setting goals allows students to take advantage of the time they spend on the Internet (M=4.49, S.D.= .752), and access to which is mainly for informational, communication, work, training and organisational purposes (M=4.65-3.74, S.D.= .631-.958).

Analysing the first phase of self-regulated learning, Table 1 shows that when students want to learn something through the Internet, they consider different aspects.

Table 1.

Variables that students consider when planning online learning

Variable	N	Mean	S. D.
Aims defined in the subject/Project	85	4.48	.666
According to the subjects as they arise	85	4.38	.845
Skills and capacities	85	4.38	.831
Work requirement	84	4.08	.996
Peers' demands	85	2.66	1.484

Students analyse their strengths and weaknesses to assess the effort they have to make in order to fulfil an assigned activity and/or task (N= 85, 81.2%).

Considering the relationship between students' metacognitive skills and motivation, in Figure 1 we observe that the use of tools and applications employed by students in the learning process is based on their functionality and usefulness, rather than their entertainment and aesthetic aspects. It means that students use digital tools and applications if they are clear and easy to learn; beautiful and sophisticated digital tools are not a relevant characteristic.
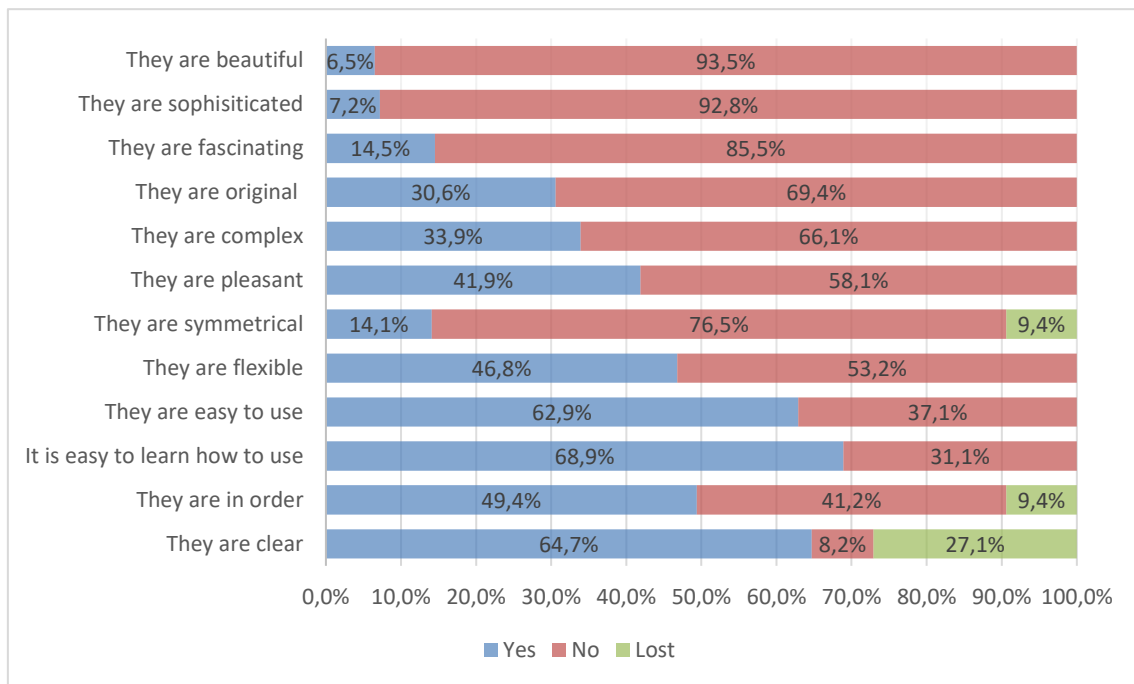
Figure 1. Students' perception of digital tools while learning

