# Self-regulated learning strategies for success in an online first-year chemistry course

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## Abstract

During their first year of study at university, many students encounter challenges in developing learning strategies that align with success in the courses in which they are enrolled. The emergence of the COVID-19 pandemic heightened the challenges as universities were compelled to transition to online learning. Therefore, this study investigated the self-reported use of learning strategies in a first-year chemistry course delivered online due to the COVID-19 pandemic to identify learning strategies associated with success. Grounded in self-regulated learning (SRL) theory, a case study approach with an explanatory mixed methods design was adopted. Quantitative data were collected using a hybrid of the Motivated Strategies for Learning Questionnaire and the Online Self-regulated Learning Questionnaire. Follow-up open-ended questions were emailed to the students for the qualitative part of the study. Statistical analysis of the quantitative data was performed using SPSS and RUMM2030, while thematic analysis was applied to the qualitative data. Students reported more frequent use of SRL strategies of environment structuring, effort regulation, and elaboration. Conversely, critical thinking, task strategies, help-seeking, and peer learning were reportedly used less often. SRL strategies linked with success in the course were identified as effort regulation, goal setting, and time management. The findings from the qualitative data revealed an impact of online learning due to the pandemic on the use of peer learning and help-seeking strategies. The paper discusses the implications of these findings for educational practices, particularly in the context of hybrid learning in the post-pandemic era.

## Introduction

Many students in their first year of university struggle to develop self-regulated learning strategies appropriate for their enrolled courses (Mickwitz et al., 2024). The use of self-regulated learning strategies has been linked to positive academic performance in literature, regardless of the mode of instruction, whether face-to-face, online, or in a blended format (Broadbent, 2017). As a result, a lack of effective learning strategies can result in poor academic performance, potentially impeding the successful transition from high school to university. The emergence of the COVID-19 pandemic, along with the subsequent lockdown measures, heightened the challenges that students were already facing. Universities were compelled to shift from face-to-face or blended instruction to online learning (Adedoyin and Soykan, 2020). This transition, regardless of the disciplines in which students were enrolled, presented students with the dual challenge of developing effective learning strategies as well as adapting to the unique difficulties associated with the advent of online learning. Hence, students needed to exhibit autonomy in their learning and possess self-regulation skills to succeed in this new learning environment.

The current study focuses on the chemistry discipline, specifically examining how students regulated their learning following the shift to online learning due to the COVID-19 pandemic. It addresses the limited research on students' use of self-regulated learning strategies in chemistry courses, particularly in online learning environments. The primary objective of this study was to investigate students' self-reported use of self-regulated learning strategies within a first-year chemistry module delivered online due to the COVID-19 pandemic. The goal was to identify learning strategies associated with academic success, which can inform the development of interventions tailored to guide first-year chemistry students toward becoming more effective self-regulators of their own learning.

# Literature review

## Self-regulated learning (SRL) theory

SRL centres around the idea that students to a certain extent have control of their learning processes and can transform mental ability into task-related skills in their academics. That is, students take an active role in shaping their educational experiences. This perspective aligns with other existing definitions of SRL in literature. For instance, Zimmerman (1989) defined SRL as the degree to which students are active participants in their learning process in terms of metacognition, motivation, and behaviour. SRL was characterized by Dowell and Small (2012) as a conscious decision made by students to attain specific goals, develop strategies to attain those goals, and their willingness to modify established strategies. Cho et al. (2017) defined it as a process in which learners systematically manage their learning in a way that improves their motivation and reflection, and thereby helps them reach their goals. In essence, these definitions highlight the idea that students play an essential role in controlling their own learning experiences and converting their mental abilities into practical academic skills. Examples of SRL strategies may include help seeking, peer learning, time management, self-evaluation, metacognitive self-regulation, effort regulation and critical thinking (Pintrich, 2000; Barnard-Brak et al., 2010).

## SRL in different learning modalities

Previous research has shown that, in general, students' use of SRL strategies is associated with good academic performance (Pintrich, 2000; Barnard-Brak et al., 2010; Olakanmi and Gumbo, 2017). However, it is important to acknowledge that, while SRL plays an important role, academic performance may also be influenced by multiple other factors including students' prior knowledge, cognitive abilities, and motivation (Richardson et al., 2012). In online learning environments, other elements such as technological proficiency, course design, and instructor support also contribute significantly to student success (Nambiar, 2020). This study focuses on the influence of SRL on students' academic performance.

The effectiveness of SRL strategies may vary across different learning contexts, emphasising the importance of tailoring strategies to different learning environments (Dettori and Persico, 2007; Cleary et al., 2012). That is, students' use of SRL strategies can vary depending on whether learning occurs in a face-to-face, blended, or online learning environment. SRL has been researched within face-to-face learning contexts, with a wealth of literature examining its impact on student outcomes (Richardson et al., 2012). Recent studies underscore the continued significance of SRL in enhancing academic performance within traditional classroom settings (Dent and Koenka, 2016; Sahranavard et al., 2018). With the evolving landscape of education,

understanding SRL in blended and online contexts is vital to inform pedagogical practices and support students' self-regulated learning in diverse educational settings.

When comparing face-to-face and blended learning environments, it was noted that, unlike in a face-to-face learning environment, students' success in blended learning environments depends more on activities they engage in outside of the classroom (online) than on what occurs in a classroom with an instructor (Gedik et al., 2012). It has been shown that students enrolled in a blended learning environment use SRL strategies more frequently than those enrolled in a face-to-face environment, having a higher SRL score than those who only studied in a face-to-face mode (Setyaningrum, 2019). The flexibility of accessing learning materials and control of learning speed in the blended learning mode was indicated as a factor for the difference in SRL scores between the two groups. The use of SRL strategies in a blended learning environment was also compared to the use of SRL strategies in an online learning environment. Using the Motivated Strategies for learning Questionnaire (MSLQ) as a data collection instrument, Broadbent (2017) found that except for the strategies of peer learning and help seeking, which were reported to be used significantly more often by blended learning students, online learning students reported utilizing all SRL strategies more frequently than blended learning students. Both groups reported moderate use of critical thinking and rehearsal strategies. In a meta-analysis to determine how students use of SRL strategies influences academic success in an online setting in higher education institutions, it was revealed that academic achievement was correlated with metacognition, time management, effort regulation, and critical thinking (Broadbent and Poon, 2015). The cognitive strategies of elaboration, rehearsal, and organization were discovered to be unrelated to online academic achievement. Rehearsal, for example, is regarded as a surface-level strategy that does not generate rich learning. Elaboration, on the other hand, is considered a higher-level strategy that entails more in-depth information processing. While elaboration appeared to be effective in a typical classroom setting (Pintrich et al., 1993), it was found to be less effective in an online setting in this meta-analysis. Nonetheless, student academic success in online courses is dependent on students' ability to regulate their learning (Wang et al., 2013). This is most especially because, in an online learning environment, students must decide when, where, and for how long they want to access learning materials within the prescribed timeframes of their enrolled modules (Harrell, 2008). Students who do not go the extra mile to accomplish tasks that will help them meet their educational goals in an online learning environment risk failing the course as instructors have limited influence, unlike in traditional face-to-face learning environments (Hart, 2012). Therefore, SRL is even more important in online learning environments. Recent research has explored various aspects of SRL in online learning. Li et al. (2020) used clickstream data to measure and support SRL, finding it effective in revealing students' time management and effort regulation. Zhu et al. (2020) linked positive attitudes and strong SRL skills to a higher intention to continue online learning. Mou (2023) highlighted the increased importance of SRL skills during the COVID-19 pandemic for successful online learning. Al Mamun and Lawrie (2023) emphasized the role of SRL strategies in enhancing engagement and learning outcomes in inquiry-based online modules.

