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Evaluating the Impact of Emotional and Cognitive Interference on Self-Regulated Learning

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Abstract: The current study looked at the connections between emotional, self-regulated learning (SRL) technique utilisation, and course completion in the domain of computer science. 233 undergraduate students in the School of Science and Computer Studies (SSCS) of computer science course (mean age: 20.6 years) made up the sample. The Positive and Negative Emotions Schedule (PANES) and the Cognitive Interference Questionnaire (CIQ) were administered to the individuals. Additionally, they finished the MSLQ's Learning Strategies Scales. Exam results served as a gauge of student mastery of the material. Positive emotions positively influenced the use of nearly all of the SRL methods, according to Pearson correlations and path analysis, while negative emotions was favourably connected to cognitive interference. The only SRL tactic to predict the success of computer science course didactics was elaboration. Finally, it was discovered that cognitive distraction was a poor predictor of course completion.

1. Introductıon

Self-regulated learning (SRL) is a concept that places an emphasis on the learner's active engagement in establishing learning goals and ensuring that those goals are met [1-4]. In academic settings, it is considered that self-regulated learning consists of taught skills rather than abilities that are fixed or inherited [2]. Because of this, different components of SRL have frequently been conceptualised as being situational and context-dependent, while the relationship between SRL and certain trait-like features has received less focus [5, 6]. Various systems and processes that monitor and regulate behaviour, including cognition, metacognition, motivation, emotions, and volition, are universally acknowledged in SRL research [1, 7, 8]. Efklides [1] and Winne [3] claim that there are two ways to define the interactions between the various SRL components: macro- and micro-levels. The macro-level representations of metacognition, motivation, and emotions (such as metacognitive knowledge, positive and negative emotions, ability beliefs, etc.) [2] that are functional across tasks or situations depend on how well SRL processes are functioning.

In other words, rather than being task-specific or micro-level, SRL is thought of as domain-specific but at a generalised level (such as self-efficacy in computer science, emotions raised in a particular course, etc.). According to Efklides [1], the macrolevel, or "Person" level, consists of a person's cognitive, metacognitive, motivational, emotional, and volitional traits. There has been a lot of focus on motivational personality traits in current SRL research, but less on emotions. According to the "metacognitive and emotions model of self-regulated learning" (the MASRL model), there are connections between individual traits and micro-level processes. In particular, it is hypothesised that emotions and motivation have an impact on metacognition, including metacognitive knowledge (MK) and metacognitive strategies (MSs). This study conceptualised emotions in terms of positive emotions, negative emotions, and cognitivism because there isn't an exhaustive list of emotions person

traits in the MASRL and because, despite the remarkable progress in the concept of self-regulated learning, there are still a number of unanswered questions about the role of emotions (general moods and specific emotions), which, aside from test anxiety [9], isn't yet fully understood [10, 11]. Focusing on emotions is crucial because its function in SRL needs to be made clear.

The proposed SRL model by Pintrich [12] of self-regulated learning, which divides learning strategies into three general categories: cognitive learning strategies, metacognitive control or self-regulation strategies, and resource management strategies, such as managing and controlling one's own time, effort, study environment, etc., was also of interest to this study. Since it has been demonstrated that qualities of self-regulated learners are favourably related to their academic accomplishment and the quality of their learning, the significance of academic self-regulation in college students is well established [13–15]. The effects of positive emotions, negative emotions, and cognitive interference are discussed in more detail in the sections that follow, along with research on how these factors relate to SRL techniques and academic success. The empirical study examined the relationships between trait positive emotions, trait negative emotions, state test anxiety (state cognitive interference), self-reported strategy use, and course attainment in computer science course in a sample of students from the SSCS.

1.1 Positive and Negative Emotion

Positive emotion (PA) and negative emotion (NA), two broad and largely uncorrelated components that have consistently emerged as the primary characteristics of emotional experience, are frequently composed of other emotions and moods [16]. Additionally, they show consistency across a range of descriptor sets, answer formats, time frames, languages, and cultural contexts [17]. Watson et al. [16] reported low to moderate correlations between the Positive Emotion and the Negative Emotion Scales of the 20-item Positive and Negative Emotion Schedule (PANES), ranging from -.12 to -.23, with other studies reporting similar findings [18], which raises the question of whether it is appropriate to regard the constructs of PA and NA as relatively independent. Additionally, using CFA, two virtually orthogonal dimensions of happy feeling and negative emotion were reported for both the 20-item and 10-item versions of the PANES (r = -.30 and r = -.10). The results from the CFA modelling are consistent with the results of the EFA and have demonstrated that the positive emotion and the negative emotion are distinct and largely independent dimensions [19]. This is true even though there have only been a small number of studies using the 20-item PANES in nonclinical samples that have used CFA. These more general constructs have been used in the majority of earlier studies on achievement goals and emotions, with PA being measured as an omnibus variable comprising emotions like enjoyment, pride, and satisfaction, and NA being measured as an omnibus variable comprising emotions like anxiety, frustration, and sadness [2, 17].

1.1.1. Emotion, Study Approaches, and Academic Success: Despite the paucity of study, several conclusions have been made regarding how emotion plays a role in self-regulation. First and foremost, emotional elements favour a person's capacity to focus on the process of achieving their goals [11]. In other words, both our cognitive and motivational systems are guided and regulated by emotion [10]. Emotion can also alter the workload on the working memory by diverting cognitive resources from the academic activity. There has also been less emphasis on emotion in research on computer science education, yet there is some consensus despite the variety of approaches: Cognition processes emotions in a variety of ways. They emotions memory and focus. They are thought to be functional, stimulate action tendencies, and play a crucial part in human coping and adaptability [20]. Two study trends support the idea that students' emotions emotions their academic performance [10]. Emotional states have an impact on cognitive and motivational processes that are important for cognitive accomplishment, according to experimental mood studies in particular. Particularly, it has been discovered that moods and emotions facilitate the processes of mood-congruent memory [21]. that is, although negative emotion might raise the mood-congruent avoidance motivation, happy emotion can improve incentive to approach tasks.