The feelings and emotions experienced by students when using different tools and applications for learning are linked to their perception of the ease of use they will have for their activities, rather than the fun and pleasurable part as shown in figure 2.
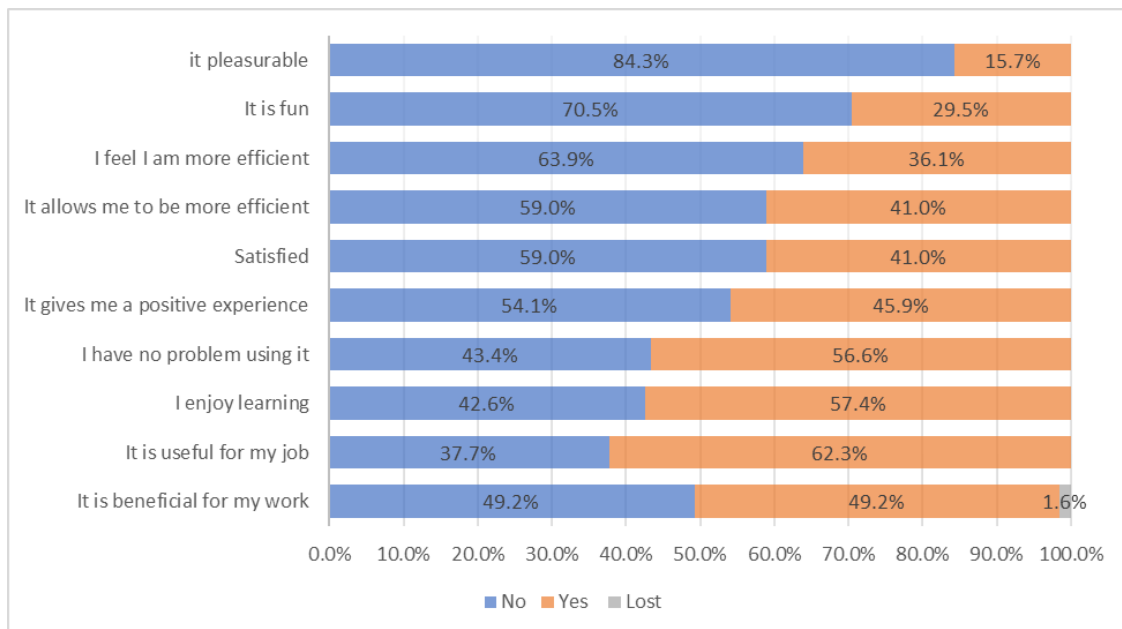

Figure 2. Students' motivation to choose digital tools.

We ran a correlation test in order to know which emotions students feel during a learning experience, and we observed that the correlation coefficient is significantly close to zero

(sig. = .000-0.05). When students use symmetric digital tools, and tools with which they feel efficient and satisfied, their learning process is fun and pleasant so they enjoy learning (see in Appendix 1). This data shows significant correlation between the metacognitive process of planning learning and students' feeling and perceptions about digital tools.

To better understand the complexity of the relationship between metacognitive skills, their motivation for online learning and emotions during learning planning, interviews were analysed and a system of dimensions and categories was developed in an iterative process of induction-deduction. The final draft of the system consists of six dimensions and sixteen categories (Table 2). The interview analysis shows that during the learning process students feel emotions that motivate or demotivate them. In table 2, we show a) a dimension which is the emotion that students feel; b) the category, the emotional response, meaning the event generating the emotion; c) the causes integrating the emotional response, and d) the occurrence. An examination of the data showed that the emotion "Anger" has 102 occurrences, "Happiness" has 227 occurrences, "Fear" has 102 occurrences, "Surprise" has 141 occurrences, "Sadness" has 147 occurrences, and "annoyance/rejection" has 57 occurrences. In this case, we identified that "Happiness" and "Surprise" have positive connotations while "Fear" and "Sadness" have negative connotations, and "annoyance /rejection" has a neutral perspective.

Table 2.

System of dimensions, emotional responses and causes.

Dimension Emotion	Category (Emotional responses)	Causes	Occurrences
Anger	Uncertainty about the learning process. (ER1)	Any task has been evaluated	6
		No feedback from teacher	24
	Hostility against the teacher (ER2)	No answers to students' message	12
		No confidence in the teacher	12
		Errors during task evaluation	16
		Teachers do not give second chances	4
	Demotivation for doing activities (ER3)	Task has no defined goal	16
	Abandon the course (ER4)	Give up during the course	12

Happiness	Motivation for further efforts in activities (ER5)	Teacher attention	11
		Recognised outstanding effort	8
		Commitment of teachers	35
		Feedback in activities	14
	Students feel accompanied (ER6)	Face-to-face advice	15
		Online advice	20
		Assertive communication with teacher	36
		Communication with peers	35
		Sharing experiences	7
	Confirmation that students use good learning resources (ER7)	Sharing learning resources with peers	25
		Curate Content	14
		Learning resources in LMS coincide with students' resources	7
Fear	Further effort in task (ER8)	Doubts on task instructions	12
		Relation effort/grade	27
		Information overload	15
		Insecure using digital tools	12
		Insecure completing the task	17
		Level of education (Higher education)	7
	Ask for solution at principal (ER9)	Teachers do not give the opportunity to reply	12
Surprise	Better self-perception (ER10)	New habits	36
		New skills	42
		Satisfied with final results	17
		Information analysis	16
		Self-judgment	12

Sadness	Enforcement of knowledge (ER11)	Good results	18
	Search for information (ER12)	Wasting time	13
		Loneliness	6
		Peers do not answer messages	5
	Fail the course (ER13)	Forfeit the scholarship	4
		Confusion with exams/tasks	18
		Disappointment	15
	Any task has been completed (ER14)	Bad organisation with peers	8
		Bad self-organisation	24
		Technical problems	21
		Change in schedules	27
		Excess of activities	6
Annoyance /rejection	Students think teacher is inattentive (ER15)	Errors in LMS	21
		Late answers to students' messages	12
	Students do not consult teacher or request help (ER16)	Autonomous	6
		Self-orientation	18

In addition to exploring the frequency of emotions in relation to metacognitive skills and learning tasks, the analysis addresses complexity by examining the links between diverse components. To that end, we explore the connections of each category which can be seen in the following figures (Figures 3 and 4) and in the Appendix 2 (Figures 1 to 4).