Overall, there is a consensus in the literature on the importance of the use of SRL strategies for good academic performance regardless of whether learning occurs in a face-to-face, blended, or online learning environment (Wang et al., 2013; Broadbent and Poon, 2015; Broadbent, 2017). According to the literature, no single set of learning strategies is proven to be effective only in face-to-face, blended, or online learning environments, although the frequency of SRL strategy use is context dependent. For example, the strategies of peer learning and help seeking

were reported to be used more frequently in blended learning environments compared to online learning environments (Broadbent, 2017).

## SRL across disciplines

The use of SRL strategies has been investigated for different disciplines. For instance, El-Adl and Alkharusi (2020) investigated the relationships of SRL strategies with students' learning motivation and academic achievement in mathematics. The findings revealed statistically significant positive relationships between SRL and motivation and academic achievement. Similar studies have been conducted in mathematics, with similar positive results (Ahmed et al., 2013; Cho and Heron, 2015; León et al., 2015). In biology, Sebesta and Bray Speth (2017) investigated the relationship between the use of SRL strategies and good performance on a college introductory biology exam. Higher achievers reported using cognitive and metacognitive strategies significantly more often than their lower-achieving peers. Lower-achieving students often indicated either not using SRL strategies or, if they did, not seeing improvements in their outcomes. The findings suggest that many students starting introductory biology courses may have limited knowledge of SRL strategies and may struggle to put them into practice, affecting their performance. Similar findings were demonstrated in the study conducted by Cogliano et al. (2022), which examined the influence of an SRL skill training program on the performance of undergraduate biology students identified as at risk of performing poorly in the course. The results indicated that providing training to students identified as likely to perform poorly significantly enhanced their performance on unit exams, in contrast to students who were similarly identified but did not undergo the training. The use of SRL strategies has shown similar results for other science subjects such as physics (Achufusi-Aka and Offiah, 2010; Stephen et al., 2018; Anayo, 2023).

This paper focuses on the use of SRL strategies in chemistry. Previous research has established a foundation for understanding SRL within the chemistry discipline. The findings align with those from studies in mathematics, biology, and physics, demonstrating a positive correlation between the use of SRL strategies and good academic performance (Lopez et al., 2013; Olakanmi and Gumbo, 2017). However, it is important to note that although the trend is similar across disciplines, the specific SRL strategies effective within each discipline may vary depending on the context. Most research on SRL in chemistry has focused on the secondary school level (Olakanmi and Gumbo, 2017; Kadioglu-Akbulut and Uzuntiryaki-Kondakci, 2021; Feldman-Maggor, 2023), with limited university level studies of SRL in chemistry. In a study in a face-to-face organic chemistry course, students' SRL strategies were limited to organization (making notes) and rehearsal (reviewing the textbook, class notes, and past problems) (Lopez et al., 2013). In contrast, another study in a first-semester general chemistry course found that students mostly endorsed effort regulation strategies (Miller, 2015). Feldman-Maggor et al. (2022) identified key factors contributing to success in online general chemistry courses, emphasising the importance of SRL and active student participation. Similarly, Purwoko et al. (2024) explored the connections between SRL, motivation, and laboratory activities among Chemistry Education students and found that SRL had a significant direct impact on both laboratory activities and student motivation, while motivation's role as a mediator between SRL and laboratory activities was statistically insignificant.

While these studies provide brief glimpses into the role of SRL in chemistry learning, studies focusing on understanding the types of SRL strategies used by university chemistry students, particularly in online learning environments, are limited. The current study, guided by SRL as a theoretical framework, addresses this gap by examining the application of SRL strategies by

first-year chemistry students in an online learning environment amid the COVID-19 pandemic. The study set out to address the following research questions:

1. Which learning strategies were reportedly used more and which were reportedly used less by the students?

2. Which learning strategies differentiated between the strongly performing and poorly performing students?

3. How did online learning as a result of the lockdown restrictions affect students' use of learning strategies?

The findings of this study shed light on students' resilience in the face of unforeseen disruptions. Since these chemistry students had enrolled for primarily face-to-face studies and not online learning as a choice, understanding how they used SRL strategies during the COVID-19 pandemic can help instructors in face-to-face and blended courses better prepare for emergencies or a changing learning landscape. Furthermore, the findings highlight the importance of equipping students with effective SRL strategies as online learning continues to be integrated into educational systems in the post-pandemic era. The findings can be used to develop tailored support systems to equip chemistry students with strategies to succeed in different learning environments. Therefore, the contribution of this study extends beyond the immediate pandemic context or online learning, providing a foundation for developing more effective teaching and learning strategies for chemistry learning in an ever-changing educational landscape.

# Research context

This study took place in a chemistry department at a large research-intensive university in South Africa. The module of interest was a second-semester, first-year general chemistry course for students majoring in natural sciences. Every year, approximately 1400 students representing diverse ethnicities, linguistic backgrounds, and academic histories enrol in this course. In this study, 1370 students were enrolled in the course, where 430 students participated in the research by completing a questionnaire. The module is mandatory for students pursuing a chemistry degree as well as other scientific disciplines such as biology, physics and geology. This second-semester course serves as a continuation of the first-semester general chemistry course and draws on some content covered in grade 12. Under normal circumstances, students would be expected to attend four 50-minute lectures per week over 14 weeks. Additionally, they participate in alternating weekly activities of 3-hour practical laboratory work and 3-hour tutorial sessions, amounting to a total of six practical and six tutorial sessions throughout the semester. Online homework, associated with international textbook publisher platforms, is used for formative assessment and to pace student's learning.

However, owing to the shift to online learning necessitated by the pandemic, all module activities were conducted online with lectures delivered through Blackboard live virtual sessions, supplemented by a discussion board platform to allow students to interact outside of formal lecture time. Furthermore, students accessed video demonstrations of laboratory experiments and completed associated assignments in their own time. They could also attend weekly live virtual tutorial sessions spanning 1 to 2 hours. No official training on online learning platforms was necessary as the student population in this study was already proficient

with technology. The university provided laptops and data to students who lacked access to the required devices and internet connections due to different socio-economic backgrounds. Likewise, the lecturers had gained experience with teaching on online learning platforms during the 2016 "Fees Must Fall" disruptions (Potgieter et al., 2019) and, as such, did not require additional training.

