

# Personality traits for self-regulated learning with generative artificial intelligence: The case of ChatGPT

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## ABSTRACT

Personality traits and educational technology may affect how well students utilise their abilities and strategies to achieve their learning objectives and potential. As generative artificial intelligence (GenAI) is creating new learning experiences, understanding the impact of five representative personality traits on students' self-regulated learning (SRL) while learning with GenAI tools can help to predict which personality traits indicate better self-regulation when learning with this innovative educational technology. Such a prediction can help educators to design effective learning activities by providing educational experiences that cater to students' different personality traits for specific learning objectives in the GenAI context. This study explored how variations in five representative personality traits affect students' SRL performance when learning with ChatGPT. It used an explanatory approach based on structural equation modelling with a path analysis design. Four hundred and nine university students participated in the study and finished a self-reported questionnaire with validated items that are driven by previous studies. The results revealed that the personality traits of openness, extraversion, and agreeableness were significant predictors of all three stages of SRL; conscientiousness was a significant predictor of the forethought and self-reflection stages; and neuroticism failed to predict any of the three stages of SRL. These results may be attributable to the subjective nature of personality traits and the cognitive characteristics of SRL skills. The findings enrich the literature on SRL by introducing personality traits and GenAI as innovative perspectives and suggesting corresponding strategies for supporting different stages of SRL.

## 1. Introduction

Highly motivated students are proactive in decision-making and display goal-oriented behaviours, and those who intentionally use purposeful strategies tend to be effective self-regulators (Bruso et al., 2020; Code, 2020). Most self-regulated learning (SRL) models highlight learners' active participation in the learning process as they use cognitive and metacognitive strategies to regulate their learning based on available information and apply standards or criteria to evaluate the need for adjustments (Kong & Yang, 2024; Molenaar et al., 2023; Wirth et al., 2020). In essence, SRL involves the use of internally generated thoughts, feelings, and actions to achieve academic objectives (Theobald, 2021). This comprehensive process has been divided into

three stages: forethought, performance, and self-reflection (Heckhausen & Kuhl, 1985; Zimmerman, 2002). Students use different strategies in each of these stages to maximise their learning outcomes (Lai & Hwang, 2023; Li et al., 2018). Studies have identified multiple factors that can influence SRL, including students' achievement levels (DiFrancesca et al., 2016), educational technology (Albelbisi, 2019), and the personal, contextual and social attributes of the learning environment that is experienced by students (Berkhout et al., 2015; Nan Cenka et al., 2022).

Among these factors, personality traits—which represent various personal attributes as well as an individual's pattern of thinking, feeling, and behaviour (Bleidorn et al., 2022)—and generative artificial intelligence (GenAI), an innovative educational technology (Chiu, 2024; Xia, Weng, Ouyang, Lin, & Chiu, 2024), are attracting growing attention in

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SRL research. Studies have revealed correlations between students' personality traits and SRL (Albar et al., 2022; Alvi & Gillies, 2015; Lin et al., 2016; Puente-Díaz et al., 2022; Woods et al., 2016). These studies tend to regard student personality as a deciding factor (Albar et al., 2022; Puente-Díaz et al., 2022; Woods et al., 2016) and SRL as the learning outcomes (Alvi & Gillies, 2015; Lin et al., 2016). Therefore, the direction of impacts when exploring the relationships between students' personality traits and their SRL performance is determined. However, these studies have not explored how students' personalities may influence their SRL profiles from the stages of forethought, performance, and self-reflection, particularly in the GenAI context (with the use of tools such as ChatGPT, Sora, and Dall-E for learning), which presents an opportunity for further investigation. Accordingly, this study investigates the relationship between students' personality traits and their performance across various SRL stages while learning with GenAI tools. The findings will contribute to the development of tailored interventions and instructional strategies to optimise the SRL experiences and outcomes of students with diverse personality profiles in the GenAI context.