The high frequency of categories in the happiness dimension creates a complex network of relationships with other categories representing a wide diversity of emotional responses, as shown in figure 3.
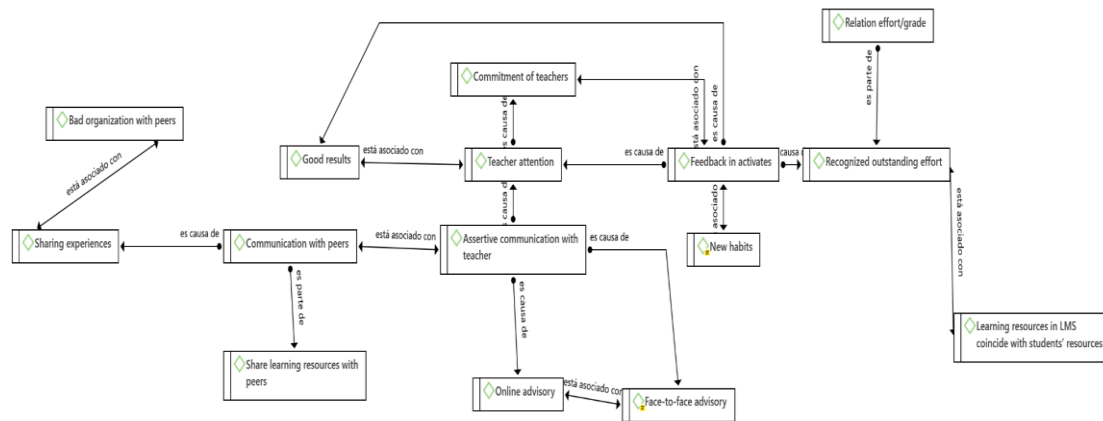
Figure 3. Network of emotional responses related to feelings of happiness

The network of the "happiness" dimension (figure 3) includes the role of teachers, their support and communicative attention in both online and onsite tutoring sessions, and feedback provided along with the appreciation of efforts. Likewise, it includes peer support, affording the opportunity to share resources and learning experiences.
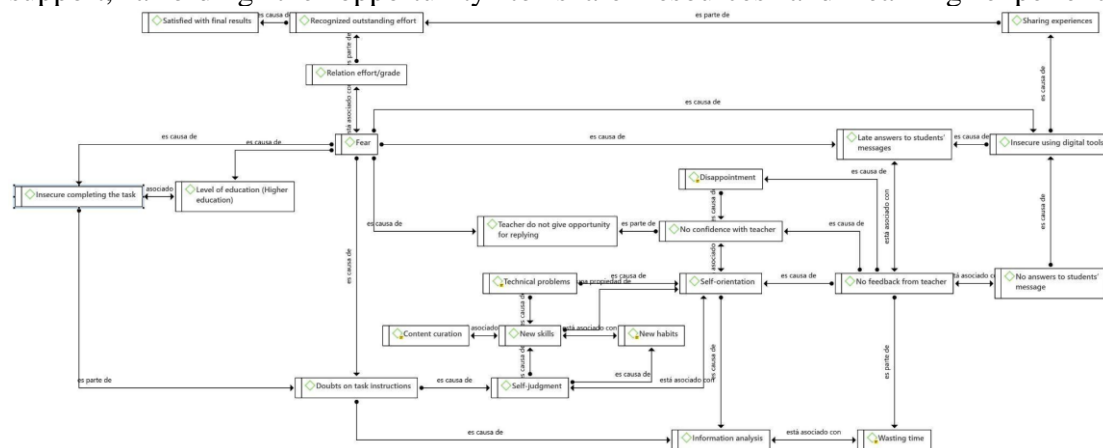

Figure 4. Network of emotional responses related to fear emotions.

On the other hand, figure 4 shows the "fear" dimension; it shows that when students feel insecure about completing tasks or using a digital tool, they are able to develop new skills and habits due to self-orientation. The feeling of fear may cause students to put more effort into doing the task, including the development of new digital skills as the following interview extract shows:

> "I click here and then there [...] I ask myself what if my task is wrong or I made a mistake. I think that I have to put more effort in my work, because undergraduate assessment is scarier than in high school, [...] I ask myself what if the tasks are not fine or this is not right or I made a mistake or the work is going wrong because it is like I feel I have to be more careful." D192

Furthermore, we recognise how "surprise" motivates the learning process because it encourages students to improve their performance when they complete tasks and throughout their academic life (see Figure 5 in Appendix 2):

> "Something very nice that happened to me was during the university entrance course the teacher asked us to do an activity. I made an effort to do it and the

