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Navigating the Transition to Second Year: Mindsets and Learning Strategies of Biomedical Science Students

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Abstract

The transition into second year can present challenges to undergraduate students' engagement, motivation, and self-perception. Psychological factors, particularly students' mindsets (self-beliefs about their abilities) play a crucial role in how they navigate challenges and succeed academically. This study investigates whether students with a growth mindset are better equipped to handle academic challenges, not only because of their self-beliefs but also through the learning strategies they employ. We examined the relationship between mindset, learning strategies and performance in second-year biomedical science students (n=256). Through thematic analysis of open-ended questions, we determined students' mindsets and learning strategies. Qualitative themes were then quantified to determine frequencies. Statistical analysis was conducted to assess the relationship between mindsets, learning strategies and performance. Nearly two-thirds of students held a growth mindset about their biomedical science ability. While students reported a diverse range of strategies, no relationship was found between mindsets and learning strategies. Despite this, growth mindset students achieved higher academic performance than students of other mindsets. Second-year biomedical science students may be growth-oriented; however, their use of learning strategies may be more complex than this study could fully capture. Targeted support may be required to ensure students can effectively apply strategies in this period.

Introduction

As students progress into their second year of undergraduate study, many experience declines in academic performance and increased difficulty adjusting to the ongoing demands of university life. (Loughlin, Gregory, Harrison, & Lodge, 2013). Second-year students often experience a decline in engagement (Gump, 2007), self-perception (Webb & Cotton, 2019), and motivation (Graunke & Woosley, 2005). Kibedi (2019) suggests that to overcome unexpected challenges, second-year students must become highly adaptable in their learning approaches. The psychological profile of the student, including goal orientation (Lieberman & Remedios, 2007), level of commitment (Graunke & Woosley, 2005; Sheard & Golby, 2007), and self-competency beliefs (Bruinsma, 2004) has been postulated to play a significant role during second year learning. Furthermore, students' 'mindset' (self-beliefs and attitudes toward their abilities) has been shown to significantly impact academic performance. Those who have a growth mindset are more likely to succeed (Yeager et al., 2019) and may be better equipped to navigate this transitional period.

Mindset theory focuses on individuals' implicit beliefs about the nature of intelligence, particularly whether these personal characteristics are innate, or capable of development through effort and experience (Dweck & Leggett, 1988). An individual with a growth mindset believes they can improve their ability through dedication, effort, and learning, while an individual with a fixed mindset believes they have an inherent amount of ability that is unchangeable (Dweck, 1999). Students with a growth mindset embrace challenges, persist through difficulties, and view setbacks as part of learning (Elinich et al., 2023). In contrast, students with a fixed mindset often avoid effort, show lower persistence, and may underachieve (Dweck & Yeager, 2019). In both children and adults, fixed and growth mindsets are equally represented in the general population, each accounting for 40% (Dweck & Molden, 2013). The remaining 20% exhibit a mixed mindset, incorporating aspects of both fixed and growth mindsets (Lou, Chaffee, & Noels, 2022). A growth mindset has also been linked to increased grit (Hochanadel & Finamore, 2015), defined as persistence and dedication despite challenges. As mindsets influence how students perceive and respond to academic challenges, they are likely to play a key role in shaping students' capacity for self-regulated learning.

Self-regulated learning (SRL) can be defined as the self-directed processes learners use to attain their learning goals. It encompasses students' ability to plan, monitor, and evaluate their own learning behaviours, making it central to adapting to increased academic demands and greater learner autonomy (Zimmerman, 2002). Research has also linked strong self-regulatory skills with sustained motivation and improved academic outcomes (Pintrich, 2004), making it a key focus for understanding how students navigate challenges such as the transition to second year. Many models of SRL exist, but one of the most widely accepted is a model by Zimmerman (2002), which consists of three phases: forethought, performance, and self-reflection, which represent a cycle of SRL. Forethought is where students first approach a learning task, analysing how the task should be performed and determining specific goals and strategies to achieve it (Lai & Hwang, 2016). Forethought informs the performance phase, which is when students experiment, monitor, and control their learning progress. Lastly, the self-reflection phase completes the cycle and is where students evaluate the effectiveness and efficiency of their learning process. Students who self-regulate will employ a range of learning strategies whilst also self-reflecting on the success of their methods (Blackmore, Vitali, Ainscough, Langfield, & Colthorpe, 2021). Research has suggested a causal relationship between strategy use and academic performance (Zimmerman & Martinez-Pons, 1986). Students' use of effective learning strategies is not only crucial for achieving academic success but also promoting deeper understanding.

Early research on learning approaches has revealed the learning strategies employed by students profoundly influence the quality of their learning outcomes (Clayton et al., 2009). Students can deploy various learning strategies to facilitate surface or deep learning (Hattie & Donoghue, 2016). In a new model of learning, Hattie and Donoghue (2016) illustrated that some surface and deep strategies allow for 'acquiring' knowledge, where information is initially gained and taken into short-term memory, while 'consolidating' is the active process of moving that knowledge into long-term memory (Table 1). While reliance on surface learning is often criticised as insufficient for long-term success (Lake & Boyd, 2015), Hattie and Donoghue (2016) suggest that use of surface strategies is an important initial step toward deeper understanding, proposing effective learning involves a combination of both surface and deep strategies. Additionally, they propose that self-regulation strategies (such as elaboration and monitoring) are particularly relevant during the phase of acquiring deep learning.