Additionally, emotions may emotions the choice of a strategy or other aspects of self-regulation [11]. Positive emotion promotes the creative, flexible, and holistic way of thinking, which has more beneficial effects for more heuristic processing. This is especially true in the context of experimental mood research, where findings suggest that negative emotion may lead to more analytical, detailed, careful, and rigid ways of processing information [10, 22, 23]. The foregoing research has some important limitations, though, including the fact that it has largely concentrated on attitudes and social judgements rather than the academic content of learning. There is undoubtedly a second study movement that looks at students' feelings in academic contexts. However, the majority

of the research on this tendency has focused on test anxiety [9] and has demonstrated that anxiety reduces performance on challenging or complicated activities that need available cognitive resources. This is because emotional factors—and therefore exam anxiety—can alter the amount of work that must be done in the working memory by consuming resources that could be used to complete academic tasks. Numerous studies have shown that having high test anxiety negatively emotionss learning and achievement across a range of age groups and academic disciplines [24]. This influence is also confirmed in the computer science field [25–30].

According to Pekrun and his colleagues' research [35, 36], which examined the relationships between particular test emotions and academic achievement, there is a negative correlation between anxiety and achievement. There is little research on how emotions, including worry, emotions achievement. Although there is some inconsistency in the relationship between general positive emotion and achievement [37], specific positive test emotions have been found to positively emotions achievement [28, 35] because they support the use of strategies, motives, cognitive resources, and self-control.

1.2. Cognitive Interference as a Cognitive Aspect of Test Anxiety

Emotional constructions can be connected to transient emotional occurrences and moods or to innate propensities for experiencing transient emotions and moods. Trait emotions and trait emotionivity refer to an individual's dispositional predisposition towards experiencing either particular emotions or even pleasant vs negative emotions generally [35, 36]. According to this viewpoint, to describe someone as test-worried means that they have a propensity to view the testing circumstance in a way that typically results in feeling anxious. The momentary context-specific assessments, emotions, and techniques that appear during a person-environment interaction are referred to as state test anxiety, on the other hand [11].

Cognitive, emotional, and behavioural components all play a part in the multidimensional construct known as test anxiety. Each aspect is understood to represent a different way that test anxiety may be displayed in response to testing circumstances. The cognitive aspect of test anxiety is made up of worry, self-preoccupation, and cognitive interference [9]. Thoughts that are unwelcome, disagreeable, and upsetting are referred to as intrusive thoughts in the context of cognitive interference. Cognitive interference is the term for thoughts that interrupt and surface during exams but are not useful for completing the current cognitive task. High-test-anxious participants are more likely to exhibit interfering cognitive responses, which divide attention between the self and the task, when they are presented with tough or difficult tasks. To distinguish between on- and off-task thoughts—those that represent task participation and are directed towards task completion—and those that are not, is a difficulty for researchers who study cognitive interference [40]. Students who are test worried may also be distracted by task-generated thoughts and other irrelevant task-related factors (such as the amount of time left to finish the exam, the difficulty of the task, or their level of proficiency), in addition to task-irrelevant thoughts.

1.2.1. Cognitive interference and academic success: All have the same outcomes. When measured as state cognitive interference, task-related worries are more accurate predictors of performance than task-irrelevant thoughts. This is in line with other data showing a negative correlation between generalised tendency to worry about a task and task performance in test-like settings. Task-related anxiety, evaluated as state cognitive interference, and performance on mathematical tasks have been reported to have varying strengths and to be either direct or indirect [9, 26, 27, 40]. Exam-anxious candidates may use less effective techniques to complete the task at hand as they become focused with irrelevant tasks. Additionally, some research has shown that test anxiety levels are positively correlated with task-generated interference [9]. Scholarly interest in the correlation between utilization of cellphone and students' performance in the classroom has been on the rise over the past decade, as seen by the proliferation of relevant papers. n addition, physically incapacitated kids may never have square with opportunities to go to class. In like manner twists up clearly essential to examine how to make innovation empowered learning conditions that empower poeple to go to classroom while thay are a long way from the premises. Students who experience test anxiety at all levels of education frequently score worse on standardised exams and get worse grades [34] than they should because anxiety and other test-taking issues negatively emotions their performance, either directly or indirectly.

1.2.2. Cognitive interference and unfavourable emotion: According to research, there is a strong correlation between unpleasant emotion and task-irrelevant thinking [38, 39]. According to Ellis and Ashbrook's resource allocation hypothesis [43], negative emotion increases the number of task-unrelated thoughts, which overload working memory and lower the available cognitive capacity [38]. In conclusion, there is reason to believe

that negative emotion as a trait can predict cognitive interference as a state in the computer science teaching course attainment in universities given the emphasis of the resource allocation model on both negative emotion and task-irrelevant thoughts. Addiction is typically associated with the use of drugs, alcohol, or any other substance, which leads to an individual's excessive use of the aforementioned things and a variety of negative health impacts. According to research done so far, internet addiction is defined as an excessive, unhealthy use of the internet and related technologies. Furthermore, it is unclear if task-irrelevant thoughts constitute a separate mediator of the deleterious effects of negative mood on performance.