> program coordinator liked it very much. She asked me for permission to publish it, so she encouraged me a lot [...] this recognition, even though it is something very simple, motivates me" D522-23

Likewise, sad emotions provoked by an unmotivated learning process can give rise to positive actions, for example, the development of autonomous learning skills and digital skills such as searching for information. In addition, feelings of sadness is associated with loneliness and disappointment that may be induced by negative teacher interaction with students (see Figure 6 in Appendix 2):

> "Sometimes I feel that I am alone and it would be better to look for help on the internet." D150

When students need to develop skills related to self-regulated learning and autonomous learning, for example, looking for and collecting information, they feel emotions of annoyance and rejection (see Figure 7 in Appendix 2):

> "A teacher asked us to make a Gantt chart but he has not taught us what it is. So, I started to read what it is, what it is for. I read, downloaded information, checked it, entered the data [then] I researched how to make the graph in an internet tutorial and I did it. But it bothers me that they ask us to do something that they have not taught us. I say, `I will have to do it. I read, check and learn what it is, and then I do it." D233

On the other hand, when students feel anger, it is often associated with emotions of "fear" and bad results during task realisation and dropping out during the course (see Figure 8 in Appendix 2):

> The platform was closed at 2 o'clock in the afternoon, but [..] it is usually [closed] at 11:55 […] I sent her a message immediately […] but so far she hasn't answered me. That kind of thing makes me angry and sometimes it kind of discourages me, why did you commit yourself to teach if you can't, or don't want to or don't like it? D241

4. Discussion

This study aims to contribute to the development of the PLE field by adding to a certain extent some new elements in the research design. On the one hand, the underpinning theoretical framework includes the systematic conception of the pedagogical strand developed over the last decade in which the different metacognitive tasks were identified and instruments were built in alignment with it (Adell & Castañeda, 2010; Prendes et al., 2016). On the other hand, beyond the individual level of metacognition in autonomous learning, it includes the complexity of the vision of sociomaterial theories in which relational and contextual elements interact in the enactment of student agency in the online learning environment. In particular, the complexity is only partially analysed in relation to the emotional level, so it answers to the need to explore emotions in the PLE context as a research gap that has been previously recognised (Castañeda et al., 2022). According to this, the methodological design includes the collection of quantitative data to obtain detailed information to be later completed in greater depth through interviews which allow comprehension of the complexity of the emotional level of learning. In alignment with this research design, we focused on two main aims: a) recognising the students' emotions during the construction and cultivation of their PLE, and b) exploring the relationship between metacognitive skills and emotions. The questionnaire revealed quantitative data that was complemented with the data obtained from the interviews.

First, in the CAPPLE questionnaire we noticed that during the PLE process, the situation most motivating students to learn is class attendance without distinction between face-to-face or online classes (Gutierrez et al., 2016; Prendes et al., 2018), showing that direct interaction with teachers is extremely important. For example, during the interviews, some students mention that having a video conference with teachers once a week was useful for helping to answer questions and solve problems. In Figure 1, we observe that when students feel confident with the resources and the aim of the task, the students will be able to assess the amount of effort required and the aspects they need in order to complete the task (Gallardo & Rivera, 2020) beyond the instrumental aspect (Kim et al., 2013). In this study, students recognise the value of digital tools through their usefulness and their contribution to the fulfilment of the task, rather than their entertainment value (Appendix 1). It means that students focus on digital tools that are beneficial for the learning process and they have no problems using them.

The selection of digital tools is based on their clarity, order, ease for learning and entertainment aspect (Figure 2). Thus, the integration of digital tools during the learning process should be based on user interaction and experience, which assumes that it is important to consider the user's experience framework for the development of learning resources (Gallardo & Rivera, 2020; Mendoza et al., 2020).

In addition, we noticed that the construction of PLE is motivated by completing tasks when students feel fear of failure in the task, obliging them to integrate different learning resources and strategies, or feelings of happiness when they see the result of their dedication during a task. The way in which teachers or instructors make students feel can be a determining factor for the creation of a PLE. For example, when students do not have effective communication with the teacher, they become discouraged and start feeling negative emotions towards the teacher. Students are motivated by both previous and new experiences so they develop new learning habits and attitudes on learning online, for example, digital research on the Internet (Appendix 2).

When students know the purpose of the task, normally as a metacognitive task during the forethought stages of learning, they feel considerably more motivated. This aspect may be linked to the use of rubrics as a way of guiding and orientating students during the task development, so they feel confident, since they already know the criteria of evaluation and recognise the amount of effort demanded by the task. Some authors (Chhetri, 2020; Fraile et al., 2017) affirm that the implementation of rubrics during the learning process has benefits and effects on self-regulated learning, self-efficacy and performance. Furthermore, having access to resources needed to complete the task is an important fact that may have influence on the strengthening of PLE management and learning outcomes as has been shown in previous studies (Hariyanto et al., 2021; Nganji, 2018). In this line, we noticed that students develop their learning environments taking into consideration the learning resources published in the institutional LMS, and the sources that they find by chance surfing on the Internet and have been useful in the completion of other tasks.