Table 1: Hattie and Donoghue (2016) categorisation of surface and deep learning strategies in acquiring and consolidating phases.

	Learning Phase	Learning Strategies	
Surface Learning	Acquiring	• Record keeping • Summarisation • Underlining and highlighting • Note-taking	• Mnemonics • Outlining and transforming • Organising notes • Working memory training • Imagery
	Consolidating	• Practice testing • Speed versus mass practice • Teaching test taking • Interleaved practice • Rehearsal • Maximising effort • Help-seeking	• Time on task • Reviewing records • Improving feedback literacy • Deliberate practice (i.e., practice with help of an expert, or receiving feedback during practice)
Deep Learning	Acquiring	• Elaboration and organisation • Strategy monitoring	• Concept mapping • Metacognitive strategies • Elaborative interrogation
	Consolidating	• Self-verbalisation • Self-questioning • Self-monitoring • Self-explanation • Self-verbalising the steps in a problem	• Seeking help from peers and peer tutoring • Collaborative learning • Evaluation and reflection • Problem solving • Critical thinking

The current study

The majority of research on the student experience beyond the first year has been conducted in the United States, with relatively few Australian studies contributing to this area (Loughlin et al., 2013; McBurnie, Campbell, & West, 2012; Willcoxson, Cotter, & Joy, 2011). This highlights the need for further research within the Australian context to better understand students' experiences beyond first year (Birbeck, McKellar, & Kenyon, 2021). The mindsets of biomedical science students remain largely unexamined, although studies in traditionally challenging STEM fields suggest a strong tendency toward a fixed mindset (Dai & Cromley, 2014; Limeri et al., 2020). In addition, a recent study by Xu, Broadbent, & Zhang (2025) found a positive correlation between a growth mindset and the use of self-regulated learning strategies among mathematics students following a mindset intervention. Given that many self-regulated learning strategies are classified by Hattie and Donoghue (2016) as enabling deep learning, this suggests that students with a growth mindset may be more inclined to adopt deep learning approaches. Understanding how students' mindsets influence their learning strategies may offer valuable insights into how biomedical science students navigate the academic demands of this challenging period. Therefore, this study aimed to investigate the relationship between mindsets, learning strategies, and academic performance.

Methodology

Participants

Participants were undergraduate biomedical science students (n=360) enrolled at the University of Queensland (UQ) in Australia studying the second-year course 'Integrated Cell & Tissue Biology' in Semester 1, 2024. Of these, only consenting students with complete datasets were included in the analysis (n=256). Students had a mean age of 19.6 ± 0.1 years, mostly identifying as female (61.5%), domestic (80.5%) and having English as their primary language (73%). The majority of participants (62.9%) were enrolled in the Bachelor of Biomedical Science degree. A further 15.2% were in the Bachelor of Science (Biomedical Science Major), with the remainder being in the biomedical science major of various dual or advanced science degrees. Mean academic performance in the course was 70.8% ± 0.8%.

Ethics

Ethical approval was granted by the institutional Human Research Ethics Committee (Ethic Approval #2018001055). Students were provided with a participant information sheet and invited to provide informed consent. An unpaired *t*-test was used to compare academic performance in the course between consenting (78%) and non-consenting (22%) students.

Course context and structure

The course is one of the first undertaken by biomedical science students in their first semester of second year. Course learning activities comprised three hours of lectures per week and five three-hour laboratory practicals during the semester. Lectures were given face-to-face, with *Echo360* (Echo360 Inc., Ohio, USA) recordings uploaded to *Blackboard* (Blackboard Inc., Washington DC, USA). Course assessment included a group practical assessment (5%), individual laboratory report (20%), two individual 'meta-learning' tasks (10%), five individual online quizzes (15%), and an individual, invigilated end of semester exam (50%).

Meta-learning tasks

The meta-learning tasks were designed to encourage students to build self-awareness of their learning processes via open-ended reflective questions (Colthorpe, Sharifirad, Ainscough, Anderson, & Zimbardi, 2018). Students were given meta-learning tasks in weeks three and eleven of semester. Each task comprised five questions available online via the course Blackboard site for one week. The two meta-learning task questions analysed in this study were posed in week 3. The question regarding mindset: *"Some people believe they have a certain amount of intelligence in bioscience, and this impacts their success. Do you agree? Please reflect on your answer providing details of why you do agree or do not agree"* was developed from the 'Theories of Intelligence Scale' for adults (Dweck, 1999). The question regarding learning strategies: "*There are various strategies that students use to aid their learning. Write down the learning strategies you have employed in the past. Which of these strategies do you rely on the most and why do you think they are most effective for you?"* was taken from Ainscough et al. (2019).