# Methodology and methods

A case study methodological approach was chosen for this study. The study followed an explanatory mixed methods design where quantitative data was collected first, followed by qualitative data to explain some of the quantitative results (Creswell and Clark, 2017).

A questionnaire was used to collect quantitative data to probe students' use of SRL strategies. This questionnaire was a hybrid of the learning strategies section of the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich et al., 1993) and the entire Online Self-regulated Learning Questionnaire (OSLQ) (Barnard et al., 2009). The MSLQ is a self-report instrument for assessing university motivational orientations of students and the use of various learning strategies. It was developed to assess the presence of SRL in a specific university course (Pintrich et al., 1993). The MSLQ is divided into two sections: a motivational section and a section on learning strategies. The motivation section of the MSLQ was not included in this study for two reasons: (i) when Rasch analysis was performed in a previous related study by Kritzinger et al. (2018), the items on the motivation section did not have appropriate statistical characteristics, and (ii) to avoid respondent fatigue due to the length of the questionnaire. Thus, only the learning strategies section of the MSLQ was considered for data collection. However, due to the COVID-19 pandemic, the first-year chemistry course on which this study is based went fully online. While the MSLQ was created before the emergence of online or blended learning, its modular system allowed for the integration of a component to probe for the use of SRL strategies specific to the online learning environment (Soemantri et al., 2018), and thus items from the OSLQ were integrated. The OSLQ was originally designed to measure the use of SRL strategies in online or blended learning environments, and unlike the MSLQ, the OSLQ consists of subscales that only assess learning strategies (Barnard et al., 2009). When the two instruments were integrated, some learning strategies were duplicated, and therefore, we chose those that resonated with the circumstances of online learning and our context. Additionally, when we closely evaluated the items within the subscales, we adapted the wording and colloquial language to better align with the participants in this study. For instance, an item from the help seeking was originally "I share my problems with my classmates online so we know what we are struggling with and how to solve our problems" and was changed to "I share my problems with my classmates online (WhatsApp, ClickUP, Facebook, etc.), so we know what we are struggling with and how to solve our problems". Table 1 presents the subscales from each questionnaire that were included in the final questionnaire along with their corresponding explanations. We defined these subscales by incorporating the definitions from the original instruments while also considering our context. It is important to note that these definitions were not shared with the students; however, they played a crucial role in the interpretation of the results. The complete final questionnaire is given in Appendix A. Students were asked to score the questionnaire items on a Likert scale of 1 to 4, with 1 representing "not at all true of me". 2 representing "seldom true of me", 3 representing "mostly true of me" and 4 representing "very true of me". The scores were used as an indication of the degree to which students utilised the learning strategies. The 4-point Likert scale was chosen to offer fewer options and to eliminate the neutral choice that can distort results. This Likert scale compelled students to

make a clear decision between agreeing or disagreeing with the items of the questionnaire (Nadler et al., 2015).

**Table 1** SRL strategies from the MSLQ (Pintrich et al., 1993) and the OSLQ (Barnard et al., 2009)

| Subscale | Explanations |
|---|---|
| MSLQ | |
| Peer learning | Collaborating with friends or classmates to study. Learning from and with peers both formally and informally. Peer learning can happen on a virtual platform, such as WhatsApp or Google Meet |
| Critical thinking | Engaging prior knowledge to analyse, review and challenge ideas presented in the course. |
| Metacognitive self-regulation | Monitoring and regulating the studying process while studying. For instance, students tracking their attention as they study or adjust the way they study when they realise it is not effective |
| Elaboration | Summarizing and paraphrasing the information one reads in the chemistry textbook and relating the information to what is already known |
| Organisation | Strategies for organising thoughts by selecting main ideas from the chemistry readings and also attempting to organise and put together what is needed to be learnt in the module |
| Effort regulation | Controlling effort and attention to course work even when there are distractions or when the work is difficult and not interesting |
| Rehearsal | A rereading of class notes, memorising and reciting lists of chemistry keywords and concepts |
| OSLQ | |
| Time management | Managing study time well, for example, by scheduling and planning times to do course work |
| Help seeking | Seeking help from others when one stumbles upon content that is difficult to understand. Taking the initiative to seek help from lecturers, tutors, friends, or anyone who might be knowledgeable in the content |
| Task strategies | Taking actions beyond the formal course requirements to benefit from learning material (textbook, class notes, etc.) and learning opportunities (real-time classes, discussion boards, assignments, etc.) provided |
| Environment structuring | Managing the study environment and ensuring that it is organised, quiet and free of distractions |
| Goal setting | Developing an action plan to motivate and guide towards achieving set goals for the chemistry module. For example, setting small goals for each of the module activities (e.g. practicals, class tests, semester tests and exam) |

The learning management system was used as a platform where quantitative data was collected from 430 students who voluntarily completed the survey. The IBM SPSS (Statistical Package for the Social Sciences) Statistics for Windows, Version 27.0, and Rasch Unidimensional Measurement Models (RUMM2030 software) were utilized to conduct the statistical analysis. The SPSS was used to generate descriptive statistics, specifically the reported frequencies of use of the learning strategies by the students as well as organising demographical data. In the RUMM program, validity and reliability of the data collection instrument were established followed by the identification of learning strategies that differentiated between strongly performing and poorly performing students.

Follow-up open-ended questions were sent to students who responded negatively to all items associated with the least endorsed subscales via email. The questions were intended to extract additional information about specific learning strategies that were found to be underutilized during the analysis of the quantitative data to investigate the possible impact of the COVID-19 pandemic on the use of those learning strategies. Appendix B has a list of follow-up questions emailed to the students. Thematic analysis using an inductive approach was applied to the qualitative results. Of the 122 students approached, 24 responded. The analysis of the emailed responses involved coding, categorisation and eventually the development of themes (Saldaña, 2021). The in vivo coding method was used where codes were short phrases that came from the participants' responses. For this study, both the 'lens of a researcher' and 'lens of the study participants' were used as viewpoints to validate the results (Creswell and Miller, 2000). To establish validity from the researcher's perspective, two members of the research team independently coded the raw data and categorised the codes, then compared them to determine whether there were any differences in the coding and came to an agreement. Students who showed a willingness to provide additional information on the follow-up survey were asked to do member checking to evaluate their individual analysed responses and determine if the researcher's interpretation reflected the ideas they wished to convey.

# Ethical considerations

This research was reviewed and approved by the ethics committee for human research at the University of Pretoria (approval number NAS075/2020). All students in the study gave their consent to be part of the research. The graduate student was responsible for recruiting participants and data collection to overcome perceived power relationships. To protect confidentiality any identifying details were removed from the data and pseudonyms were used for reporting.