## 2. Literature review

### 2.1. Self-regulated learning

The origins of the concept of SRL can be traced to Zimmerman (1986) and Pintrich et al. (1993), who distinguished SRL from metacognition and built a foundation for future research. Since then, the concept has grown and diversified, with various SRL models and frameworks having been developed (Panadero, 2017; Tinajero et al., 2024). Meanwhile, researchers have exceeded the scope of defining and conceptualising SRL to examining how it can be enhanced through educational practices to benefit students. For example, Xu and Ko (2019) investigated the potential of professional development programmes designed based on community of practice principles to improve teachers' knowledge and foster students' SRL. Zheng (2016) evaluated the effectiveness of SRL scaffolds in facilitating students' regulation of their learning in computer-based learning environments. Furthermore, some researchers have investigated domain-specific applications of SRL and the instructional practices that help to improve students' SRL. For example, Teng and Zhang (2020) and Sins et al. (2024) put forward a compilation of methods for examining SRL and connecting it to instruction, and their findings highlighted the necessity of SRL as a dynamic process of lifelong learning in the ever-changing educational setting.

SRL is a multifaceted learning process that requires students to take control of their learning experiences by managing their cognitive, metacognitive, affective, and motivational states (Molenaar et al., 2023). The process of SRL is regarded as a set of proactive and intentional endeavours undertaken by students to help them achieve their learning goals, including monitoring and regulating their learning and controlling their cognition, motivation, and behaviour (Wirth et al., 2020). Butler and Winne (1995, p. 245) proposed that 'the most effective learners will be self-regulating', because they can actively engage in the learning process. When students are learning, they set goals, monitor their progress, and make adjustments as necessary. Some studies have reported that SRL can improve students' academic performance. For example, Theobald's (2021) meta-analysis demonstrated that SRL training programmes improved academic performance, enhanced SRL strategies, and motivated students. A scoping review conducted by Xu et al. (2023) illustrated the efficacy of SRL in enhancing students' academic performance in both online and blended learning contexts.

Researchers have also examined the distinct cyclical phases of SRL to understand its underlying mechanisms. For example, Heckhausen and Kuhl (1985) introduced the idea of implementing SRL strategies in three phases: pre-actional, actional, and post-actional. Zimmerman (2002) proposed a similar model by dividing the SRL cycle into three main stages: forethought, performance, and self-reflection. Pintrich (2000) incorporated a fourth phase into his version of the SRL cycle, which

comprised forethought, monitoring, control, and reflection. Although these cyclical models categorise students' learning processes differently, they show some similarities. In the first stage, commonly called forethought, students set goals and devise strategic plans (Chen & Bonner, 2020; Kong & Yang, 2024). In the second stage, represented by Zimmerman's performance phases and the combination of Pintrich's monitoring and control phases, students engage in the learning activity while implementing cognitive strategies and techniques such as self-instruction, focusing attention, and continuous monitoring (Li et al., 2021; Xu et al., 2023). The concluding stage, often referred to as self-reflection or evaluation, encompasses the strategies and actions that students undertake after completing the learning activity (Çakiroğlu & Öztürk, 2023). In this stage, students engage in self-evaluation (e.g. through social comparisons) and refine their skills and strategies accordingly for application to upcoming learning endeavours (Silverajah et al., 2022).

### 2.2. 'Big Five' personality traits

The Big Five personality traits model, also known as the five-factor (personality) model, OCEAN, or CANOE, constitutes a comprehensive framework for understanding human personality (Piepiora, 2021; Vlachogianni & Tselios, 2022). The traits in the model represent five broad dimensions of personality, namely openness, conscientiousness, extraversion, agreeableness, and neuroticism, each of which corresponds to a cluster of characteristics. Unlike binary categories, the Big Five model recognises the complexity of human personality: the five traits exist on a continuum and individuals can fall anywhere along each dimension. 'Openness to experience' refers to a person's preference for routine and practicality versus imagination and spontaneity; individuals who are high in openness like to learn new things, are insightful, and have diverse interests (Awwad & Al-Aseer, 2021; Jirásek & Sudzina, 2020). Individuals who are high in conscientiousness are reliable, organised, methodical, and thorough and exhibit impulse control and goal-directed behaviours (Bruso et al., 2020; Moore et al., 2022). Individuals who are high in extraversion seek external stimulation and thrive on social interaction; derive energy from social interactions; and tend to be energetic, talkative, and assertive (Blevins et al., 2022). The trait of agreeableness relates to how people approach relationships with others. Agreeable individuals are friendly, cooperative, compassionate, and kind (Wilmot & Ones, 2022). The fifth trait, neuroticism, is associated with emotional instability, negative emotions, moodiness, and anxiety (Peters et al., 2020).