Thematic analysis

Students' responses from the meta-learning questions were subjected to thematic analysis using *NVivo 12* (QSR International, MA, USA). Data was coded for its semantic (explicit) meaning rather than latent (implicit) meaning (Braun & Clarke, 2024). Deductive thematic analysis was performed to code student responses against a specific mindset rubric and learning strategy framework created for this study (Table 2; Table 3). Mindset definitions were developed based on mindset theory and research (Dweck, 1999; Lou et al., 2022; Yeager & Dweck, 2012) and were adapted based on the perspectives and language of the students. Responses were coded against a framework of learning strategies based on the SRL strategies from Nota, Soresi, and Zimmerman (2004), Zimmerman (2002), and Zimmerman and Moylan (2009). This framework was further expanded via inductive thematic analysis. Learning strategies were then deductively categorised into surface versus deep based on Hattie and Donoghue (2016) and adapted for this study. Some strategies included both surface and deep aspects, depending on how students applied them. Study groups and peer collaboration were categorised as 'Seeking Social Assistance–Deep' when students engaged in collaborative learning rather than simply seeking answers from experts. 'Organising and Transforming Records' was classified as surface-level unless students were creating mindmaps or questions. 'Creating Mindmaps' aligned with deep strategies such as concept mapping (Hattie & Donoghue, 2016), while 'Creating Questions' was considered deep due to its use for self-evaluation. These were grouped under 'Organising and Transforming Records–Deep'. A second naïve researcher independently coded 25% of student responses from the mindset question to determine the reliability of the coding (O'Connor & Joffe, 2020). Following discussions with the second researcher and iterative revisions, inter-rater reliability results exceeded 90%.

Statistical analysis

Quantitative results were created from the frequency of each theme. Statistical analyses were completed using *GraphPad Prism 10* and *SPSS Statistics 29*, with statistical significance set at $p<0.05$. Unless otherwise stated, results are expressed as mean ± SEM. Students' overall percentage in the course was used to measure academic performance. When comparing fixed, mixed, and growth mindset students' number of surface and deep strategies, a non-parametric Kruskal-Wallis test with Dunn's multiple comparisons was used. Chi-square tests of independence with Holm's correction were used to compare reported use of specific learning strategies across mindset groups. A multiple linear regression analysis was performed to investigate the impact of specific surface and deep learning strategies on academic performance, while controlling for mindset (Theobald & Freeman, 2014). To ensure the regression was not underpowered, surface and deep strategies were analysed separately. All assumptions were checked and met (Laerd Statistics, 2015).

Table 2: Coding rubric for biomedical science students' mindsets. Adapted from mindset theory and research by Dweck (1999), Lou et al. (2022), and Yeager and Dweck (2012).

Mindset	Definition
Fixed	The student believes their bioscience ability is innate and unchangeable. Success in bioscience is seen as predetermined by natural intelligence.
Mixed	The student displays a mix of fixed and growth beliefs about their bioscience ability. They are undecided about the role of intelligence in bioscience success and may consider other varying factors as influencing success outcomes.
Growth	The student believes bioscience ability can be developed through dedication, effort, and learning. They may acknowledge others can more easily excel; however, they see effort as the key to overcoming any initial differences in intelligence and do not view it as a limiting factor towards their success.

Table 3: Coding framework for self-regulated learning strategies used to code students past learning strategies, including example student responses. This framework is adapted from Nota et al. (2004), Zimmerman (2002), and Zimmerman and Moylan (2009) to suit a tertiary learning environment. Learning strategies were categorised as either surface or deep based on Hattie and Donoghue (2016).

SRL Phase	Learning Strategy	Learning Approach	Definition and Coding Notes	Example Student Response
Forethought	Goal Setting and Planning	Surface	Setting goals and planning the sequencing or specific timing for the completion of goals.	*Using a journal or diary with a calendar to plan on a week-to-week basis.*
	Strategic Planning	Surface	Developing plans to use specific learning strategies or behaviours to improve learning.	*Reading the general topics before going into the lecture helps me to take in more knowledge.*
Performance	Attending Lectures	Surface	Attending or watch lectures.	*I've found it most beneficial to try and never miss a lecture.*
	Environmental Structuring	Surface	Organising or modifying physical and personal environments to enhance learning and/or reduce distractions.	*One thing I have started to employ is having a specific study spot at home and at uni which I will only use for work.*
	Interest Incentives	Surface	Using study methods to make study more enjoyable.	*I try to gamify my study by creating many checklists that I can feel good for gradually ticking.*
	Keeping Records	Surface	Keeping a record of course content.	*I found the strategy to be most successful is to make consistent notes along the way.*
	Organising and Transforming Records	Surface/Deep	Surface: Adapting learning materials using strategies like highlighting, annotating, mnemonics, flashcards, organising and summarising notes, or using visual aids (e.g. diagrams, flowcharts). Deep: Concept mapping, creating mind maps, and creating questions for future self-evaluation.	Surface: *I refine my notes, incorporating additional details from the [lecture] slides and organizing them in a manner that resonates best with my understanding.* Deep: *I also draw mind maps…so that I have an easy visual way to look back at my notes and see the relationships between topics*
	Practical Application*	Surface	Acquiring knowledge and facilitating learning through hands-on experience and real-world activities.	*Using the knowledge in an experiment and then furthering that knowledge based with things I learn within the practical helps me concrete the knowledge in my head.*
	Rehearsing and Memorising	Surface	Efforts to rehearse and memorise content by regular or overt repetitive practice of learning material.	*The flashcards that I've made throughout the semester are proving to be the most successful tool for my learning.*