1.3. Mathematical performance and self-regulated learning approaches

Self-regulation as an event suggests that self-regulated learning takes place in specific contexts and that associations between the use of SRL (cognitive, metacognitive, and resource management) strategies and academic achievement vary depending on the subject area. As a result, self-regulation as an event suggests that self-regulated learning should be investigated at the course level, that is, for each individual discipline or study subject [44, 45]. According to Duncan and McKeachie [46], students' usage of strategies is dependent on the nature of the academic activity, and Pintrich [2] claimed that there is no self-regulating technique that works equally for all people and for all tasks. Particularly, it appears that cues from the learning task and environment influence the cognitive component of SRL, such as the application of cognitive strategies [47]. According to research, social studies classrooms were less engaging and more regimented, linear, and structured [48]. Cognitively, math problems were frequently less interesting than the more varied and open-ended social studies problems. These results suggest that the type of cognitive strategy that must be employed depends on the context in which the learning activity is embedded. However, some researchers have found a substantial inverse relationship between students' final statistics, geometry, and computer science course grades and their use of deep learning strategies (such as organisation, elaboration, and critical thinking) [49–51]. In conclusion, the literature evaluation on SRL strategies demonstrates a patchy relationship between the usage of SRL strategies and academic success in the area of computer science. However, none of the aforementioned research incorporated activities for teaching computer science. Therefore, the question is whether the usage of SRL strategies is associated with university students' course performance in the field of computer science didactics.

1.4. Objective

The objective of the current study was to investigate the relationship between emotion (i.e., trait positive emotion and trait negative emotion) and cognitive interference (i.e., task-oriented worries as state), the use of SRL strategies (i.e., cognitive, metacognitive, and resource management), and academic performance in university students.

The MASRL model [1] predicts the following interactions between each of the aforementioned person attributes and the SRL strategies: It is considered that both positive and negative emotions, as well as cognitive interference, are related to metacognition in the form of metacognitive strategies (MSs) and learning strategies, which represent the individual's typical methods for managing cognition and learning.

It was specifically hypothesised that the employment of cognitive, metacognitive, and self-regulating methods will be linked to both trait positive emotion and trait negative emotion with regard to emotion (Hypothesis 1). We hypothesized that trait positive emotion will be positively correlated with the use of learning strategies (Hypothesis 1a) based on the research of Bless et al. [22], Fiedler [23], Malmivuori [28], and Pekrun et al. [35, 36]. However, because the relationships between negative emotion and the SRL strategies are more complex, we predicted either no associations or low negative associations based on the research of Magno [39].

It was proposed that learning techniques would operate as a mediator between the impacts of positive and negative emotion on academic achievement since trait features are more remote from performance than the use of learning strategies. In particular, since numerous studies [5, 32, 49] have demonstrated that different aspects of each one of the three general categories of SRL strategies (cognitive, metacognitive, and resource management) emerged as good predictors of performance in computer science, trait positive and negative emotions were anticipated to have an indirect effect on course attainment mediated by use of cognitive, metacognitive, and resource management strategies (Hypothesis 2).

The resource allocation model of Ellis and Ashbrook [43] and the findings of Linnenbrink et al. [38] and Magno [39] predicted that negative emotion as a characteristic would be favourably correlated with cognitive interference as a state (Hypothesis 3a). We hypothesised that the effects of negative emotion on academic

performance will be moderated by cognitive interference because trait variables are more remote from performance than state features (Hypothesis 3b). It was hypothesised that cognitive interference, a cognitive component of test anxiety, will have a detrimental impact on course completion (Hypothesis 4), either directly [24, 25, 28–30] (Hypothesis 4a) or indirectly [25–27] through the employment of learning strategies [1, 9] (Hypothesis 4b). Finally, we anticipated either no associations or modest negative associations between the separate categories of positive emotion and negative emotion (Hypothesis 5) based on the research of Crawford and Henry [18], Tellegen et al. [19], and Watson et al. [16].

2. Methodology

2.1 Participants

180 undergraduate students who were enrolled in a computer science didactics course at the SSCS at The Federal Polytechnic Ado Ekiti, Nigeria (131 males and 102 females; mean age = 20.6 years; SD = 2.5) made up the sample. 76.44% of the course's students voluntarily participated in the study, which was open to everybody.

2.2 Instruments

2.2.1 Positive and Negative Emotion Schedule (PANES): The PANES [16] is a self-report survey that has two 10-item scales: one for positive emotion and the other for negative emotion. Moraitou and Efklides translated the PANES into English for a prior study and evaluated its construct validity [55]. Participants were asked to rate how much they generally felt each item's description. Responses ranged from 1 (very few or never) to 5 (too many times) on a Likert-type scale.

Trait Positive Emotion and Trait Negative Emotion were the two PANES variables whose internal consistency was satisfactory, with Cronbach's α = .81 and .86, respectively.

2.2.2 The Cognitive Interference Questionnaire (CIQ): The CIQ [41] can be used as a state measure of cognitive interference because it gives an index of intrusive thought in a particular context. The CIQ is a 22-item questionnaire created to assess, after performance on a task, how often participants had different kinds of thoughts while working on it and how much they were perceived as interfering with concentration. Task-oriented worry and off-task thoughts are the two sorts of thoughts that the CIQ measures, according to its creators [41]. In the current investigation, the task-oriented concerns dimension was applied. On a 5-point scale ranging from 1 (never) to 5 (very often), participants were asked to rate how often task-related thoughts interrupted them as they worked on their exam for the didactics of computer science course. Cronbach's α was deemed acceptable:.77.

The first author translated the first 10 items of the CIQ into English for the purposes of a previous study, and the single factor structure of the English version of the CIQ's task-oriented worries dimension was confirmed with CFA [56]. These items provided post-performance reports of the frequency of occurrence of task-oriented worries.