The Big Five personality traits have been studied in connection with learning and academic performance. Studies have suggested that certain personality traits can be advantageous or disadvantageous for students in the classroom (Dong et al., 2022; Moore et al., 2022; Wilmot et al., 2022). For example, openness to experience is positively correlated with academic performance, because having this trait enables students to approach academic tasks with an inquisitive mindset and a willingness to explore novel concepts (Gatzka & Hell, 2018). Conscientiousness also plays a role in academic success, as conscientious students are more likely to persist in their learning, complete assignments on time, and demonstrate self-regulatory behaviours that are conducive to learning (Ljubin-Golub et al., 2019). The effects of the extraversion trait are mixed, with some studies demonstrating the positive impact of extraversion on students' social engagement and enthusiasm (Smillie et al., 2015) and others reporting advantages for introverted over extraverted students due to the former's independent and reflective tendencies (Blevins et al., 2022; Hills & Argyle, 2001). A high level of neuroticism has a negative effect on academic performance, as it interferes with students' ability to manage stress, maintain focus, and handle challenging material with confidence (Widiger & Oltmanns, 2017).

Understanding personality traits as a factor influencing students' learning experiences can help instructional designers to create more inclusive, responsive learning environments to meet the needs of various

types of learners and promote their individual development (Rivers, 2021). For instance, providing opportunities to conduct independent research, project-based learning, and an in-depth exploration of topics may help to capitalise on the intellectual curiosity and diligence of open and conscientious students (Stieger et al., 2020); balancing individual work, small-group discussions, and whole-class activities can address the differences in social interaction and solitary reflection between extraverted and introverted learners (Khodabandeh, 2022); and counseling, stress management strategies, and low-stakes formative assessments can help ameliorate anxiety symptoms in neurotic students (Sion et al., 2023).

### 2.3. Personality traits and SRL for learning with GenAI

Understanding the interplay between personality traits and SRL can shed light on individual differences in learning strategies, motivation, and academic performance. Many studies have suggested that personality traits can influence students' SRL. For example, individuals with higher openness have greater personal agency in exploring alternative perspectives and embracing complexity, which can enhance their metacognitive awareness when generating new ideas (Puente-Díaz et al., 2022). Conscientious individuals tend to engage in planning, self-monitoring, and self-reflection, which can facilitate their adoption of effective learning strategies and promote change in response to training (Woods et al., 2016). Extraverted and agreeable individuals have preferences for collaborative learning and seeking social support, which can help them to engage in interactive discussions and benefit from social interactions in terms of improved SRL outcomes (Alvi & Gillies, 2015; Lin et al., 2016). In contrast, neuroticism might have a negative impact on students' SRL strategies (Albar et al., 2022).

Furthermore, the interplay between personality traits and SRL is influenced by contextual factors, such as instructional strategies, learning environments, and task characteristics (Pintrich, 2000; Tinajero et al., 2024). Carefully matching students' personality traits with the instructional environment, such as by providing autonomy for individuals who need it (e.g., the open and conscientious students), can improve students' learning satisfaction and performance (Pawlowska et al., 2014). The emerging technology, GenAI can be utilised as a set of innovative educational tools to shape the instructional environment and change students' learning experiences (Sedlbauer et al., 2024). In a previous study, we suggested that students can receive diverse forms of support, including automatic feedback, intelligent tutoring, and personalized learning experiences, from intelligent computer-assisted learning environments (Weng & Chiu, 2023). Students with different personality traits will be able to meet their demands in the GenAI learning context. For example, introverted students, who tend to exhibit shyness or hesitation in a traditional classroom, will be able to reduce their fear of expressing their opinions with ChatGPT (Hamid et al., 2023). Further, some scholars have considered the possible advantages of GenAI for SRL. For example, Chiu (2024) used the Delphi method to study the perceptions of in-service teachers regarding how ChatGPT-based learning activities help students with different stages of SRL. Ng et al. (2024) designed a comparative study of student groups using different digital tools to investigate how ChatGPT improves students' SRL and science education outcomes. Kong and Yang (2024) developed a human-centred framework for the use of GenAI tools to support SRL in domain-knowledge learning.