# Results and discussion

The demographics of the sample are shown in Table 2 where "n (out of 430)" represents students who completed the questionnaire, while "N (out of 1370)" denotes the entire study population. The similarity in percentages of various demographics between the sample and the population indicates that the sample was a good representation of the study population. Both the sample and the population had more females than males, and most of the students did not speak English as their home language. The sample was mostly made up of first-time entering students. Repeating students and students from an extended program made up a small portion of the sample. Extended program students are those who had to enrol in bridging courses because they did not meet the requirements for direct admission to mainstream degrees. In effect, these students do the same content as mainstream students but over a longer period. The extended program students would thus have had an additional year to acclimate to the university environment and thus the decision was made to analyse the group separately as this may have influenced their learning strategies, especially in terms of peer learning and help seeking behaviours. The pass rate for the exam was low for both the sample (31%) and the population (29%). This was not surprising given the historically low pass rate for the module (e.g.), in 2019 (47% of students passed the exam), and in 2018 (41%) and the forced transition to online learning.

**Table 2** Demographic characteristics of the sample

| Characteristics | Categories | n (out of 430) | N (out of 1370) |
|---|---|---|---|
| Gender | Female | 312 (73%) | 932 (68%) |
| | Male | 118 (27%) | 438 (32%) |
| History | First-time entering | 295 (69%) | 931 (68%) |
| | BSc extended program | 73 (17%) | 220 (16%) |
| | Repeaters | 62 (14%) | 219 (16%) |
| Home language | English | 150 (35%) | 493 (36%) |
| | Non-english | 278 (65%) | 877 (64%) |
| Examination performance | Fail | 252 (59%) | 795 (58%) |
| | Pass | 134 (31%) | 397 (24%) |
| | Did not write | 44 (10%) | 178 (13%) |

## RQ1: Which learning strategies were reportedly used more and which were reportedly used less by the students?

This section presents findings on which learning strategies were reported to be used more frequently by the entire sample and which were reported to be used less frequently. Before assessing the frequency of use of learning strategies in SPSS, the internal consistency of the instrument was examined. Each subscale had already been validated in the original instruments in larger-scale studies, but we wished to validate the combination in our context. The scores obtained from the 61-item instrument demonstrated sufficient internal consistency, with an overall high Cronbach's alpha coefficient of 0.93. Although there is no clear consensus on the optimal threshold for interpreting Cronbach's alpha values in science education research, most scholars consider values above 0.70 to be acceptable (Taber, 2018). When assessing the internal consistency of scores by subscale, Cronbach's alpha values varied from 0.50 for task strategies to 0.77 for critical thinking. The lower internal consistency for task strategies is not surprising as the subscale consists of a variety of unrelated actions that a student could have taken to enhance their learning. Similarly, a student who endorses rehearsal strategies (0.58) would be unlikely to use all the strategies grouped under that subscale. The lower internal consistency for the subscales indicates that the learning strategies listed are unique and not simply a reformulation of the same strategy. Hence, the high Chronbach's alpha value for the whole instrument is not inflated by redundant items. We were satisfied that the instrument was fit for purpose.

The Likert scale answers were converted to numerals and total scores for individual learning strategies were calculated for each participant using the following method: if a student responded to PL1 with 2 (seldom true of me), PL2 with 1 (not at all true of me), PL3 with 4 (very true of me), and PL4 with 3 (mostly true of me), then the total score for peer learning for that student becomes a 10. For each learning strategy, the total score per participant was normalized by dividing it by the number of items in the respective learning strategy. Table 3 contains the descriptive statistics of the normalised total scores for the different learning strategies as well as the Cronbach's alpha values obtained for each learning strategy. A high mean normalized score indicates that the learning strategy was reported to be used most frequently by the students, while a low score indicates the opposite.

**Table 3** Self-regulated learning scores and internal consistencies for each subscale (n = 430)

| Subscale | No of items | Mean of normalised total scores (SD) | α |
|---|---|---|---|
| Peer learning | 4 | 2.00 (0.71) | 0.68 |
| Help seeking | 4 | 2.10 (0.72) | 0.70 |
| Task strategies | 5 | 2.21 (0.52) | 0.50 |
| Critical thinking | 5 | 2.30 (0.64) | 0.77 |
| Time management | 4 | 2.44 (0.65) | 0.62 |
| Rehearsal | 4 | 2.71 (0.61) | 0.58 |
| Organisation | 4 | 2.80 (0.65) | 0.67 |
| Metacognitive self-regulation | 12 | 2.80 (0.44) | 0.73 |
| Goal setting | 5 | 2.86 (0.61) | 0.72 |
| Elaboration | 6 | 2.95 (0.51) | 0.66 |
| Effort regulation | 4 | 3.12 (0.59) | 0.69 |
| Environment structuring | 4 | 3.25 (0.58) | 0.68 |

Students reported frequent use of learning strategies of environment structuring, effort regulation, elaboration, and goal setting. Conversely, for critical thinking, task strategies, help seeking, and peer learning, responses indicated that these learning strategies were employed the least. Items under environment structuring pertained to the student's ability to manage their study environment, keeping it organized, quiet, and distraction-free. The items comprising effort regulation focused on perseverance and working hard to complete course tasks, even if they are difficult and uninteresting. Elaboration involves the process of incorporating and linking new information with what one already knows. Goal setting refers to developing an action to achieve learning goals. Unsurprisingly, students reported use of a wider range of learning strategies within the context of online learning during the COVID-19 pandemic. Students needed to maintain perseverance and dedication to stay engaged with coursework despite the challenges of remote learning such as potential distractions or feelings of isolation. Also, to succeed, students had to create and maintain their learning environment at home to make it conducive to learning. Furthermore, to understand the chemistry content students had to integrate their existing knowledge with the new information presented in the course. Frequent use of these learning strategies for an online learning environment has also been reported by several other studies as shown in a review by Broadbent and Poon (2015).

It was concerning however, that peer learning and help seeking strategies were reportedly used the least by students particularly since these strategies are expected to play a significant role in the learning process and have also been shown to be associated with good performance in chemistry (Horowitz et al., 2013; Miller, 2015; Uzezi and Deya, 2017). Students often turn to peers for assistance and seek help from instructors when facing challenges however, it appears to not be the case for our students. These findings were not entirely surprising, given that the abrupt transition to online learning may have limited opportunities for in-person peer interactions and made it more challenging for students to seek immediate assistance. The findings are consistent with Broadbent (2017), who found that online university students engaged less in peer learning and help seeking strategies. Additionally, factors such as digital barriers and unfamiliarity with online platforms may have discouraged students from actively participating in peer learning and help seeking. A follow-up survey was conducted to look into

the impact of online learning and lockdown restrictions on the use of these strategies presented under RQ3 below.