2.2.3 The Motivated Strategies for Learning Questionnaire(MSLQ): As a gauge of self-regulated learning, Pintrich et al. [57] created the MSLQ. The MSLQ is divided into two sections: learning strategies and motivating strategies. University students' utilisation of various learning strategies in college courses was evaluated in this study using the learning strategies section. 50 items make up the MSLQ's learning strategies section, which is broken down into nine subscales to measure rehearsal, elaboration, organisation, and critical thinking (which represent the cognitive and metacognitive aspects of self-regulated learning), as well as environment and time management, effort regulation, peer learning, and help seeking (which represent the management aspect of self-regulation). Responses are given on a 7 point Likert scale with 1 being the least true of me and 7 being the most true of me. In the subscale that measures elaboration, an example may be, "When reading for this class, I try to relate the material to what I already know." "When I study for this class, I set goals for myself in order to direct my activities in each study period," is an example from the subscale used to test metacognition. As an illustration, consider the statement "I usually study in a place where I can concentrate on my course work" from the subscale used to assess study environment management. For the sample of the current investigation, Cronbach's α also matched those of Pintrich et al. [57] (provided in parenthesis): .65 (.78) for rehearsal; .59 (.71) for elaboration;.84 (.74) for organization;.75 (.85) for critical thinking;.79 (.86) for metacognition; .85 (.86) for environment and time management;.78 (.89) for effort regulation;.78 (.87) for peer learning; and.67 (.72) for asking for assistance.

2.2.4 Course Attainment: The final course grade that the students received, which was transformed to a 10-point scale (M 4.52; SD = 2.30), was used to determine the students' course attainment in the didactics of computer science. The final course grade was determined by (a) an essay (maximum score: 3) and (b) a test, which was given at the end of the semester and required memorization of knowledge from textbooks (maximum score: 7).

2.3 Procedure

The use of human subjects in the research was authorised by the institution. All participants supplied informed consent, were given the assurance of secrecy, and were given code numbers in order to maintain their identities. In the classroom, surveys were administered. At the start of the semester, the PANES was given. Prior to answering the questionnaire, participants also submitted demographic data, such as their age, gender, and class level. The CIQ was given after their final test in the computer science didactics course, while the MSLQ was given at a session at the end of the semester.

2.4. Statistical Evaluation.

In addition to using route analysis, a structural equation modelling (SEM) technique for analysing structural models using observed variables, Pearson correlations were generated in order to analyse the relationships between the various components of the study. The various scales were combined into sum scores. In particular, a path analysis with manifest variables was performed to test the model illustrating the hypothesised correlations between the subscales of positive and negative emotionss, cognitive interference, SRL strategies, and course attainment in computer science didactics. The general rule is that personality traits are relatively enduring, so when an association is found between a trait (such as positive and negative emotions) and a specific behaviour (such as reaching one's goal), it is reasonable to assume that the trait caused the behaviour rather than the other way around. However, it is undoubtedly true that the accomplishment of specific goals (e.g., passing an exam) may enhance one's level of trait positive emotions and trait negative emotions. Therefore, graded performance, state cognitive interference, and the nine self-regulated learning techniques were regarded as domain-specific factors, while the two emotional components were handled as trait-like variables.

3. Results

Table 1 displays a correlation matrix between course completion in Computer sciencema, positive and negative emotions, cognitive interference, and SRL methods. Figure 1 shows the path model that was confirmed. The dotted lines represent the effects of the domain-specific factors directly on course completion. As predicted by (H1) and (H1a), the utilisation of a variety of cognitive, metacognitive, and resource management strategies was associated with trait positive emotions. With the exception of critical thinking, it was specifically favourably associated with the application of all cognitive, metacognitive, and resource management methods. In other words, the employment of the SRL techniques increases as trait positivity increases. It also appears that a student's trait good emotions may be advantageous to performance (H2) because all of the cognitive, metacognitive, and resource management strategies—aside from practise and peer seeking—were positively connected with course accomplishment. However, path analysis, while elaboration was the only SRL technique discovered to be positively related to course accomplishment (explained variance: 11–12%) (H2), did not reveal this interesting Pearson correlation result.

Contrary to (H1) and (H2), trait negative emotions was not correlated with SRL strategy use or performance, either directly or indirectly through control of SRL strategy use. It appears that trait negative emotions neither supports nor hinders the employment of the SRL technique in the subject matter domain of teaching computer science (H1b). Trait negative emotions was positively related to cognitive interference and, through this, adversely related to course accomplishment, as hypothesised in (H3a) and (H3b). The degree to which a student experienced task-oriented worries while working on the examination tasks and the degree to which these thoughts are viewed as interfering with concentration seem to be explained by a student's trait negative emotions (explained variance: 18–19%), which is translated into lower graded performance.

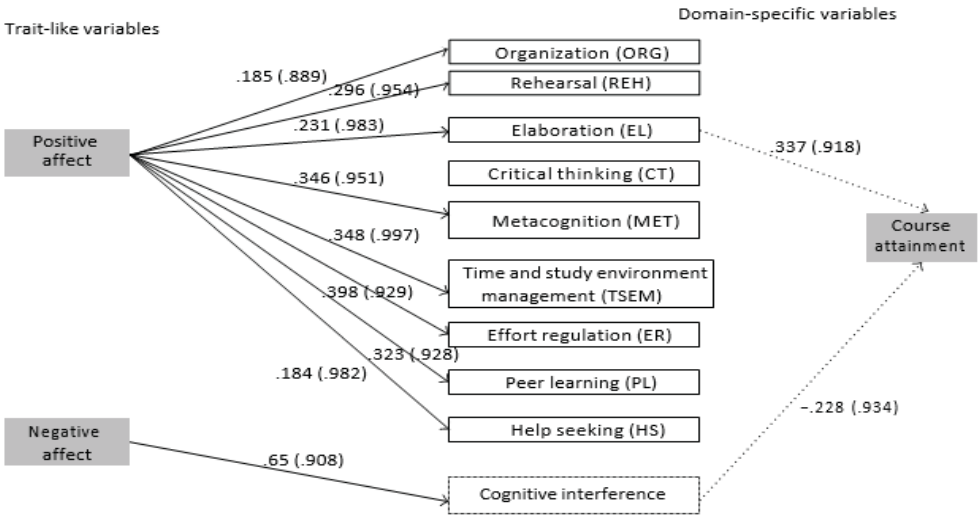

Fig 1: The final path model displaying the relationships among negative affect, positive affect, cognitive interference, self-regulated learning strategies, and course attainment in the didactics of mathematics subject matter

State cognitive interference was discovered to be directly and adversely associated to course completion (explained variance: 4%), as hypothesised in (H4a). Contrary to (H4b), nevertheless, it was not discovered that cognitive interference was indirectly related to performance via regulation of the use of SRL strategies since, other from a positive association with rehearsal, there were no relationships between SRL strategies and task-oriented anxieties. Finally, contrary to (H5)'s hypotheses, no correlation between positive and negative impacts was discovered. This result is in line with the results of the PANES creators, who discovered that the instrument's dimensions of positive and negative emotions are separate and mostly independent from one another.