	Reviewing Records	Surface	Revisiting course materials (e.g. notes, slides) to memorise or reinforce content without significant modification.	*I like to watch the lecture after attending the lecture in person to ensure that I have noted down important information.*
	Seeking Information	Deep	Seeking further information from non-social sources not associated with the course.	*I have also turned to seeking further content outside lectures to crystallise the concepts we are taught.*
	Seeking Social Assistance	Surface/Deep	Surface: Soliciting help from lecturers, tutors and other experts. Deep: Utilising study groups and collaborating with peers to deepen understanding.	Surface: *Getting help from tutors.* *Deep: I formed study groups with classmates to ask each other questions and explain complex concepts.*
	Self-Consequences	Surface	Arrangement or imagination of rewards or punishment for success or failure.	*The pressure to succeed with my peers made me study in advance for each practise test.*
	Self-Paced Learning*	Surface	Choosing to complete their learning at their own pace.	*I usually watch lectures slowly online so that I don't miss any single piece of information.*
	Time Management	Surface	Organising study tasks, keeping up with content, estimating time, and tracking progress and deadlines.	*A learning strategy I have found to be effective is to stay on top of the content and do the assessment pieces as they come out.*
Self-Reflection	Active Reappraisal of Records*	Deep	Critically engaging with and refining notes or resources to deepen understanding or restructure knowledge.	*Actively reviewing the content…has ensured that I have a good foundation of knowledge and allows me to see what concepts I am still struggling with.*
	Self-Evaluation	Deep	Evaluating the quality or progress of learning and/or effectiveness of learning strategies used.	*It was very important for me to regularly evaluate my knowledge and abilities…this helped me figure out what I needed more help with or more practice with.*

*Additional theme identified through inductive thematic analysis.

Results

Consenting students performed significantly better (70.4% ± 0.8%) than non-consenting students (61.8% ± 1.9%; Mann-Whitney test, $p<0.0001$).

Mindsets

Consenting students (n=256) responses from the meta-learning question regarding inherent bioscience intelligence were categorised into growth, mixed, or fixed mindsets (Table 2). Students' mindsets varied (Figure 1); however, second-year biomedical science students were more inclined to embrace a growth mindset about their biomedical science ability (65%). This was followed by a smaller proportion categorised as mixed (22.5%) or fixed (12.5%) mindsets. A small number of responses (n=25) did not directly address the question and were excluded from all mindset analyses.

Learning strategies

Students (n=256) reported 17 different learning strategies they had employed in the past (Table 3; Figure 2). 'Self-Evaluation' (66.4%), a deep strategy, was the most frequently reported learning strategy. This was followed by many surface strategies including 'Rehearsing and Memorising' (58.6%), 'Organising and Transforming Records–Surface' (44.5%), and 'Keeping Records' (28.1%).