Critical thinking was also underutilised by students in the current study. The items that comprise the critical thinking sub-scale concern the students' ability to use the course material as a starting point to develop new ideas, as well as questioning theories, interpretations, and conclusions presented in the course. We postulate that the nature of the first-year general chemistry course in the present study provided limited opportunities for the use of the items listed as critical thinking learning strategies. The chemistry course in question is designed in a way that the information presented in the course is introductory and is about well-established foundation models that form the basis of the hierarchical nature of chemistry, better understood for their utility requiring no questioning or interrogation. Therefore, the nature of the course may have made the use of critical thinking skills presented in the questionnaire impractical.

## RQ2: Which learning strategies differentiated between the strongly performing and poorly performing students?

Before differentiating the use of the learning strategies by performance, the validity and reliability of the data collection instrument were established in the RUMM program. It was observed that peer learning and help seeking did not conform to the Rasch measurement model, indicating that these two learning strategies did not reflect a measure of self-regulation but instead pointed to other factors that might be interfering. Hence, the two learning strategy subscales were removed from the instrument. Additional items that did not fit the Rasch model were removed from this analysis (TS2). The instrument was valid and reliable for measuring SRL at the subscale level, but not at the individual item level, even after removing the peer learning and help-seeking subscales and the item that displayed misfit. A Differential Item Functioning (DIF) analysis was used to differentiate SRL strategy use between poorly performing and strongly performing students. Strongly performing students managed to achieve an exam mark of 50% or higher, whereas poorly performing achieved an exam mark of 49% or lower. DIF refers to the observation that subgroups of respondents within a sample may respond in a significantly different manner to an individual item despite equal levels of the underlying characteristic being measured (Retief et al., 2013). The mathematical derivation of DIF in Rasch analysis implies that artificial DIF always manifests to balance the calculations. Hence, the item showing the greatest DIF was systematically resolved until no DIF remained at the 0.01 confidence level. The analysis was carried out on a refined instrument where the help-seeking and peer learning subscales and one misfitting item had been removed. This analysis focused only on first-time entering students (n = 295) who had no prior university experience, offering insight into the learning strategies linked to passing exams in an online learning environment during a pandemic without the influence of prior university experiences. Plotting DIF on the item characteristic curves (ICC) showed that students who passed the exam endorsed effort regulation, goal setting (Fig. 1), and time management more than those who failed the exam. The difference was most pronounced among more self-regulated students, suggesting that these strategies could have been particularly effective for learning.

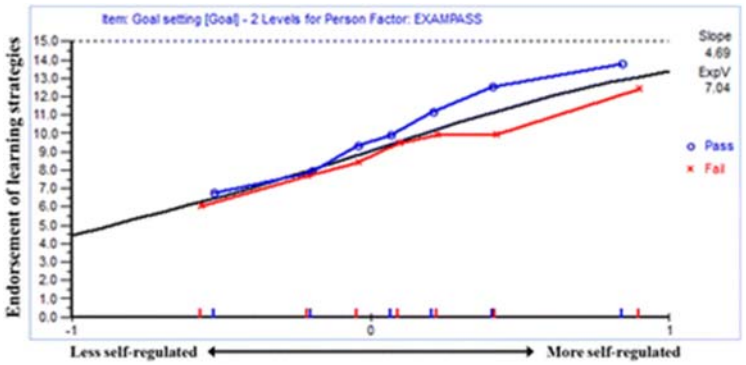


**Fig. 1** ICC to illustrate the presence of DIF for Goal setting super-item for exam pass/fail subgroups.

The findings are consistent with those of Broadbent and Poon (2015) and Broadbent (2017), who concluded that effort regulation and time management were related to good performance in an online learning environment. Similarly, goal setting has been linked to improved performance in a face-to-face medical sciences programme (Yusuff, 2018). Time management was also linked to performance in a first-year general chemistry context. Miller (2015) found that the management of time and study environment, metacognitive self-regulation, and peer learning were positively associated with performance. Therefore, the pandemic and the consequent move to online learning may have elicited different learning strategies for general chemistry. Students' ability to push themselves, plan their work, set goals for themselves, and manage their time effectively may have contributed to their success in the course, as these learning strategies were reported to be used more often by strongly performing students. It is noteworthy that the entire sample exhibited a positive overall response to the items related to effort regulation and goal setting (see Table 3). This suggests that even students who did not pass the course exam reported using these learning strategies to some extent, although less frequently compared to successful students. We posit that the decision of strongly performing students to persist in using these learning strategies slightly more often than unsuccessful students might have played a role in their performance in the course exam.

## RQ3: How did online learning as a result of the lockdown restrictions affect students' use of learning strategies?

Peer learning and help seeking were the least used learning strategies, as indicated by SPSS analysis. These subscales exhibited a misfit to the Rasch model due to unexpected endorsement patterns among good and poor self-regulators. As such, a follow-up survey was conducted to explore the potential influence of lockdown restrictions on the implementation of these strategies. Students were asked to explain their reasons for not using these strategies, allowing for an evaluation of any influences linked to the lockdown. Participants of the follow-up survey were purposefully selected according to how they responded to the items that make up the peer learning and help seeking subscales. Students who responded with "not at all true of me" or "seldom true of me" for all items that make up either peer learning or help seeking subscale were invited to participate in the follow-up survey. The follow-up survey was completed by 24 students. The subsample was mostly made up of first-time entering students, with only one extended program student and two repeating students. Half of the subsample indicated English as their first language; additionally, half of the subsample passed the exam. Fourteen students responded under the peer learning strategy. Ten students responded under the help seeking strategy. We present the reasons outlined by the students for each subscale, including some

quotations from their responses. The names attached to the quotations are pseudonyms to conceal their identities.

## Peer learning

Working independently. Five students stated a preference to study chemistry independently and did not feel the need to study with their peers. One student believed they are more productive when they study alone. "…I honestly like working by myself and find it easier to understand the work when I do it myself… however I realized that this method of studying was not always effective and in future will try to work with others" ~ Mandla (first-time entering, non-English, exam failed)

Isolation due to the pandemic. Students were required to attend classes online from their homes due to the unexpected shift to online learning caused by the pandemic. At least five students stated that they did not collaborate with their peers due to the isolation. Students mentioned that they were unfamiliar with their peers and never had the chance to establish relationships in the class; therefore, they were unable to engage in peer learning. "I didn't work with classmates because I really didn't know my classmates" ~ Naledi (first-time entering, non-English, exam failed)

Understanding content and confusion. One Student stated that they were often confused and unsure about what they understood. As a result, they were unable to reach out to their peers for collaboration. The student also stated that they believed their classmates were just as confused as they were and that studying with them would not yield positive outcomes. "…I often did not work with others because I myself am uncertain about what I truly understand or what is it exactly that confuses me in this module. Everything is mixed up. Secondly, my peers seem equally as confused as me at times …" ~ Brenda (first-time entering, English, exam failed)