We also noticed that students have emotional responses to specific situations during their learning process (see Table 2). For instance, when students do not have effective communication with the teacher, they can respond in two different ways: 1) they can independently improve their own digital skills by searching for information in order to complete the task while improving their PLE or 2) simply fail the course without

enhancing their digital skills, learning strategies or learning environments. So, in this case, we noticed that one negative experience can provoke two possible emotional responses: one positive and one negative. These two variables, according to existing literature, are associated with the locus of control which can influence learning achievement (Nasir et al., 2021), and determine the manner in which a student responds to stimuli or situations, so it depends on each student's characteristics (Kim et al., 2013). Likewise, this is closely related to the SRL cycle and those students with higher intrinsic motivation and autonomous skills will develop resilient strategies to achieve a successful learning process (Nota et al., 2004).

In the same line, considering Figure 3 and 4, and Appendix 2, we observed that when students felt that teachers cared about their learning, they had a positive attitude towards developing their learning environment (Cho et al., 2021; Shaikh & Khoja, 2012; Shaikh & Khoja, 2014; Yen et al., 2019). Happiness and experiencing a happy learning performance is a determining factor in achievement in the academic field. Thus, if students enjoy a positive learning experience with emotions associated with happiness or surprise, these learning experiences will contribute to the development of their metacognitive skills (Sidi et al., 2018) such as information organisation, goal settings while motivating their learning performance, and the application of appropriate learning strategies. Self-perception influences a person's motivation but at the same time, the emotional experience can vary depending on their perception of the causal structure (Kim et al., 2013). During the interviews, we noticed that when students feel comfortable and confident in their own digital skills, they focus on completing the task but on the other hand they show no interest in learning the use of a specific digital tool unless the new digital tools are in fact really necessary. This aligns with the influence of self-perception for the usage of digital skills in the learning process shown in previous research (Dittman et al., 2020; Ramírez & Barragán, 2018). Students learn how to use new digital tools and applications, not through the teacher's instructions, but by focusing on completing the task. In some cases, what is of greater importance to the student are the end results rather than the digital tools employed (Figure 4). Therefore, the PLE approach is characterized by being flexible and adaptive to students' metacognitive skills.

Feelings associated with anger and sadness have commonly negative learning experiences (see Appendix 2) and can even lower metacognitive processes (Cloude et al., 2020) and may, for example, lead to the student failing a class or even dropping out altogether. During the forethought phase, negative feelings should be taken into consideration, since negative learning experiences may have both short and long term consequences.

5. Conclusions

In this research, we analysed the role played by online students' emotions during the learning process for the construction of their PLE; we considered the importance of learning experiences whether positive or negative and how this may influence the development of students' PLE, and their metacognitive skills. While the qualitative data showed the importance of aspects such as students interaction with teachers and peers, academic and technical difficulties, self-perception and self-confidence, the quantitative data confirmed motivational issues for the successful usage of digital tools and applications during the learning experience in the performance phase of SRL. In addition, the development of metacognitive skills and emotions is clearly interrelated, which means

that the development of metacognitive skills in self-regulated learning is associated with feelings such as, rejection, feelings of happiness increase motivation, and feelings of sadness and fear are related to the developments of instrumental and pedagogical skills and abilities. The development of metacognitive skills and certain emotions and feelings are entangled in a complex network of sociomateriality that enables the construction of a PLE for long-life learning.

Data obtained showed that although different students may feel the same emotion, their emotional response can vary depending on previous experiences, and the identification of the type of locus of control and SRL skills also proved to be of great importance, as has been shown in other research studies. This aspect may be important for establishing learning strategies, although new research is necessary. In addition, we observed that PLE development is influenced mainly by what students learn during their academic task and has its basis in the formal environment, considering not only the institutional LMS but other digital tools and applications that students use to complete their task. A positive PLE is influenced by emotions, previous experiences, task instructions, access to learning resources, teacher interactions and institutional environments.

Based on the emotions that students feel while they develop their PLE, regardless of whether they are integrating a new digital tool, developing a new learning strategy, or establishing a new interaction, previous experiences will affect their decisions, as highlighted by Zimmerman's cyclic SRL model (2002). Past emotions and experiences both positive and negative, task difficulty and learning goals contribute to different emotional responses, so it is importance to consider the emotional aspect throughout the learning process.

The limitations observed during the study resided in the number of participants in the survey and the subsequent interviews, so in future studies it would be necessary to extend both the number of participants and learning modalities. Furthermore, since we observed that teachers represent one of the key elements during PLE construction and they play a paramount role as drivers for the development of learning experiences, we suggest that further research should include teachers as well as students and their role in general as well as their role specifically during the learning process and PLE construction should be explored with greater depth.