The results of these investigations can help educators and learners understand the importance of self-regulation skills and tailor instructional approaches to foster more effective and adaptive learning experiences with GenAI. However, although researchers have discussed the interaction between students' personality traits and their utilisation of SRL strategies (Albar et al., 2022; Bruso et al., 2020; Theobald, 2021), no studies have specifically examined how the five major personality traits influence the distinct stages of the SRL process in the GenAI context from the perspective of students.

## 3. Method

### 3.1. Research model and participants

This study asked the following research question: how and to what extent do the Big Five personality traits influence the three phases of SRL—forethought, performance, and self-reflection—when using ChatGPT? We tested our proposed model of this relationship (as shown in Fig. 1) using structural equation modelling with a path analysis design.

The sampling method is to recruit students from different academic backgrounds, ages ranging from 18 to 22 years old. They all expressed they learn with ChatGPT. Data were collected from 409 students (male: 211, female: 198; social science: 71, engineering: 128, art: 72, science: 138) from three universities who consented to participate in the study and then completed a questionnaire, which took approximately 30 min. Ethical approval for the study was obtained from the authors' university.

### 3.2. Instruments

In addition to gathering demographic information (e.g. student ID and gender), the questionnaire included scales for the five focal personality traits and three stages of SRL across eight constructs. Each of the eight scales consisted of three or four items, with responses given on a 5-point Likert scale (1: strongly disagree; 5: strongly agree). Three university scholars reviewed the items to confirm the clarity and comprehensibility of the wording.

#### 3.2.1. Personality traits

To measure the students' personality traits, we adapted items from the Big Five Personality Trait Short Questionnaire developed by Morizot (2014). All the items started with 'I see myself as someone who ...'. The items for the openness to experience trait, with original reliability of  $\alpha = 0.99$ , were '... is original, often has new ideas', '... is curious about many different things', and '... is ingenious, reflects a lot'. The items for the conscientiousness trait ( $\alpha = 0.97$ ) were '... works conscientiously, does the things he/she has to do well', '... is a reliable student/worker, who can be counted on', and '... does things efficiently, works well and quickly'. The items for the extraversion trait ( $\alpha = 0.98$ ) were '... likes to talk, expresses my opinion', '... is full of energy, likes to always be active', and '... is a leader, capable of convincing others'. The items for the agreeableness trait ( $\alpha = 0.98$ ) were '... is helpful and generous with

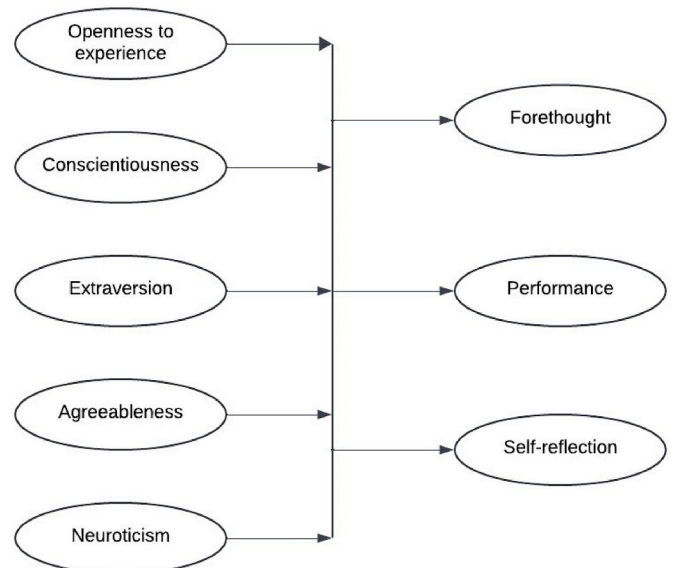


Fig. 1. Proposed model.

others', '... is lenient, forgives easily', and '... likes to cooperate with others'. The items for the neuroticism trait ( $\alpha = 0.96$ ) were '... is generally relaxed, handles stress well', '... is emotionally stable, not easily upset', and '... stays calm in tense or stressful situations'.