Lack of data and internet connectivity. Students come from different areas with varying levels of network connectivity, with some locations having inadequate network connections. Furthermore, data prices are high, and some students are unable to afford them. As a result, Muzi found it challenging to connect with his peers through online platforms. "I did not have enough data, nor a good enough connection to allow video calls to friends." ~ Muzi (first-time entering, non-English, exam passed)

## Help seeking

Study preference. Some students preferred not to seek assistance from instructors or anyone knowledgeable in the topic, preferring instead to sort out their confusion utilizing materials such as the prescribed textbook, online sources, or course materials. "I prefer to go through the textbook and YouTube videos to try and figure out what I don't understand in my own way." ~ Anna (first-time entering, English, exam passed)

Pandemic related reasons. Students mentioned that the shift to online learning posed challenges in seeking assistance from instructors, classmates, or individuals knowledgeable about the content. Some students indicated they struggled with framing written questions effectively to receive satisfactory answers. Additionally, those who preferred seeking help from classmates expressed concerns about the limited opportunity to get to know their peers. "I don't have any contacts of my classmates to ask for help from them. I often did not know how to phrase the questions I had to lecturers and our tutors." ~ Bontle (repeating, non-English, exam failed). "I think would mainly be because of the online environment this semester…" ~ Khethiwe (first-time entering, non-English, exam passed)

As a result of online learning, students were unable to seek help from instructors face-to-face and instead had to rely on emails or the discussion board. Due to the high volume of emails that instructors get from students, responses to students were delayed, discouraging students from seeking help in the future. "…being in contact with lecturers was convenient…now everyone would be trying to email the lecturers or tutors, then you would not be able to get an immediate response." ~ Sipho (Extended programme, non-English, exam failed)

Understanding of content and confusion. Students were often confused by the content, which left them uncertain about their difficulties and thus reluctant to seek help. Some students stated that they were often behind on their work and hence were hesitant to request assistance from instructors. "The main reason I didn't ask for help is because If I didn't understand something, I couldn't pinpoint what I didn't understand. So, I just felt like I didn't understand anything." ~ Julia (first-time entering, English, exam failed)

"I did not ask for help mainly because I felt that I was so behind in my work and asking for help would require me to be knowledgeable of the basic terminologies and content … there was so much I did not know so even if I were to seek help and receive an answer from someone it would be useless/hopeless" ~ Sibo (first-time entering, non-English, exam failed)

Three common reasons for poor use of peer learning and help seeking strategies emerge from the follow-up survey: pandemic-related reasons (isolation and lack of resources), comprehension of content where students were often confused, and personal study preference. Reasons related to a lack of adequate resources to engage in successful online learning were expected, as they are part of the known challenges associated with online learning (Adedoyin and Soykan, 2020; Fishbane and Tomer, 2020). From the identified themes, it can be inferred that the pandemic-driven shift to online learning had an impact on the students' adoption of these learning strategies. However, for certain students, not employing these strategies was a matter of personal preference. Our findings reveal that some students who expressed a preference for not using these learning strategies ultimately failed the exam. Therefore, it is plausible that personal barriers and preferences may have negatively affected the students' performance.

Specific to peer learning, the abrupt shift to online learning did not allow higher education institutions enough time to prepare content to support peer activities and peer learning technologies to assist when learning occurs online (Mukhtar et al., 2020). That is, peer learning opportunities were limited in the online learning design, and as a result, students have had to create peer learning opportunities themselves. This was also a challenge due to the lockdown restrictions that did not allow people to move around and isolated the students before they had the opportunity to get to know one another. Therefore, students were unable to benefit from cooperative learning. According to the findings, some students attempted to reach out to their peers but were unsuccessful ("I've reached out once or twice but the lack of enthusiasm combined with my introverted nature led to me studying on my own"). Some students who demonstrated a desire to engage in peer learning but were limited by circumstances failed the exam. Although there is no direct relationship between these students' performance and their lack of peer learning activities, previous research has found a positive correlation between peer learning and good academic performance (Chen et al., 2010; Shen et al., 2013; Miller, 2015; Uzezi and Deya, 2017). The lack of peer learning opportunities may have impacted the students' performance.

In terms of help seeking, previous research has demonstrated that better learning benefits can be obtained when students engage in appropriate help seeking behaviours and when instructors give efficient help mechanisms and resources. Furthermore, asking for help has been shown to contribute to a broad pattern of student resilience in overcoming barriers to learning and achievement (Newman, 2002; Koc and Liu, 2016). In this study, students revealed that isolation had an impact on their use of help seeking strategies. Students did not seek help from their peers for the same reasons they did not engage in peer learning. Aside from the effects of lockdown regulations, help seeking in the online environment can be influenced by several elements such as technology, course management system, nature of the course, and student and instructor personalities (Koc and Liu, 2016). This was consistent with students who stated that they felt more comfortable seeking help from their peers before approaching instructors; thus, it is likely that these students believed that seeking help from their peers posed less of a threat to them in terms of having their lack of knowledge exposed in front of their instructors. For students who reported not seeking help due to personal preference, Butler (2006) and Koc and Liu (2016) highlighted that sometimes a self-regulated learner may avoid seeking help because they strive for autonomous learning. Additionally, some students are likely to seek help if the situation allows them to first attempt to resolve difficulty on their own and the help is supportive of their autonomy in the long run. Furthermore, when students do not seek help, it may indicate that they are unable to construct a legitimate question or are too ashamed to seek help and guidance (Koc and Liu, 2016) and thus end up choosing not to seek help. One student made this point in the follow-up survey: “When it comes to asking questions in discussion boards and live virtual lectures, that often relates to a difficulty in asking questions, and almost a fear of it…Some of it obviously relates to ego; asking a question and feeling stupid…”. Students' help-seeking behaviours are influenced by various factors, including their comfort with peer interactions, personal preferences for autonomy, and the perceived risks of exposing their knowledge gaps. These factors, compounded by the challenges of an online learning environment, may deter students from seeking the help they need. These barriers could be mitigated by creating a supportive environment where participants feel comfortable asking for help and structuring opportunities for help-seeking such as scheduled question-and-answer sessions or peer support groups.

# Implications for practice

The reported low utilization of help-seeking, and peer learning, strategies associated with success in other studies, underscores the importance for instructors to integrate opportunities for peer learning into the course structure and to consider how to remove barriers to help seeking. These learning strategies are context-dependent, as observed in the follow-up survey. Actively incorporating and encouraging the use of these learning strategies is especially important in online learning contexts. Emphasising these strategies in instructional materials and activities has the potential to enhance students’ SRL skills and, ultimately, their performance.