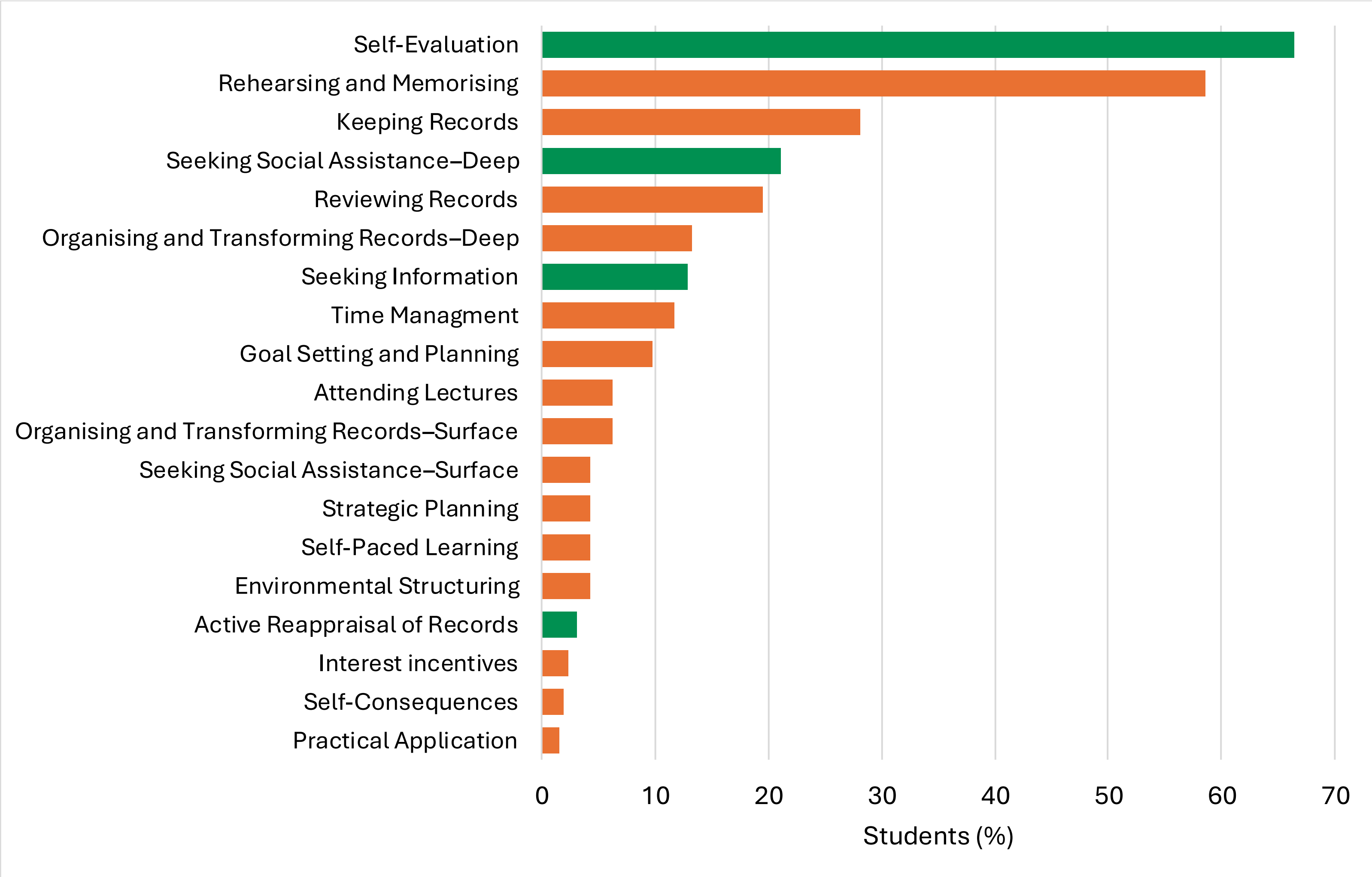

Figure 2: Learning strategies previously employed by second-year biomedical science students (n=256). Learning strategies were categorised as either surface (orange) or deep (green) based on Hattie and Donoghue (2016). Results show the percentage of students reporting each learning strategy. Students could report multiple strategies.

Mindsets and learning strategies

To determine whether the number of surface and deep learning strategies reported by students varied across mindset groups, Kruskal-Wallis tests with Dunn's multiple comparisons were conducted. Students tended to report more surface strategies (2.4 ± 0.1) than deep strategies (1.6 ± 0.1). No significant differences were found in the number of surface strategies (Figure 3A) reported by students with fixed, mixed, or growth mindsets. Similarly, there was no significant difference between the number of deep strategies reported by students with fixed, mixed, or growth mindsets (Figure 3B). Chi-square tests with Holm's correction were conducted to compare reported use of specific learning strategies across mindset groups; however, no significant differences were found (p>0.05).