Table 1: Zero-order correlations among negative affect, positive affect, cognitive interference, self-regulated learning strategies, and course attainment in the didactics of mathematics subject matter

	Negative affect (NA)	Positive affect (PA)	Cognitive interference (CI)	Organization (ORG)	Rehearsal (REH)	Elaboration (EL)	Critical thinking (CT)	Metacognition (MET)	Time and study environment management (TSEM)	Effort regulation (ER)	Peer learning (PL)	Help seeking (HS)	Course attainment (CA)
NA	1.00												
PA	-.14	1.00											
CI	.45**	-.12	1.00										
ORG	.00	.22*	.09	1.00									
REH	.11	.29**	.21*	.62**	1.00								
EL	.00	.23*	.05	.52**	.48**	1.00							
CT	-.05	.15	.05	.29**	.28**	.62**	1.00						
MET	.07	.38**	.10	.50**	.58**	.61**	.52**	1.00					
TSEM	-.12	.30**	-.06	.41**	.52**	.38**	.14	.47**	1.00				
ER	-.13	.31**	-.06	.40**	.44**	.40**	.21**	.53**	.66**	1.00			
PL	.11	.30**	.08	.23**	.26**	.39**	.32**	.38**	.12	.12	1.00		
HS	.13	.20*	.06	.12	.13	.24**	.23**	.29**	.13	.06	.63**	1.00	
CA	-.13	.12	-.23**	.18*	.11	.36**	.22**	.21*	.28**	.26**	.23**	.04	1.00

Note: *P = .05 (2-tailed), **P = .01 (2-tailed).

4. Discussion

The current study concentrated on 3 of the student characteristics—namely, positive emotions, negative emotions, and cognitive interference—on self-regulated learning. This study demonstrated that

significant trait-like qualities, such as trait positive and trait negative emotions, and domain-specific characteristics, such as state cognitive interference, are connected to SRL strategies and course attainment.

The findings of the current study demonstrate that personality predispositions have an impact on SRL strategy utilisation and academic accomplishment in some contexts [1, 5], without undermining the idea that SRL abilities can generally be learned. As both of them seem to be linked to metacognitive knowledge in the form of strategies (the SRL cognitive, metacognitive, and resource management strategies), which one tends to use when dealing with a task (for example, a didactic of computer science course examination essay), emotions and cognitive interference can lead to decisions regarding top-down self-regulation [1]. These results support the significance of emotional elements in self-regulated learning and the predictions made for the individual characteristics by the MASRL model.

4.1. Positive effects on the use of the SRL strategy and course completion.

Positive emotions obviously stands out as a potent predictor when it comes to the predictive potential of positive and negative emotions for the application of the SRL method. Particularly, it was discovered that positive emotions favourably influenced the usage of the majority of cognitive, metacognitive, and resource management methods in the domain of computer science didactics. In a didactics of computer science undergraduate course, it appears that students with positive emotions are more likely than their counterparts who lack positive emotions to use a greater variety of self-regulated learning strategies to learn new and advanced material and apply concepts to problem solving and scientific inquiry.

The above finding is consistent with the literature showing that positive emotions benefits students' achievement in a significant test, such as a test in the didactics of computer science course, reinforcing the efficient use of self-regulated learning strategies [28, 35, 36]. Elaboration, a higher order cognitive strategy, was found to be positively associated with course attainment in computer science teaching. Therefore, when interventions are created to teach college students how to be self-regulated learners, the encouraging effect of the positive emotions on the adoption of the SRL approach should be taken into consideration.

4.2. Effects of Negative Emotions on the Use of SRL Strategies and Course Attainment.

Negative emotions, in contrast to positive emotions, was not linked to the adoption of any SRL method. Negative emotions, which in the current study was designated as a broad variable and included feelings like worry, frustration—which is one of the causes of anger—and shame—was found to have no effect on performance when SRL methods were employed. These findings are supported by Pekrun et al.'s [35, 36] argument that the impact of anxiety [9], as well as that of anger and guilt on achievement, need not always be detrimental. For certain people and under certain conditions, it might be proven to be beneficial or even neutral for project success.

4.3. Effects of the SRL Strategy on Course Attainment.

The only SRL approach that was found to predict graded performance in computer science education was elaboration, despite the fact that practically all of the SRL strategies were found to be positively connected with it. This result is in line with earlier studies that found that while high course performers frequently reported using more deep SRL cognitive strategies (like organisation, elaboration, and critical thinking) than low performers [60, 61], the use of these strategies did not always predict success in college science courses [29, 32, 52, 53]. It appears that early childhood education majors who have a propensity for efficiently paraphrasing and summarising the course material will likely fare better than their peers in a didactics of computer science undergraduate course. Wolters and Pintrich [30] showed that although academic achievement and the use of self-control (metacognitive) strategies were similar for male and female students in computer science, the social sciences, and English, female students used more metacognitive strategies overall. These results can be linked to test anxiety: anxious students were more likely to use cognitive techniques but less likely to use self-regulating (metacognitive) strategies and more likely to receive poorer grades [30]. Similar to those students, participants in the current study used a higher level of elaboration; yet, their final course grade was very low (converted to a 10-point scale, M = 4.62), and it was discovered that state cognitive interference negatively influenced their course accomplishment (explained variance: 4%).