The findings indicating the association of effort regulation, goal setting and time management with success in the course exam, suggest the importance for instructors to actively promote the use of these learning strategies to enhance success for all students. Instructors can play a crucial role in guiding students on how to employ these strategies effectively by providing explicit instructions, resources, and support for incorporating these learning strategies into regular study sessions and test/exam preparation. Furthermore, these learning strategies are recognized for their association with success in any learning environment. This implies that students can be encouraged to apply these learning strategies in any learning mode.

The association of limited use of peer learning and help-seeking strategies with the lockdown restrictions imposed during the COVID-19 pandemic highlights the necessity for a learning environment capable of withstanding external disruptions. Higher learning institutions should strive to cultivate learning environments that empower students to use SRL strategies known for success in any circumstance. Institutions should prepare for unforeseen events that may disrupt the regular flow of learning. This involves having contingency plans in place to maintain support systems during emergencies or unexpected situations. For instance, in the crisis-induced adoption of online learning, students should still have the ability to engage in peer learning and seek assistance as needed. Future online chemistry courses, including both crisis-induced and intentional online courses, should integrate flexible support mechanisms. This could include alternative communication channels, virtual collaboration tools, and accessible platforms that allow students to seek assistance and engage in peer learning irrespective of external constraints. In contrast, there could be an increased emphasis on fostering independent learning skills. Students should be equipped with the tools and strategies to navigate their studies autonomously when collaborative learning opportunities are constrained.

# Suggestions for future research

The following areas for further research are proposed. Data on students' reported use of learning strategies throughout the semester was collected near the end of the semester, and the findings were related to students' exam performance. For future work, the predictive ability of the SRL strategies on exam performance could be investigated using data collected at the start of the semester to allow for early intervention to improve success rates.

The individual strategies used to probe for critical thinking were deemed inappropriate for use in a first-year general chemistry course. Future research should identify critical thinking strategies that would be productive for learning chemistry concepts. This research would complement studies on how to develop critical thinking skills specifically in the context of chemistry. There may be learning strategies pertinent to chemistry that have not been probed as the MSLQ and OSLQ, developed out of educational psychology for application in any course. A grounded approach could reveal other productive learning strategies for chemistry, such as the use of handheld models for developing understanding of molecular structures.

The present study was conducted during the COVID-19 pandemic, another area for future research could be conducting a longitudinal analysis to track changes in SRL strategies over an extended period including the post-pandemic era. This could provide insights into the long-term effects of the COVID-19 pandemic and lockdown restrictions on students' learning habits, allowing researchers to observe whether any changes persist or dissipate as learning returns to normal. Future work could also investigate how institutions have adapted their support systems and resources post-pandemic to facilitate effective SRL strategy utilization. Understanding how institutions evolve in response to lessons learned during the pandemic can inform future strategies for supporting student learning. Another longitudinal study should track how SRL strategies mature among students as they progress through a chemistry degree. This study would follow a group of students from their initial enrolment in a chemistry degree program and continue to monitor their use of SRL strategies as they advance to higher levels of study aiming to identify the most effective strategies at different stages of a chemistry degree.

# Limitations

The reliance on a questionnaire for data collection in our study introduces the possibility of self-report bias, as participants may provide responses that align with social desirability rather than reflecting their actual SRL behaviours. In addition, participants volunteered to take part in this study, which introduces the potential for self-selection bias. While the sample demographics closely align with those of the population described in Table 2, this voluntary participation may still lead to differences in engagement or motivation that affect the study's findings. To mitigate this, future research could incorporate objective measures or observations alongside self-reports, providing a more comprehensive understanding of students' engagement with SRL strategies. Additionally, the potential for memory recall issues poses a challenge, as participants may struggle to accurately remember and report their past behaviours. This limitation could be mitigated by using more frequent and immediate data collection methods, such as weekly or bi-weekly surveys, to capture real-time insights into SRL strategies. However, these approaches would be more demanding of participants. In addition, the internal consistency of some of the measures in our study, specifically for task strategies and rehearsal, was relatively low, as indicated by Cronbach's alpha values. This limitation should be noted, as it could affect the reliability of these subscales, keeping in mind that the overall internal consistency is very high. One possible explanation for the discrepancy could be the change in the Likert scale used, from a 1–5 scale to a 1–4 scale. Even though the change of the scale was to exclude the neutral option, this alteration may have impacted the clarity of response options or participants' ability to accurately express their level of agreement, thereby lowering the reliability of the scales. Future research using this instrument should consider testing and refining these measures to ensure more reliable results.

Moreover, learning is contextual, that is, it is concerned with the behaviour of people and is hence not governed by strict laws, and it is influenced by a wide range of factors. As a result, the outcomes of this study cannot be extended to various learning settings. The research was conducted at only one institution of higher education, which limits the generalizability of the findings. It would be desirable to expand the study by bringing in students from other universities. Finally, the study did not delve into potential variations in SRL strategies based on the specific topics or sub-disciplines within chemistry. Different branches of chemistry may demand distinct cognitive skills and learning approaches. A more granular investigation into how SRL strategies vary across various chemistry topics could provide valuable insights for educators tailoring instructional approaches to different facets of the discipline.

# Conclusions

This study aimed to investigate the use of SRL strategies in a first-year chemistry course presented online during the COVID-19 pandemic. The objective was to identify SRL strategies associated with success, specifically focusing on learning strategies linked to passing the first-year chemistry course exam. The study addressed research questions related to the overall reported use of SRL strategies by students, the differentiation of SRL strategies between strongly performing and poorly performing students, and the impact of online learning due to lockdown restrictions on students' use of SRL strategies. Data were collected using an instrument that integrated learning strategies from both the MSLQ and the OSLQ.

The results revealed that learning strategies such as environment structuring, effort regulation, and elaboration were reported to be used more frequently, while task strategies, help seeking,

and peer learning were reportedly used less frequently. The low reported use of help seeking, and peer learning was attributed to the impacts of online learning during the COVID-19 pandemic, personal preference and insufficient understanding of the chemistry course content. In the context of the study, the learning strategies of effort regulation, goal setting and time management were found to be associated with success.

The findings of this study emphasise the impact of changing circumstances, such as the shift to online learning, on students' use of SRL strategies. The results confirm that the adaptability and effectiveness of SRL strategies are influenced not only by discipline but also by the changing dynamics of the learning environment. The observed patterns in learning strategies highlight the importance of tailoring instructional methods to optimise the use of learning strategies known to be associated with success. Moving forward, instructors must play a role in directing students towards strategies that are appropriate for the demands of specific learning environments. Furthermore, the results prompt a recognition that certain strategies may not be universally suitable for all courses highlighting the need to delve deeper into the contextual relevance of the different learning strategies in various disciplines and considering innovative approaches to foster their application by the students.

# Author contributions

LR contributed to the conceptualization of the project, data collection, data analysis, writing the first draft and editing. AK contributed to the supervision of the project, conceptualization, data analysis, and reviewing of the manuscript. LAP contributed to the supervision of the project, conceptualization, Rasch analysis, data analysis, writing and editing the manuscript, and funding.