In the early days PLEs were considered as innovative and emerging trends although over the last decade they have come to represent a fundamental approach in addressing learning in hybrid environments, allowing students to harmonise experiences and aims into a process in which they can establish their agency by taking decisions, while considering their diverse individual elements, relations and contexts. In this vision, cognitive processes, under the approaches of self-regulated and autonomous learning have already been addressed in research (Castañeda et al., 2022). However, subjective aspects such as motivations, attitudes and beliefs along with feelings and emotions have previously tended to be unexplored and from a socio-material approach they are elements that must be considered as a relevant part of the PLE.

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Appendix 1

When I learn, how do I feel when I use digital tools and applications?		When learning on Internet, how do I decide what to learn?			
		According to the subjects as they arise	According to the skills and abilities I have.	According to the expected job needs I will have	According to to what I think my colleagues will demand
I have not problems	Pearson Correlation	0.045	-0.049	0.004	.248*
	Sig. (2-tailed)	0.688	0.662	0.968	0.024
	N	83	83	82	83
It let me be efficient	Pearson Correlation	0.183	0.089	0.137	.230*
	Sig. (2-tailed)	0.098	0.423	0.220	0.036
	N	83	83	82	83
I have a positive experience	Pearson Correlation	0.068	-0.067	-0.108	-0.012
	Sig. (2-tailed)	0.600	0.608	0.407	0.924
	N	61	61	61	61
It is useful	Pearson Correlation	-0.049	0.049	-0.008	-0.002
	Sig. (2-tailed)	0.709	0.709	0.949	0.988
	N	61	61	61	61
I enjoy learning	Pearson Correlation	0.068	-0.034	0.097	.303*
	Sig. (2-tailed)	0.603	0.793	0.459	0.018
	N	61	61	61	61
It is fun	Pearson Correlation	0.017	-.333**	-0.132	0.117
	Sig. (2-tailed)	0.895	0.009	0.312	0.369
	N	61	61	61	61
It is enjoyable	Pearson Correlation	0.013	-0.067	-0.039	0.121
	Sig. (2-tailed)	0.906	0.546	0.730	0.277
	N	83	83	82	83
I feel pleased	Pearson Correlation	0.074	-0.074	0.172	-0.041
	Sig. (2-tailed)	0.573	0.570	0.186	0.755
	N	61	61	61	61
I feel efficient	Pearson Correlation	0.201	0.118	0.203	0.164
	Sig. (2-tailed)	0.120	0.366	0.116	0.207
	N	61	61	61	61
It i s benefic for my tasks	Pearson Correlation	-0.004	0.100	0.074	0.180
	Sig. (2-tailed)	0.978	0.442	0.570	0.165
	N	61	61	61	61

					I chose digital tools and applications, when they are							
When I learn, how do I feel when I use digital tools and applications?		Neat	Symmetric	Clear	Nice	Complex	Original	Sophisticated	Fascinating	Beautiful	Flexibles	Easy to use	Easy to learn to use
I have not problems	Pearson Correlation	.414**	.240*	0.036	0.098	0.086	0.049	0.150	0.126	0.148	0.001	0.034	-0.137
	Sig. (2-tailed)	0.000	0.029	0.778	0.446	0.506	0.707	0.175	0.330	0.250	0.993	0.793	0.291
	N	83	83	62	62	62	62	83	62	62	62	62	61
It let me be efficient	Pearson Correlation	.358**	.246*	.291*	0.180	.444**	0.111	.241*	-0.178	0.106	.331**	.377**	.517**
	Sig. (2-tailed)	0.001	0.025	0.022	0.161	0.000	0.390	0.029	0.166	0.410	0.009	0.003	0.000
	N	83	83	62	62	62	62	83	62	62	62	62	61
I have a positive experience	Pearson Correlation	0.186	.480**	0.125	0.204	.371**	0.091	0.027	-0.012	0.155	0.243	0.144	0.175

RED. Revista de Educación a Distancia. Núm. 71, Vol. 23. Artíc. 3, 1-enero-2023

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	Sig. (2-tailed)	0.152	0.000	0.336	0.115	0.003	0.486	0.835	0.926	0.234	0.059	0.269	0.181
	N	61	61	61	61	61	61	61	61	61	61	61	60
It is useful	Pearson Correlation	0.024	0.192	0.251	.465**	.279*	-0.061	0.143	0.038	0.069	0.199	0.191	0.157
	Sig. (2-tailed)	0.857	0.139	0.051	0.000	0.029	0.640	0.270	0.774	0.595	0.125	0.141	0.231
	N	61	61	61	61	61	61	61	61	61	61	61	60
I enjoy learning	Pearson Correlation	-0.107	-0.009	0.106	.408**	0.066	0.150	0.062	-0.015	0.228	.289*	.388**	.332**
	Sig. (2-tailed)	0.410	0.943	0.417	0.001	0.611	0.248	0.635	0.907	0.077	0.024	0.002	0.010
	N	61	61	61	61	61	61	61	61	61	61	61	60
It is fun	Pearson Correlation	.312*	.636**	0.120	0.242	.363**	0.031	0.028	0.136	-0.026	0.104	-0.038	0.032

Metacognitive skills and emotions in the construction of Personal Learning Environments. Ramírez-Mera, U., Tur, G.