4.4 Relationships between negative emotion and cognitive interference.

The current study's intriguing conclusion relates to the positive correlation between trait negative emotions and state cognitive interference. Negative effect as disposition, which has been designated and measured as a broad variable and comprises feelings like worry and annoyance, has already been mentioned [2, 35, 36]. Given that state cognitive interference, a cognitive aspect of test anxiety, is defined as an immediate emotional state that occurs before or during a specific test [9], it is likely that more general tendencies like trait negative emotions and/or test anxiety as personality traits account for a large portion of its variance. The specific findings and the indirect (through state cognitive interference) negative effects of trait negative emotions on achievement in the didactics of computer science course also fit within the framework of the resource allocation theory [43], which states that trait negative emotions increases the number of intrusive thoughts, which overload working memory and reduce the amount of available cognitive resources. Generally speaking, the cognitive-attentional (interference) model, which links test anxiety with deficiencies in retrieval of previously learned information, is consistent with the lack of relationships between SRL techniques and cognitive interference.

5. Limitation of the study

Since the MSLQ does not adequately reflect participants' actual usage of SRL technique, this study's self-report self-regulatory abilities measure has lower validity. Self-regulated learning data is a more precise way to measure processes connected to SRL. Since behavioural and observational measures of self-regulation (such as real-time measurements of learning strategies, think-aloud protocol data, or video-based assessment of strategy use) cannot be used to directly measure academic self-regulation, more rigorous designs are required. It's important to keep in mind how limited the sample was, particularly in terms of age and gender. Additionally, it is unknown if results would follow the same pattern if college students from subjects other than early childhood education were engaged.

6. Conclusion

Our research suggests that emotions, a general tendency, has distinct effects on students' usage of SRL strategies and academic achievement in the field of computer science didactics. Future studies should clarify how emotional factors predispose people to use SRL (how emotional factors encourage or discourage people to become self-regulating learners) and how these dispositions interact with learning situations to develop useful self-regulation strategies in various college student groups and age groups. Future study will also benefit from examining the various specialised emotions that arise in the academic setting, such as hope, pride, rage, and shame, and evaluating the potential contributions that these emotions may make to self-regulated learning.

References

[1] Kesuma, A. T., Harun, Z., Putranta, H., & Kistoro, H. C. A. (2020). Evaluation of the self-regulated learning model in high schools: A systematic literature review. *Universal Journal of Educational Research*, *8*(10), 4792-4806.

[2] Hamidi, S., & Ghafournia, N. (2021). Investigating the relationship among Iranian EFL teachers' self-regulation, effective teaching, gender, and teaching experience. *International Journal of Foreign Language Teaching and Research*, *9*(35), 167-186.

[3] Draper, S., & Maguire, J. (2023). The different types of contributions to knowledge (in CER): All needed, but not all recognised. *ACM Transactions on Computing Education*, *23*(1), 1-36.

[4] Ajibade, S. S. M., Ahmad, N. B., & Shamsuddin, S. M. (2019, August). An heuristic feature selection algorithm to evaluate academic performance of students. In *2019 IEEE 10th Control and System Graduate Research Colloquium (ICSGRC)* (pp. 110-114). IEEE.

[5] Babakhani, N. (2014). The relationship between the big-five model of personality, self-regulated learning strategies and academic performance of Islamic Azad University students. *Procedia-Social and Behavioral Sciences*, *116*, 3542-3547.

[6] Cui, T., Cheng, E. H., Kam, C. C. S., & Liu, Q. (2023). A Moderated Mediation Model of Socio-Economic Status, Hope, Teacher-Student Relationship, and Autonomous Learning among Chinese Middle School

Students. *Child Indicators Research*, *16*(2), 671-688.

[7] Bakaç, C., & Kehr, H. M. (2023). Unpacking the Relationship between Fear Motives and Self-Control Strategies among Managers: The Mediating Role of Intrusive Thoughts. *Behavioral Sciences*, *13*(5), 384.

[8] Ajibade, S. S. M., Dayupay, J., Ngo-Hoang, D. L., Oyebode, O. J., & Sasan, J. M. (2022). Utilization of Ensemble Techniques for Prediction of the Academic Performance of Students. *Journal of Optoelectronics Laser*, *41*(6), 48-54.

[9] Saeed, N., Zare, H., Moosapour, N., Sarmadi, M., & Hormozi, M. (2023). The Study of Relationship Between Studentsâ Cognitive and Meta-cognitive Strategies and Interactions in Virtual Education with Academic Achievement. *Research and Planning in Higher Education*, *16*(4), 73-96.

[10] Sucuoğlu, H. (2022). The Relationship Between Pre-Service Teachers' Online Self-Regulation Skills and Cognitive Emotion Regulation Skills. *Education Quarterly Reviews*, *5*(4).

[11] Shi, Y., Chen, L., Jia, K., Qu, Z., & Yang, H. H. (2022, July). Investigating Human Side Factors on Middle School Students' Self-Regulated Learning in the Smart Classroom Environment. In *2022 International Symposium on Educational Technology (ISET)* (pp. 301-305). IEEE.

[12] Rozsypalkova, J., Brzobohata, H., & Nedoma, R. (2021). Self-regulated learning of Czech military professionals in relation to their age, language proficiency and educational attainment. In *ICERI2021 Proceedings* (pp. 1078-1086). IATED.

[13] Pintrich, P. R., & De Groot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of educational psychology*, *82*(1), 33.

[14] Al-Hawamleh, M. S., Alazemi, A. F., Al-Jamal, D. A., Al Shdaifat, S., & Rezaei Gashti, Z. (2022). Online learning and self-regulation strategies: Learning guides matter. *Education Research International*, *2022*.

[15] Mattia, G., Di Leo, A., Principato, L., Mattia, G., Di Leo, A., & Principato, L. (2021). Measuring the Constructs of Impulse Buying, Cognitive Dissonance, and Affect State. *Online Impulse Buying and Cognitive Dissonance: Examining the Effect of Mood on Consumer Behaviour*, 31-36.