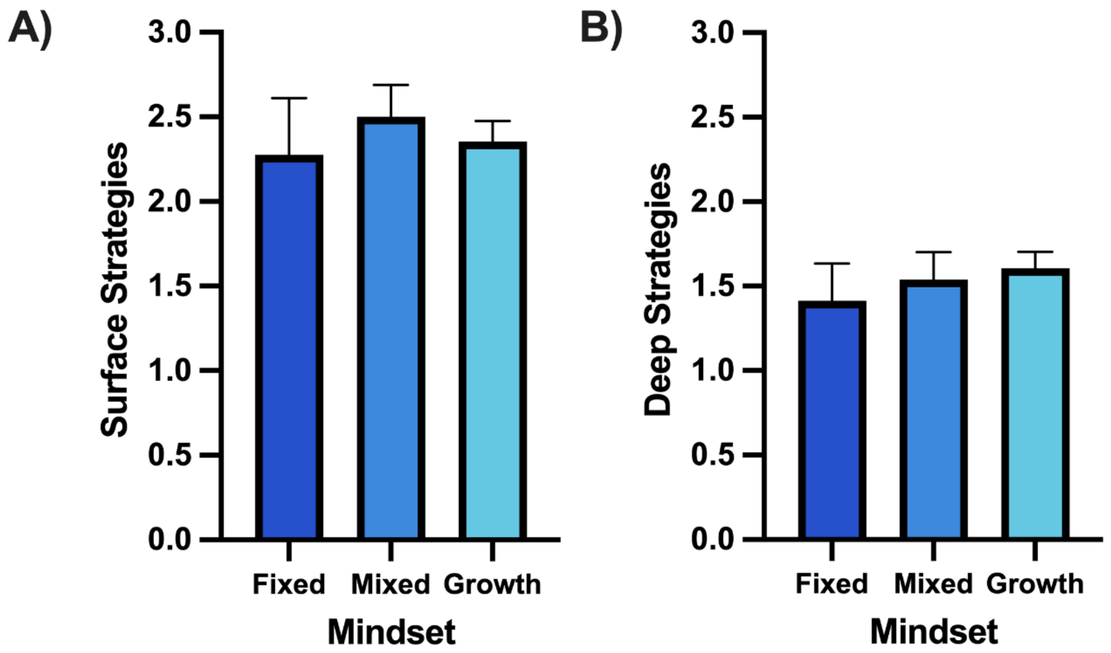

Figure 3: Comparison of the number of A) surface and B) deep learning strategies used in the past by biomedical science students with fixed (n=29), mixed (n=52), and growth (n=150) mindsets. Data is presented as mean ± SEM. Kruskal-Wallis tests with Dunn's comparisons found no significant differences in strategy use across mindset groups (p>0.05).

To further observe how students utilised surface and deep learning strategies, students were categorised into five groups: 'Surface' (student reported only surface strategies), 'Majority Surface' (student reported more surface strategies than deep), 'Surface and Deep' (surface and deep strategies were equally reported), 'Majority Deep' (student reported more deep strategies than surface), and 'Deep' (student reported only deep strategies). Regardless of mindset, most students fell into the 'Majority Surface' category (Figure 4). Chi-square tests with Holm's correction found no significant relationship between mindset and the proportion of surface versus deep learning strategies reported by students ($p>0.05$).

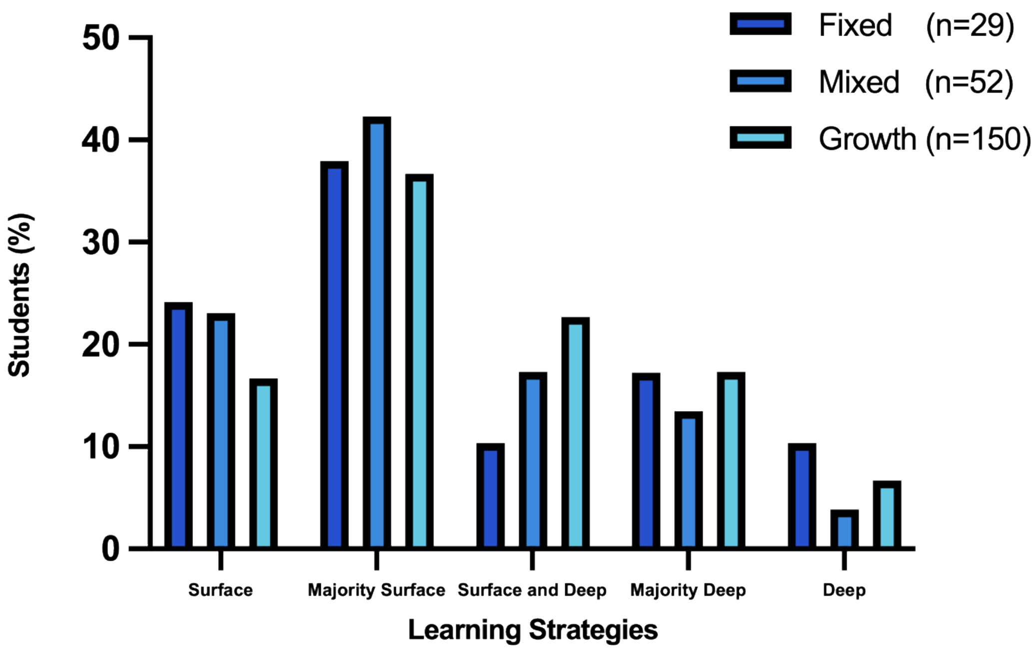

Figure 4: Surface versus deep strategies reported by biomedical science students (n=231). Students were classified based on their proportional use of surface versus deep strategies in the past and grouped by mindset: fixed (n=29), mixed (n=52), and growth (n=150).

Multiple linear regressions were performed to evaluate the impact of learning strategies on academic performance when controlling for mindset (Table 4). Growth mindset students were selected as the reference group, serving as the baseline for comparing academic performance across mindset groups. In all regression models, fixed mindset students had significantly lower academic performance compared to growth mindset students ($p<0.05$). The first model was used to predict academic performance from students' use of deep strategies. The model statistically predicted academic performance [$F_{(7,220)} = 3.078$, $p<0.01$, adj. $R^2 = 0.06$]. Students' use of 'Self-Evaluation' was associated with a 4.1% increase in academic performance ($p<0.05$). The second model including surface strategies also predicted academic performance [$F_{(15,212)} = 2.177$, $p<0.01$, adj. $R^2 = 0.072$]. In this model, both fixed and mixed mindset students performed significantly lower than growth mindset students, indicating certain models may have been more sensitive to mindset differences, depending on the variables included in the analyses. 'Attending Lectures' was excluded from the model due to collinearity. 'Keeping Records' was associated with a 4.9% increase in academic performance ($p<0.05$).