### 3.2.2. SRL stages

The students' performance in the SRL process was examined for the three stages of forethought, performance, and self-reflection. The items for all three stages were adapted from the Online Self-regulated Learning Questionnaire developed by Barnard et al. (2009). There were four items for forethought ( $\alpha = 0.88$ ): 'I set standards for my assignments in online courses', 'I set short-term (daily or weekly) goals as well as long-term goals (monthly or for the semester)', 'I keep high standards in my learning with ChatGPT', and 'I know where I can study most efficiently when learning with ChatGPT'. The four items for performance ( $\alpha = 0.77$ ) were 'I try to take more thorough notes when learning with ChatGPT', 'I prepare my questions before learning with ChatGPT', 'I work on extra problems when learning with ChatGPT', and 'I allocate extra study time when learning with ChatGPT'. The four statements for self-reflection ( $\alpha = 0.91$ ) were 'I summarise my learning to examine my understanding of what I have learned when learning with ChatGPT', 'I ask myself a lot of questions about the output from ChatGPT', 'I communicate with my classmates to find out how I am doing when learning with ChatGPT', and 'I communicate with my classmates to find out what I am learning that is different from what they are learning'.

### 3.3. Data analysis

After collecting the data, we used the structural equation modeling (SEM) method supported by Mplus to conduct the data analysis (Byrne, 2013). The five personality traits, including openness, conscientiousness, extraversion, agreeableness, and neuroticism, were regarded as the exogenous variables. The three stages of SRL, forethought, performance, and self-reflection were regarded as the endogenous variables. All the relevant variables were standardized to reduce potential bias arising from the wide range of variances (Lei & Wu, 2007). To evaluate statistical significance, we set a 95% confidence interval (CI) with 1000 bootstrap samples (Nevitt & Hancock, 2001).

## 4. Results

### 4.1. Descriptive statistics

Table 1 shows the descriptive statistics for the latent variables. All of the variables demonstrated internal reliability, with alpha ( $\alpha$ ) values ranging from 0.77 to 0.99 (thus fairly high, at  $> 0.76$ ; Taber, 2018). The data were normally distributed, as identified by the skewness and kurtosis values (where an absolute value of approximately one indicates slight nonnormality; Lei & Lomax, 2005). The range of all factor loadings was acceptable, at between 0.79 and 0.95 (factor loading threshold  $> 0.7$ ; Hair et al., 2009).

The goodness-of-fit of the measurement model was examined. The measured items suggested a good model fit (Hair et al., 2010):  $\chi^2/df = 1.59$  ( $< 3.0$ ); RMSEA = 0.04 ( $< 0.08$ ); SRMR = 0.01 ( $< 0.05$ ); TLI = 0.99

( $> 0.90$ ); CFI = 0.99 ( $> 0.90$ ). As shown in Table 2, almost all of the variables showed significant positive correlations with each other, with  $p < 0.01$ . This indicates that all the prerequisite assumptions for path analysis were fulfilled.

### 4.2. Relationships between personality traits and students' SRL

Path analysis reveals a model's adequacy by providing the path coefficients and R-squared values ( $R^2$ ). Path coefficients indicate the strength of the relationships between variables, and  $R^2$  values show the amount of variance in the endogenous latent variables accounted for by the exogenous latent variables. In this study, examining these statistics helped to clarify the ways in which personality traits were found to influence students' SRL.

In the research model, the regression paths were set directly from the five independent latent variables (i.e. the five personality traits of openness, conscientiousness, extraversion, agreeableness, and neuroticism) to the three dependent latent variables (i.e. the three stages of students' SRL, namely forethought, performance, and self-reflection). The model demonstrated a good fit to the data (Hair et al., 2010, pp. 629–686):  $\chi^2/df = 1.59$  ( $< 3.0$ ); RMSEA = 0.04 ( $< 0.08$ ); SRMR = 0.01 ( $< 0.05$ ); TLI = 0.99 ( $> 0.90$ ); CFI = 0.99 ( $> 0.90$ ).

The path analysis results (shown in Table 3) indicated that the five external variables accounted for 31% of the variability in the internal variable associated with students' forethought. Extraversion had the largest effect, with  $\beta = 0.33$ . Openness, conscientiousness, and agreeableness had almost the same effects (e.g.,  $\beta = 0.18$ ). The effect of neuroticism was not significant. The results further indicated that the five external variables accounted for 29% of the variation in the students' performance. Extraversion, openness, and agreeableness had similar effects,  $\beta = 0.28$ , 0.25, and 0.24, respectively. The effects of conscientiousness and neuroticism were not significant. Furthermore, the five variables explained 31% of the variance in students' self-reflection. Extraversion had the largest effect ( $\beta = 0.26$ ), followed by openness ( $\beta = 0.25$ ), conscientiousness ( $\beta = 0.21$ ), and agreeableness ( $\beta = 0.16$ ). The impact of neuroticism was not significant.