Página **2** de **27**

	Sig. (2-tailed)	0.014	0.000	0.356	0.060	0.004	0.815	0.832	0.295	0.841	0.426	0.771	0.810
	N	61	61	61	61	61	61	61	61	61	61	61	60
It is enjoyable	Pearson Correlation	.383**	.735**	0.184	.285*	.636**	-0.085	0.136	0.125	0.026	0.232	0.067	0.091
	Sig. (2-tailed)	0.000	0.000	0.153	0.025	0.000	0.513	0.221	0.332	0.841	0.070	0.602	0.487
	N	83	83	62	62	62	62	83	62	62	62	62	61
I feel pleased	Pearson Correlation	-0.007	0.230	0.091	0.158	.308*	0.231	-0.051	-0.065	0.049	.341**	0.209	.312*
	Sig. (2-tailed)	0.957	0.074	0.486	0.224	0.016	0.073	0.694	0.620	0.710	0.007	0.105	0.015
	N	61	61	61	61	61	61	61	61	61	61	61	60
I feel efficient	Pearson Correlation	-0.079	-0.013	0.163	0.181	.318*	0.158	-0.133	-0.216	0.215	0.242	.280*	.347**

	Sig. (2-tailed)	0.547	0.919	0.209	0.163	0.012	0.223	0.305	0.094	0.096	0.060	0.029	0.007
	N	61	61	61	61	61	61	61	61	61	61	61	60
It is benefit for my tasks	Pearson Correlation	-0.183	-0.082	0.162	.458**	0.247	.289*	0.097	-0.059	0.250	0.226	.390**	.350**
	Sig. (2-tailed)	0.157	0.530	0.211	0.000	0.055	0.024	0.459	0.654	0.052	0.079	0.002	0.006
	N	61	61	61	61	61	61	61	61	61	61	61	60

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).
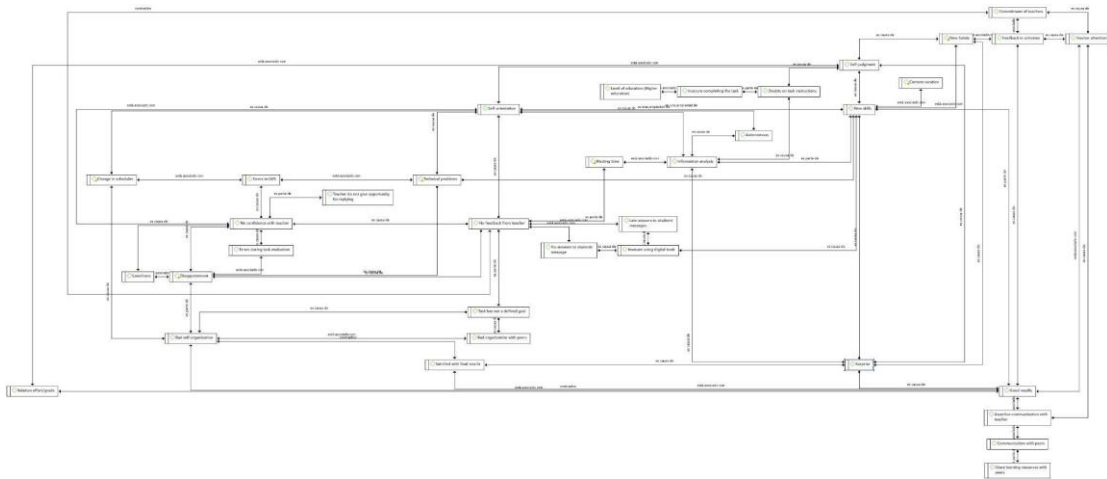
Appendix 2

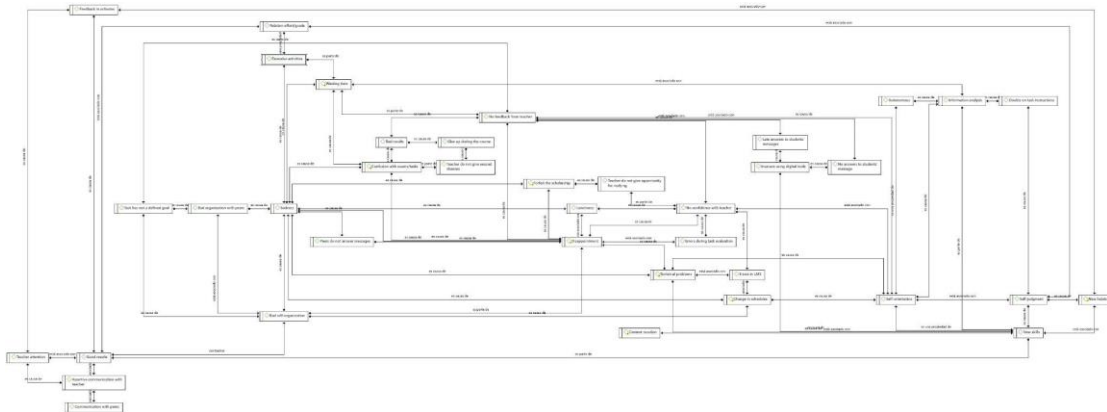Figure 1. Network of emotional responses related to surprise emotions.