Table 4: Multiple linear regression analysis predicting academic performance from the types of surface and deep learning strategies when controlling for mindset groups (n=228). β, Standardized regression coefficient; B, Unstandardized regression coefficient. Growth mindset students were used as the reference group for comparing academic performance across mindsets. Significant variables are bolded. Significance is indicated by *p<0.05.

	B	SE	β	t	Sig.
Model 1: Deep Strategies					
Organising and Transforming–Deep	2.369	2.008	.076	1.180	.239
Seeking Information	.643	2.624	.016	.245	.807
Seeking Social Assistance–Deep	-.241	2.129	-.007	-.113	.910
Active Reappraisal of Records	-3.439	4.539	-.049	-.758	.449
Self-Evaluation	**4.065**	**1.888**	**.141***	**2.153**	**.032***
Fixed Mindset	**-9.286**	**2.718**	**-.228***	**-3.417**	**<.001***
Mixed Mindset	-3.518	2.162	-.108	-1.627	.105
Model 2: Surface Strategies					
Goal Setting and Planning	3.101	2.998	.067	1.034	.302
Strategic Planning	7.021	5.570	.111	1.261	.209
Environmental Structuring	-2.498	3.911	-.056	-.639	.524
Interest Incentives	3.400	6.061	.037	.561	.575
Keeping Records	**4.929**	**2.044**	**.162***	**2.412**	**.017***
Organising and Transforming Records–Surface	-.481	1.811	-.018	-.266	.791
Practical Application	-3.139	6.748	-.030	-.465	.642
Rehearsing and Memorising	-2.281	1.870	-.083	-1.220	.224
Reviewing Records	2.002	2.305	.058	.869	.386
Seeking Social Assistance–Surface	.016	2.092	.001	.008	.994
Self-Consequences	7.354	6.799	.071	1.082	.281
Self-Paced Learning	-3.073	4.418	-.046	-.696	.487
Time Management	4.481	2.766	.107	1.620	.107
Fixed Mindset	**-10.914**	**2.718**	**-.268***	**-4.015**	**<.001***
Mixed Mindset	**-4.541**	**2.202**	**-.139**	**-2.062**	**.040***

Discussion

This study aimed to investigate whether having a growth mindset was associated with increased use of deep learning strategies and improved learning outcomes in a second-year physiology course. The results indicated most students embraced a growth mindset, however, no relationship was found between mindsets and reported use of surface versus deep learning strategies. Despite this, students with a growth mindset outperformed those with a fixed mindset. These findings suggest second-year biomedical science students may be growth-oriented; however, their use of learning strategies may be more complex than this study could fully capture.

Almost two-thirds of second-year biomedical science students held a growth mindset regarding their biomedical science ability (Figure 1). This contradicts prior research suggesting undergraduate STEM students typically exhibit fixed mindsets. In introductory STEM courses, specifically in biology (Dai & Cromley, 2014), computer science (Flanigan et al., 2017), and math (Shively & Ryan, 2013), students exhibited primarily stronger fixed mindsets or weak growth mindsets. Additionally, students tend to have an increasingly fixed mindset as they progress through STEM courses (Dai & Cromley, 2014). Limeri et al. (2020) found this same trend amongst students in a second-year chemistry course and proposed that academic performance may also influence mindset in a reciprocal manner, where students' academic outcomes can impact and shape their mindset. Conversely, success within courses may also reinforce a growth mindset. As such, the high proportion of growth mindset students in biomedical science may reflect prior or continued academic success or may suggest that biomedical science students are inherently more growth-oriented than those in other STEM disciplines.

Second-year biomedical science students reported using a diverse range of learning strategies (Figure 2). Self-evaluation emerged as the most frequently reported strategy. This was surprising, as earlier research on second-year allied health and pharmacy students studying physiology indicated limited use of or reliance on self-evaluation (Colthorpe, Ogiji, Ainscough, Zimbardi, & Anderson, 2019; Colthorpe et al., 2018). Self-evaluation refers to the assessment of one's performance and awareness of one's strengths and weaknesses (Hewitt, 2011). For successful self-evaluation, students must use either externally or internally generated feedback regarding their performance to evaluate their progression towards goals (Bol, Hacker, Walck, & Nunnery, 2012). Regardless of mindset, students' use of self-evaluation emerged as a positive indicator of academic success (Table 4). This aligns with findings from Sebesta and Bray Speth (2017) who also found self-evaluation was associated with greater academic performance in undergraduate biology students. The frequent use of self-evaluation in this cohort may reflect a growing capacity for self-regulated learning, particularly during the transition to second year, where students are required to take greater ownership of their academic development. As such, fostering self-evaluative practices may be a valuable target for interventions aimed at improving performance in biomedical science programs.