[16] Watson, D., & Clark, L. A. (2022). THE PANES-X: manual for the positive and negative affect schedule-expanded form. The University of Iowa. 1994. *Unpublished manuscript.[Google Scholar]*.

[17] Verity, D., Eccles, F. J., Boland, A., & Simpson, J. (2020). Does perceived control mediate the relationship between stigma and well-being for individuals with Parkinson's disease?. *Journal of the Neurological Sciences*, *414*, 116841.

[18] Antunes, R., Couto, N., Vitorino, A., Monteiro, D., & Marinho, D. (2019). Physical activity and affect of the elderly: Contribution to the validation of the Positive and Negative Affect Shedule (PANES) in the Portuguese population. *Journal of Human Sport and Exercise*, 1-9.

[19] Quintanilla, V. A., & Gallardo, J. (2022). Interpreting the relationship between emotions and understanding in computer science: An operational approach applied to measurement with preservice elementary teachers. *The Journal of Mathematical Behavior*, *68*, 101012.

[20] Rączy, K., & Orzechowski, J. (2021). When working memory is in a mood: Combined effects of induced affect and processing of emotional words. *Current Psychology*, *40*, 2843-2852.

[21] Das, G., Roy, R., & Naidoo, V. (2020). When do consumers prefer partitioned prices? The role of mood and pricing tactic persuasion knowledge. *Journal of Business Research*, *116*, 60-67.

[22] Annuar, N., Sabri, M. D., Mutalib, H. A., Rahman, N. L. A., Mutalib, S. K. M. S. A., Daud, D., & Johan, M. R. M. (2021). Empowering self-directed learning through technology, organization and personal support in open and distance learning: A conceptual review. *Turk. J. Physiother. Rehabil*, *32*, 23303-23313.

[23] Fenouillet, F., Prokofieva, V., Lorant, S., Masson, J., & Putwain, D. W. (2023). French Study of Multidimensional Test Anxiety Scale in Relation to Performance, Age, and Gender. *Journal of Psychoeducational Assessment*, 07342829231186871.

[24] Ajibade, S. S. M., Bahiah Binti Ahmad, N., & Mariyam Shamsuddin, S. (2019, August). Educational data mining: enhancement of student performance model using ensemble methods. In *IOP Conference Series: Materials Science and Engineering* (Vol. 551, No. 1, p. 012061). IOP Publishing.

[25] Wenzel, K., & Reinhard, M. A. (2021). Learning with a double-edged sword? beneficial and detrimental effects of learning tests—taking a first look at linkages among tests, later learning outcomes, stress perceptions, and intelligence. *Frontiers in Psychology*, *12*, 693585.

[26] Xu, F., Cai, Y., & Tu, D. (2020). Psychometric properties of TAS, TAI, FAT test anxiety scales 6 in Chinese university students: a Bifactor IRT study. *Current Psychology*, 1-14.

[27] Chamberlin, S. A., & Parks, K. (2020). A Comparison of Student Affect after Engaging in a Mathematical Modeling Activity. *International Journal of Education in Computer science, Science and Technology*, *8*(3), 177-189.

[28] Dinc, E., Memnun, D. S., & Aydin, B. (2020). Mathematical Problem-Solving Achievement and Motivational Strategies for Learning. *i-Manager's Journal on Educational Psychology*, *14*(2), 1.

[29] Cho, H. J., Yough, M., & Levesque-Bristol, C. (2020). Relationships between beliefs about assessment and self-regulated learning in second language learning. *International Journal of Educational Research*, *99*, 101505.

[30] Mamiya, B., Powell, C. B., Shelton, G. R., Dubrovskiy, A., Villalta-Cerdas, A., Broadway, S., ... & Mason, D. (2022). Influence of Environmental Factors on the Success of At-Risk Hispanic Students in First-Semester General Chemistry Breadcrumb. *Journal of College Science Teaching*, *51*(4).

[31] Ortega-Torres, E., Solaz-Portoles, J. J., & Sanjosé-López, V. (2020). Inter-relations among motivation, self-perceived use of strategies and academic achievement in science: a study with spanish secondary school students. *Sustainability*, *12*(17), 6752.

[32] Huang, S., Jiang, Y., Yin, H., & Jong, M. S. Y. (2021). Does ICT use matter? The relationships between students' ICT use, motivation, and science achievement in East Asia. *Learning and Individual Differences*, *86*, 101957.

[33] Cotner, S., Jeno, L. M., Walker, J. D., Jørgensen, C., & Vandvik, V. (2020). Gender gaps in the performance of Norwegian biology students: the roles of test anxiety and science confidence. *International Journal of STEM Education*, *7*, 1-10.

[34] Roos, A. L., Goetz, T., Krannich, M., Jarrell, A., Donker, M., & Mainhard, T. (2021). Test anxiety components: an intra-individual approach testing their control antecedents and effects on performance. *Anxiety, Stress, & Coping*, *34*(3), 279-298.

[35] Brannen, S. F., Beauchamp, D., Cartwright, N. M., Liddle, D. M., Tishinsky, J. M., Newton, G., & Monk, J. M. (2021). Effectiveness of group work contracts to facilitate collaborative group learning and reduce anxiety in traditional face-to-face lecture and online distance education course formats. *International Journal for the Scholarship of Teaching and Learning*, *15*(2), 5.

[36] Feraco, T., Resnati, D., Fregonese, D., Spoto, A., & Meneghetti, C. (2023). An integrated model of school students' academic achievement and life satisfaction. Linking soft skills, extracurricular activities, self-regulated learning, motivation, and emotions. *European Journal of Psychology of Education*, *38*(1), 109-130.

[37] Kiuru, N., Spinath, B., Clem, A. L., Eklund, K., Ahonen, T., & Hirvonen, R. (2020). The dynamics of motivation, emotion, and task performance in simulated achievement situations. *Learning and Individual Differences*, *80*, 101873.