## 5. Discussion and conclusion

This study investigated how the Big Five personality traits relate to students' SRL in a GenAI-facilitated learning environment (specifically, with the use of ChatGPT). It fits within the scope of "personalized and intelligent educational systems" in the journal *Computers and Education: Artificial Intelligence*. The personality traits of openness, extraversion, and agreeableness significantly predicted all three stages of students' SRL, and conscientiousness significantly predicted students' forethought and self-reflection. Neuroticism did not predict any of the SRL stages (as shown in Fig. 2). This discussion presents three empirical findings, one theoretical contribution, and two practical recommendations for educators and instructional designers.

### 5.1. Empirical implications

As expected, the personality traits of openness to experience, extraversion, and agreeableness were all strongly associated with the three SRL phases of forethought, performance, and self-reflection. These findings imply that the personality traits that reflect a greater tendency for collaboration and socialisation are more likely to foster all three stages of SRL in learning environments with GenAI. This is consistent with the results of SRL studies conducted in other learning settings, such as real-life classrooms and blended environments (Alvi & Gillies, 2015; Lin et al., 2016; Puente-Díaz et al., 2022). The personality traits of openness to experience, extraversion, and agreeableness share tendencies towards collaborative learning and seeking social support (Awwad & Al-Aseer, 2021; Blevins et al., 2022; Jirásek & Sudzina, 2020; Wilmot & Ones, 2022). These common tendencies are a good match for

**Table 1**  
Descriptive statistics (N = 409).

Variable	Mean	SD	Skewness	Kurtosis
Openness	3.67	1.25	−0.77	−0.49
Conscientiousness	3.76	1.13	−0.94	0.11
Extraversion	3.58	0.96	−0.15	−0.89
Agreeableness	3.62	1.09	−0.60	−0.35
Neuroticism	2.59	1.10	0.52	−0.36
Forethought	3.87	1.21	−0.90	−0.34
Performance	3.90	1.24	−1.01	−0.10
Self-reflection	3.60	1.25	−0.63	−0.63



**Table 2**  
Correlations between the study variables.

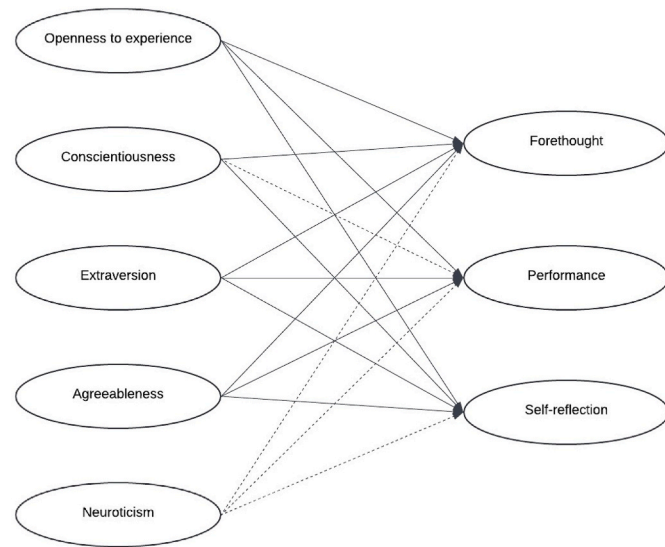
Independent variable	1	2	3	4	5	6	7	8
Openness	1							
Conscientiousness	0.34 <sup>a</sup>	1						
Extraversion	0.41 <sup>a</sup>	0.28 <sup>a</sup>	1					
Agreeableness	0.37 <sup>a</sup>	0.29 <sup>a</sup>	0.40 <sup>a</sup>	1				
Neuroticism	−0.07	−0.19 <sup>a</sup>	−0.19 <sup>a</sup>	−0.17 <sup>a</sup>	1			
Forethought	0.39 <sup>a</sup>	0.34 <sup>a</sup>	0.43 <sup>a</sup>	0.37 <sup>a</sup>	−0.14 <sup>a</sup>	1		
Performance	0.41 <sup>a</sup>	0.26 <sup>a</sup>	0.39 <sup>a</sup>	0.37 <sup>a</sup>	−0.17 <sup>a</sup>	0.38 <sup>a</sup>	1	
Self-reflection	0.44 <sup>a</sup>	0.37 <sup>a</sup>	0.40 <sup>a</sup>	0.37 <sup>a</sup>	−0.13 <sup>a</sup>	0.31 <sup>a</sup>	0.47 <sup>a</sup>	1

\*p < 0.05.