Figure 2. Network of emotional responses related to sadness emotions.
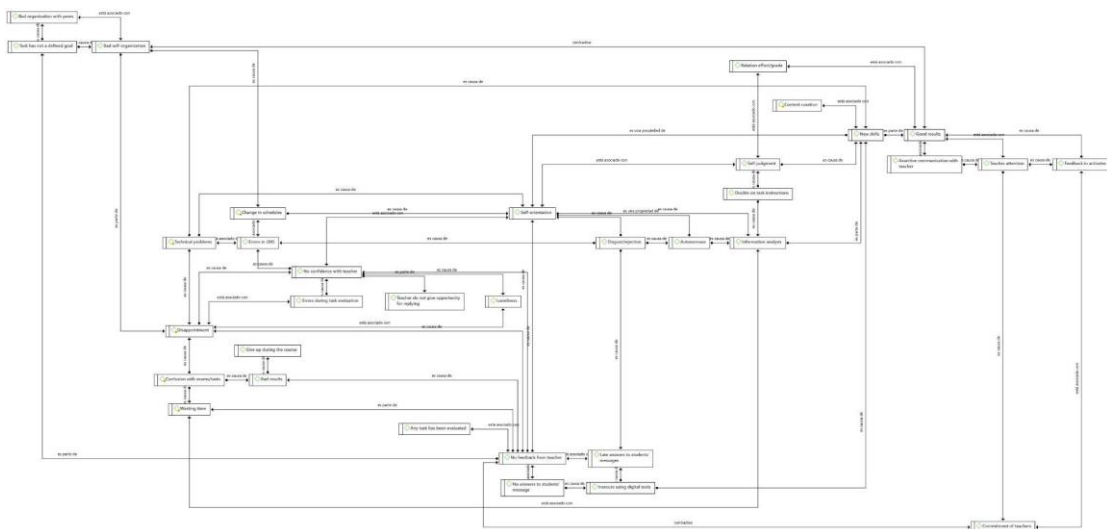
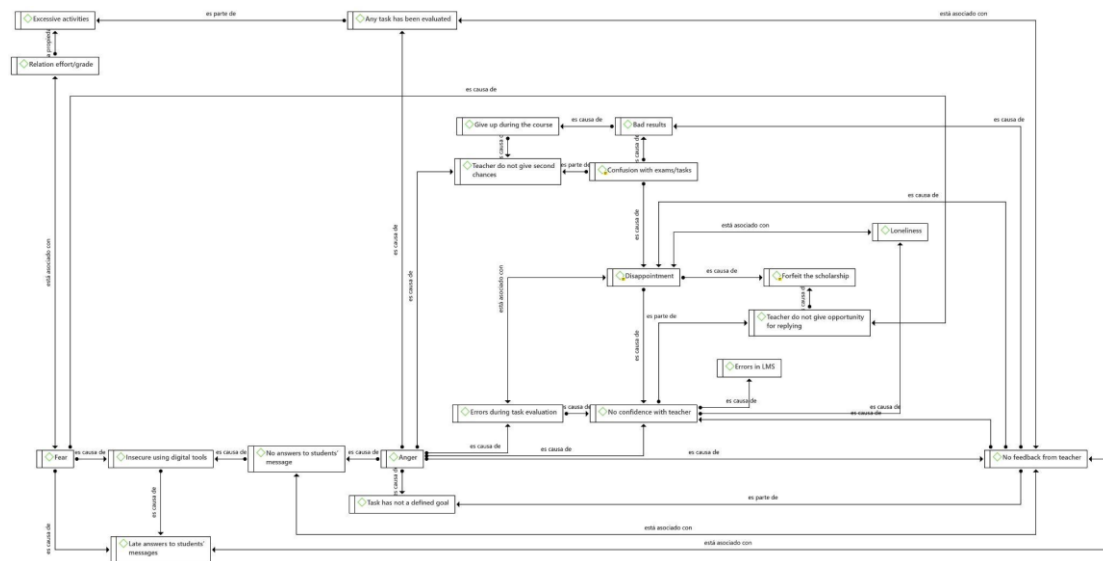Figure 3. Network of emotional responses related to disgust/rejection emotions.

Figure 4. Network of emotional responses related to anger emotions.