# Data availability

Data for this article are stored on figshare at
https://doi.org/10.25403/UPresearchdata.27020338.v1.

# Conflicts of interest

There are no conflicts of interest to declare.

# Appendices

## Appendix A: Final questionnaire

| Subscale | Item code | Item statement |
|---|---|---|
| Rehearsal | Re1 | When I study for this course, I practice saying the material to myself a number of times |
| | Re2 | When studying for this course, I work through my lecture notes and the course materials a number of times |
| | Re3 | I memorise key words to remind myself of important concepts in this course |
| | Re4 | I make lists of important items for this course and memorize the lists |
| Elaboration | El1 | When I study for this course, I make use of information from different sources, such as lectures, course material, and discussions |
| | El2 | I try to relate ideas in this course to those in other courses whenever possible |
| | El3 | When studying for this course, I try to relate the material to what I already know |
| | El4 | When I study for this course, I write brief summaries of the main ideas from the textbook and my lecture notes |
| | El5 | I try to understand the material in this course by making connections between the course materials and the concepts from the lectures |
| | El6 | I try to apply ideas from course material in other course activities such as lectures and discussions |
| Organisation | Or1 | When I study for this course, I make an outline of the material to help me organise my thoughts |
| | Or2 | When I study for this course, I go through the content material and try to find the most important ideas |
| | Or3 | I make simple charts, diagrams, or tables to help me organise course material |
| | Or4 | When I study for this course, I go over my lecture notes and make an outline of important concepts |
| Critical thinking | CT1 | I find myself questioning things I hear or read in this course to decide if I find them convincing |
| | CT2 | When a theory, interpretation, or conclusion is presented in the lecture or in the course materials, I try to decide if there is good supporting evidence |
| | CT3 | I treat the course material as a starting point and try to develop my own ideas about it |
| | CT4 | I try to play around with ideas of my own related to what I am learning in this course |

| Subscale | Item code | Item statement |
|---|---|---|
| | CT5 | Whenever I find a claim or conclusion in this course, I think about possible alternatives |
| Metacognitive self-regulation | M1 | During lecture time I miss important points because I'm thinking of other things. (reverse coded) |
| | M2 | When studying for this course, I make up questions to help focus my reading |
| | M3 | When I become confused about something I'm reading for this course, I go back and try to figure it out |
| | M4 | If course content is difficult to understand, I change the way I study the material |
| | M5 | Before I study new course material thoroughly, I page (or scroll) through it to see how it is organised |
| | M6 | I ask myself questions to make sure I understand the material I have been studying in this course |
| | M7 | I try to change the way I study in order to fit the course requirements |
| | M8 | I find that I study for this course but don't know what it is all about. (reverse coded) |
| | M9 | I determine what I am supposed to learn from the material before I start studying |
| | M10 | When studying for this course I try to determine which concepts I don't understand well |
| | M11 | When I study for this course, I set goals for myself in order to direct my activities in each study session |
| | M12 | If I get confused taking notes in this course, I make sure I sort it out afterwards |
| Effort regulation | ER1 | I feel so lazy or bored when I study for this course that I give up before I finish what I planned to do. (reverse coded) |
| | ER2 | I work hard to do well in this course even if I don't like what we are doing |
| | ER3 | When course work is difficult, I either give up or only study the easy parts. (reverse coded) |
| | ER4 | Even when course materials are boring and uninteresting, I manage to keep working until I finish |
| Peer learning | PL1 | When studying for this course, I try to explain the material to a classmate or friend (virtually or in person) |
| | PL2 | I try to work with other students from this course to complete the course assignments (virtually or in person) such as class, tutorial, and self-assessment exercises |
| | PL3 | When studying for this course, I set aside time to discuss course material with other students from the class (virtually or in person) |
| | PL4 | I do not have anyone with whom I can discuss the material that I am learning in this course." (reverse coded) |

| Subscale | Item code | Item statement |
|---|---|---|
| Goal setting | GS1 | I keep a high standard for my learning in this course |
| | GS2 | I set goals to help me manage study time for my learning in this course |
| | GS3 | I set short-term (daily or weekly) goals as well as long-term goals (monthly or for the semester) |
| | GS4 | I set standards for my course assignments |
| | GS5 | I don't compromise the quality of my work because it is online |
| Task strategies | TS1 | I use the discussion board to ask questions I have about the course content |
| | TS2 | I read aloud instructional materials posted online to fight against distractions |
| | TS3 | I try to take more thorough notes of the course content because notes are even more important for learning online than in a regular classroom |
| | TS4 | I do extra problems in addition to the assigned ones to master the course content |
| | TS5 | I prepare my questions before joining a virtual class discussion (Blackboard Live virtual lecture) |
| Time management | TM1 | I allocate extra studying time for my course work because I know it is time-demanding |
| | TM2 | I try to schedule the same time every day or every week to study for this course, and I observe the schedule |
| | TM3 | I try to distribute my studying time for this course evenly across days |
| | TM4 | I attend all my lectures for this course |
| Environment structuring | ES1 | I know where I can study most efficiently for this course |
| | ES2 | I choose the location where I study to avoid too much distraction |
| | ES3 | I find a comfortable place to study |
| | ES4 | I choose a time with few distractions to study for this course |
| Help seeking | HS1 | I share my problems with my classmates online (WhatsApp, ClickUP, Facebook, etc.), so we know what we are struggling with and how to solve our problems |
| | HS2 | If needed, I try to meet my classmates. (virtually or in person) |
| | HS3 | I am persistent in getting help from the instructor (lecturer or tutor) through the discussion board or in a live virtual lecture |
| | HS4 | I find someone who is knowledgeable in course content so that I can consult with him or her when I need help |

### Appendix B: Follow-up survey questions

Study strategy: Peer learning. Working together with friends or classmates as a way of studying the course.

Question: From the questionnaire, your responses indicated that you often did not work with your classmates to study chemistry in the course. Reflecting back on the module, please elaborate on why that was the case. (You can list as many reasons as you want)

Study strategy: help seeking. Asking for help from fellow classmates, lecturers or tutors, or anyone who may be knowledgeable in the content.

Question: From the questionnaire, your responses indicated that when you came across content you could not understand you often did not seek help from your fellow classmates, lecturers or tutors, or anyone who may be knowledgeable in the content of the course. Reflecting back on the module, please elaborate on why that was the case. (You can list as many reasons as you).

# Acknowledgements

We acknowledge valuable contributions of Marietjie Potgieter (University of Pretoria, Department of Chemistry) for her contribution towards conceptualisation of the project, and for conducting the initial Rasch analysis. We thank the National Research Foundation of South Africa for the Scarce Skills Masters Scholarship awarded to L. Rakhunwana (Grant Number: 122736). We thank the University of Pretoria for financial support.

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