[38] Van Woezik, T., Reuzel, R., & Koksma, J. (2019). Exploring open space: a self-directed learning approach for higher education. *Cogent Education*, *6*(1), 1615766.

[39] Akerman, A., Naftalovich, H., Akiva-Kabiri, L., & Kalanthroff, E. (2020). Inhibiting the emergence of involuntary musical imagery: Implications for improving our understanding of intrusive thoughts. *Cognitive Therapy and Research*, *44*, 885-891.

[40] Petričević, E., Rovan, D., & Pavlin-Bernardić, N. (2022). Contextual and individual determinants of engagement in physics from the perspective of elementary school physics teachers. *International Journal of Science Education*, *44*(9), 1399-1418.

[41] Ahern, E., Bockting, C. L., & Semkovska, M. (2019). A hot-cold cognitive model of depression: integrating the neuropsychological approach into the cognitive theory framework. *Clinical Psychology in Europe*, *1*(3), 1-35.

[42] Fathi, J., & Shirazizadeh, M. (2019). Fostering self-regulated learning of Iranian EFL students: An investigation of the effect of self and peer assessment in L2 writing. *Journal of Foreign Language Research*, *9*(1), 123-146.

[43] Kuhlmann, S. L., Bernacki, M. L., Greene, J. A., Hogan, K. A., Evans, M., Plumley, R., ... & Panter, A.

(2023). How do students' achievement goals relate to learning from well-designed instructional videos and subsequent exam performance?. *Contemporary Educational Psychology*, *73*, 102162.

[44] El-Adl, A., & Alkharusi, H. (2020). Relationships between self-regulated learning strategies, learning motivation and computer science achievement. *Cypriot Journal of Educational Sciences*, *15*(1), 104-111.

[45] Adetola, O., Shamsuddin, S. M., Chweya, R., & Ajibade, S. S. M. (2020). Social communication of students on social media network platform: A statistical analysis. *Journal of Science, Engineering, Technology and Management ISSN: 9989-7858*, *2*(2).

[46] Wellberg, S. (2023). Teacher-made tests: why they matter and a framework for analysing computer science exams. *Assessment in Education: Principles, Policy & Practice*, *30*(1), 53-75.

[47] Honicke, T., Broadbent, J., & Fuller-Tyszkiewicz, M. (2020). Learner self-efficacy, goal orientation, and academic achievement: exploring mediating and moderating relationships. *Higher Education Research & Development*, *39*(4), 689-703.

[48] Zaidi, A., Ajibade, S. S. M., Musa, M., & Bekun, F. V. (2023). New Insights into the Research Landscape on the Application of Artificial Intelligence in Sustainable Smart Cities: A Bibliometric Mapping and Network Analysis Approach. *International Journal of Energy Economics and Policy*, (4), 287.

[49] Esnaashari, S., Gardner, L., Rehm, M., Arthanari, T., & Filippova, O. (2023). A Comparison of the Predictability of Final Scores for Freshmen and Upper-Level Students in Blended Learning Courses. *International Journal of Information and Education Technology*, *13*(4).

[50] Primi, C., Bacherini, A., Beccari, C., & Donati, M. A. (2020). Assessing math attitude through the Attitude Toward Computer science Inventory–Short form in introductory statistics course students. *Studies in Educational Evaluation*, *64*, 100838.

[51] Losada-Otalora, M., Pena-Garcia, N., & Sanchez, I. D. (2020). Interpersonal conflict at work and knowledge hiding in service organizations: the mediator role of employee well-being. *International Journal of Quality and Service Sciences*, *13*(1), 63-90.

[52] Lam, K. K. L., & Zhou, M. (2020). A serial mediation model testing growth mindset, life satisfaction, and perceived distress as predictors of perseverance of effort. *Personality and Individual Differences*, *167*, 110262.

[53] Vasileiou, D., Moraitou, D., Papaliagkas, V., Pezirkianidis, C., Stalikas, A., Papantoniou, G., & Sofologi, M. (2021). The relationships between character strengths and subjective wellbeing: Evidence from Greece under lockdown during COVID-19 pandemic. *International Journal of Environmental Research and Public Health*, *18*(20), 10868.

[54] Sofologi, M., Foutsitzi, E., Papantoniou, A., Kougioumtzis, G., Zaragas, H., Tsolaki, M., ... & Papantoniou, G. (2023). The Effect of Secondary Education Teachers' Metacognitive Knowledge and Professional Development on Their Tacit Knowledge Strategies. *Journal of Intelligence*, *11*(9), 179.

[55] Segura-Robles, A., Moreno-Guerrero, A. J., Parra-González, M. E., & López-Belmonte, J. (2021). Adaptation and validation of the motivated strategies for learning questionnaire for spanish adolescents. *European Journal of Investigation in Health, Psychology and Education*, *11*(1), 142-153.

[56] Farriol-Baroni, V., González-García, L., Luque-García, A., Postigo-Zegarra, S., & Pérez-Ruiz, S. (2021). Influence of social support and subjective well-being on the perceived overall health of the elderly. *International journal of environmental research and public health*, *18*(10), 5438.

[57] Almaleki, D. (2021). The Precision of the Overall Data-Model Fit for Different Design Features in Confirmatory Factor Analysis. *Engineering, Technology & Applied Science Research*, *11*(1), 6766-6774.

[58] Wahyudiati, D., Rohaeti, E., Wiyarsi, A., & Sumardi, L. (2020). Attitudes toward chemistry, self-efficacy, and learning experiences of pre-service chemistry teachers: Grade level and gender differences. *International Journal of Instruction*, *13*(1), 235-254.

[59] Blanca Postigo, J. M., Cañizares Sales, J., & Leiva-Brondo, M. (2022, July). Student's approach to learning per student basis in two subjects of biotechnology degree. In *Proceedings 14th annual International Conference on Education and New Learning Technologies (EDULEARN22)* (pp. 3621-3626). IATED.