Given the challenges of the transition to second year, it was hypothesised that growth mindset students would report using more deep learning strategies, as this mindset promotes perseverance and adaptive learning behaviours (Burnette, O'Boyle, VanEpps, Pollack, & Finkel, 2013; Yeager et al., 2019). However, there were no significant differences in the number of surface and deep learning strategies used by students across mindset groups (Figure 3). Most second-year biomedical science students reported a mix of both surface and deep strategies (Figure 2), with no clear predominance of either (Figure 4). These findings reinforce the model of Hattie and Donoghue (2016), where students must employ a combination of surface and deep strategies for effective learning. However, knowledge of a strategy does not guarantee students are aware of how to apply it effectively (Zimmerman, 2000). Indeed, Hattie and Donoghue (2016) also noted that the effectiveness of a learning strategy depends not just on the strategy itself, but on when and how it is used within the learning process. Stanton et al. (2015) highlighted that while many undergraduate students can identify appropriate learning strategies, they may lack the awareness and skills to apply these effectively. Second-year biomedical science students possess a strong awareness of effective self-regulatory strategies; however, further investigation is needed to assess whether there is a gap between knowing and effectively using learning strategies within the learning process.

Despite varying mindsets, students tended to report predominantly surface strategies when reflecting on the strategies they use most often (Figure 4). However, as the data capture the range of strategies reported rather than their frequency or context of use, it remains possible that deep strategies were used more frequently or that surface strategies served a supportive role in deeper learning processes, as outlined in Hattie and Donoghue's (2016) model. Students' selection of learning strategies is context-dependent (Ramsden, 1988). The balance of surface and deep strategies used depends on the perceived demands of the task (Hattie & Donoghue, 2016). For example, students are more likely to utilise surface strategies when learning environments reward rote memorisation of facts. Indeed, surface strategies are more utilised in science degrees (Parpala, Lindblom-Ylänne, Komulainen, Litmanen, & Hirsto, 2010). This may also be attributed to the nature of STEM courses, often content-heavy and demanding, (Holschuh, 2000), thereby encouraging a greater reliance on surface strategies. In the current study, the biomedical science course featured a diverse range of assessments, including multiple-choice questions, short-answer questions and scientific writing tasks. These formats likely encouraged students to draw on both surface-level recall and deeper conceptual understanding, depending on the specific demands of each task. If the goal is for students to strive for a deeper understanding, assessments need to align with this objective, compelling students to employ deep strategies (Broekkamp & Van Hout-Wolters, 2007). Further investigation may be required to evaluate how well biomedical science courses support these goals.

Moreover, our findings suggest that mindset did not influence students' selection of learning strategies (Figure 3; Figure 4). However, prior research has demonstrated the interrelationships between a growth mindset, grit, and resilience (Calo, Peiris, Chipchase, Blackstock, & Judd, 2019; Hochanadel & Finamore, 2015). Core principles of this mindset (such as increasing effort, embracing challenges, and persisting through setbacks) may encourage sustained effort and perseverance in the application of learning strategies. For instance, a learning strategy may be applied inconsistently or repeatedly over time (Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013). Consequently, students' self-reported strategy use may not have fully captured how mindsets impact strategy application. Given that growth mindset students in this study outperformed students of other mindsets (Table 4), future studies should consider alternative methods for assessing the effectiveness and application of students' learning strategies to better capture these potential nuances.

Limitations and future directions

Open-ended questions served as an effective method for exploring students' perspectives and learning strategies. However, self-reported data comes with inherent limitations, including response bias and differences in how participants interpret questions (Rosenman, Tennekoon,

& Hill, 2011). For example, some students may have used certain strategies but did not recall them during the meta-learning task. Additionally, students may have reported strategies they were familiar with rather than those they used consistently or effectively, highlighting that knowledge of a strategy does not necessarily reflect its practical application (Zimmerman, 2000). To address these limitations, future research could incorporate longitudinal or observational methods to better capture how students apply learning strategies across the learning process.

While our cohort was highly representative with a large consenting group (78%), our non-consenting group (22%) was both small and significantly lower-performing academically, which may have introduced a degree of selection bias into the dataset. Given prior research showing a positive association between growth mindset and academic performance (Yeager et al., 2019), it is possible that students with a growth mindset were over-represented in our consenting cohort. It is also important to note that student mindsets are not static. There is evidence to suggest that mindsets can shift over time, even without formal intervention (Limeri et al., 2020). As this study was conducted early in Semester 1, it is possible that students were still in the midst of adjusting to the academic and psychological demands of second year. Conducting follow-up investigations later in the semester or across the academic year could offer deeper insights into how students' learning strategies and mindsets evolve with time and experience.

Significance and implications for practice

This study found most second-year biomedical science students held a growth mindset about their biomedical science ability. Consequently, these students may be better equipped to overcome the challenges of second year learning, as they believe their abilities can be developed through dedication, effort, and learning. Although we did not observe a relationship between mindsets and surface versus deep learning strategies, these findings reinforce that mindset could play a role in improving student outcomes. Students also demonstrated awareness of a wide range of self-regulatory strategies. However, further investigation is warranted to determine whether students not only recognise these strategies but also understand how to apply them effectively. In particular, we found the use of self-evaluation and record-keeping were associated with improved academic performance regardless of mindset. These strategies could serve as key targets for interventions designed to enhance academic success during the second year. As biomedical science students progress through increasingly complex academic challenges, fostering both a growth mindset and the effective use of self-regulatory strategies may serve as an essential foundation for academic success during this transitional period.

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