<sup>a</sup> p < 0.01.

**Table 3**  
Results of path analysis.

Independent variables	Path coefficient	SE	CR	P	Supported Yes/No
Forethought <— Openness	0.18	0.06	3.02	<0.01	Yes
Forethought <— Conscientiousness	0.18	0.06	3.16	<0.01	Yes
Forethought <— Extraversion	0.33	0.07	4.52	<0.001	Yes
Forethought <— Agreeableness	0.18	0.06	2.99	<0.01	Yes
Forethought <— Neuroticism	−0.03	0.05	−0.56	0.57	No
Performance <— Openness	0.25	0.06	3.85	<0.001	Yes
Performance <— Conscientiousness	0.06	0.07	0.88	0.38	No
Performance <— Extraversion	0.28	0.09	3.27	<0.01	Yes
Performance <— Agreeableness	0.24	0.08	2.92	<0.01	Yes
Performance <— Neuroticism	−0.09	0.06	−1.48	0.14	No
Self-reflection <— Openness	0.25	0.05	5.33	<0.001	Yes
Self-reflection <— Conscientiousness	0.21	0.06	3.68	<0.001	Yes
Self-reflection <— Extraversion	0.26	0.08	3.29	<0.01	Yes
Self-reflection <— Agreeableness	0.16	0.07	2.35	<0.05	Yes
Self-reflection <— Neuroticism	−0.02	0.05	−0.32	0.75	No



**Fig. 2.** Associations between personality traits and SRL (the solid lines represent significant effect; the dotted lines represent no significant effect).

SRL as some previous studies proposed that social cognitive theory is the basis for the definition of SRL concepts and models (Zhang et al., 2022; Zimmerman, 1995). Essentially, these socially oriented personality traits represent a prime motivation or bridge for students to cultivate SRL throughout the forethought, performance, and self-reflection stages.

The second empirical finding was that the personality trait of conscientiousness was a partial predictor of students' SRL, having significant positive effects on students' forethought and self-reflection stages but no significant influence on the performance stage. This

finding implies that the ChatGPT learning environment suits the preference of conscientious students for the inward-driven activities of planning and self-reflection. A conscientious personality encourages these inward-driven activities, with studies having observed that conscientious students tend to be reliable, organised, methodical, and thorough and that they typically demonstrate self-control, persistence, and goal-oriented behaviours (Bruso et al., 2020; Ljubin-Golub et al., 2019; Moore et al., 2022). These characteristics can be beneficial for task planning and self-reflection. However, during the performance phase when students are learning with ChatGPT, a stronger conscientiousness trait does not necessarily produce better goal-oriented behaviours. One possible explanation is that as the ChatGPT platform can produce an abundance of information effortlessly, students can achieve their goals in less time and with less effort when using this GenAI tool compared with other approaches (Escalante et al., 2023; Yang et al., 2024). Given the convenience of ChatGPT, students using this platform may have less chance to struggle over their studies, thereby weakening their intention to persist in learning.

The third and final empirical finding was that the personality trait of neuroticism did not predict the student's performance in any of the three phases of SRL when learning with GenAI. This echoes the results of most studies of neuroticism and SRL, which have found that neuroticism does not enhance students' SRL strategies (Albar et al., 2022; Peters et al., 2020). This finding indicates that when using the ChatGPT platform for learning, personality traits that are capable of generating cognitive behaviours (i.e. openness, extraversion, agreeableness, and conscientiousness) have more predictive power for developing SRL than traits that deal with students' psychological states/emotions (i.e. neuroticism). The research findings related to neuroticism can be explained with reference to the attributes of SRL, personality traits, and GenAI platforms. For example, SRL requires students to take charge of their own learning experiences by managing their cognitive, metacognitive, affective, and motivational states (Molenaar et al., 2023). Although

neuroticism may make it difficult for students to focus and manage stress (Widiger & Oltmanns, 2017), ChatGPT provides students with the certainty that they can always find the answers and information they need (Azaria et al., 2024). GenAI thus empowers students and reduces their experience of negative psychological states/emotions, thus eliminating the effects of the neuroticism trait.

### 5.2. Theoretical contributions

The three empirical findings enhance understanding of SRL by incorporating personality traits and how they predict different stages of SRL in GenAI learning environments. Studies on the development of the three SRL stages have either not focused on GenAI learning as a new context for SRL (Alvi & Gillies, 2015; Lin et al., 2016; Puente-Díaz et al., 2022) or not done so from the perspective of students (Chiu, 2024). In this study, the participating students were engaged with the ChatGPT system. The findings showed that the ChatGPT learning environment was an important instructional strategy in supporting the three stages of SRL and that the Big Five personality traits had different effects on different stages of students' SRL when learning with GenAI. Our study suggests that instructors should design activities that focus on different personality traits to foster particular stages of SRL in GenAI learning environments. In particular, they should aim to capitalise on students' openness, conscientiousness, extraversion, and agreeableness traits when developing the forethought stage; nurture students' openness, extraversion, and agreeableness traits when developing the performance stage; and leverage students' openness, conscientiousness, extraversion, and agreeableness traits when developing the self-reflection stage.

### 5.3. Practical recommendations

Two practical recommendations are provided to help instructional designers and teachers match student personality traits with SRL in GenAI-facilitated learning environments. The first recommendation is to design learning activities that foster collaboration (Weng, Cui, Ng, Jong, & Chiu, 2022). Collaborative learning environments match students' personality traits of openness to experience, extraversion, and agreeableness (Blevins et al., 2022; Wilmot & Ones, 2022), with benefits for the forethought, performance, and self-reflection stages of their SRL. GenAI learning environments can be constructed as collaborative learning environments within which students can establish different types of collaboration, including interpersonal collaboration with their peers and teachers and human-machine collaboration (interacting with the learning system) (Su et al., 2023; Ye et al., 2023).

The second recommendation is to design learning tasks with appropriate levels of difficulty to maximise the benefits of the GenAI-facilitated learning environment. This recommendation is supported by the second and third findings of this study, which suggest that the application of GenAI platforms to education is a double-edged sword for students. On one hand, the certainty that such platforms can provide sufficient information to answer all of their questions can reduce students' anxiety and other negative emotions connected with neuroticism (Peters et al., 2020). On the other hand, the great convenience of GenAI platforms may reduce the opportunities available for students to drill and practice, which are vital for their persistence and are linked to their conscientiousness (Bruso et al., 2020; Moore et al., 2022). Learning tasks that can foster students' positive psychological states/emotions while challenging them would be beneficial for learners' SRL development when learning with GenAI.

### 5.4. Limitations

The findings of this study provided a more comprehensive understanding of the dynamics between individual differences and SRL processes in the context of GenAI. However, the study has four limitations. First, our research data were drawn from students using ChatGPT;

further experiments with other GenAI tools are needed to validate the results. Second, this study focused on university students, although the impact of a GenAI-facilitated learning environment on SRL may differ across educational levels. Similar research is needed in K–12 settings. Third, as a cross-sectional study, this research was not sufficiently equipped to shed light on the process by which the five focal personality traits influence the three stages of SRL in GenAI learning contexts. Structural equation modelling can identify relationships but cannot support in-depth explanations of these relationships (Kline, 2023). Future studies could use different empirical designs to investigate the issues. Also, gender and major of students may affect the relationships between personal traits and SRL. Future studies are suggested to understand the moderating effects of gender and major. Fourth, this study relied on self-reported measures of personality traits and SRL; the results should be validated in future research using more objective measures, such as personality tests and tracking of students' SRL behaviours.

### Statements on open data and ethics

The study was approved by an ethical committee with ID: SBRE-23-0189. Informed consent was obtained from all participants, and their privacy rights were strictly observed. The data can be obtained by sending request e-mails to the corresponding author.

### CRediT authorship contribution statement

**Xiaojing Weng:** Writing – original draft, Methodology, Formal analysis, Conceptualization. **Qi Xia:** Writing – review & editing, Validation, Methodology, Formal analysis. **Zubair Ahmad:** Writing – review & editing, Validation. **Thomas K.F. Chiu:** Writing – review & editing, Methodology, Conceptualization.

### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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