Journal of University Teaching & Learning Practice

Volume 19
Issue 2 *Quarterly Issue 1*

Article 08

2022

Are undergraduate students studying smart? Insights into study strategies and habits across a programme of study

Suzanne Fergus
University of Hertfordshire, United Kingdom, s.fergus@herts.ac.uk

Recommended Citation

Fergus, S. (2022). Are undergraduate students studying smart? Insights into study strategies and habits across a programme of study. *Journal of University Teaching & Learning Practice, 19*(2), 110-127. https://doi.org/10.53761/1.19.2.8

Are undergraduate students studying smart? Insights into study strategies and habits across a programme of study

Abstract

The approach that students take in their studies at university is critical not only for their academic success but is equally important in life-long learning for their career and professional development. Heutagogy is the study of self-determined learning and it is important that we appraise how students in higher education are developing their metacognitive awareness in how they learn and study effectively. Cognitive science is an interdisciplinary research area that involves the scientific study of the human mind. It helps provide new knowledge in relation to areas such as memory, problem solving, knowledge transfer and understanding of complex topics. Cognitive science has demonstrated that re-testing oneself on material when learning, enhances and promotes greater retention of knowledge compared to re-reading the material. Learning that is distributed or spaced out over multiple study sessions also allows for greater retention of knowledge in the longer-term compared to 'cramming' of information. To evaluate the use of effective study approaches and habits across three different levels of study in an undergraduate pharmacy programme, a survey study was employed. A paper-based survey was completed by first-, second- and third-year undergraduate pharmacy students (n=192) during class sessions. Although there was some evidence of metacognitive awareness such as using testing (retrieval practice) with practice problems; across all years, suboptimal study approaches such as rereading, copying notes and cramming were endorsed. A schedule of deadlines shaped the organisation of study and time management for most students. Self-testing was predominantly used to test learning rather than an approach used during learning. There was evidence of a difference between the cohorts in relation to decisions for prioritizing studying, returning to review course material and re-reading. The evidence from this study demonstrates that learners would require training on metacognitive awareness and effective study strategies to enable their self-determined learning capabilities to evolve. The linear progression through a programme of study alone will not achieve this. There is a need to embed and emphasize effective strategies for learning into curricula and for faculty to utilise metacognitive awareness in their teaching.

Practitioner Notes

1. Self-determined learning places an expectation that learners self-regulate and take responsibility for their learning. Student's independent study within a programme helps to consolidate learning.
2. Study habits and preferences vary among individuals however there is clear evidence from cognitive science that not all study approaches are effective.
3. Undergraduate students are using suboptimal study methods such as rereading notes, recopying notes and cramming information the night before a test. Self-testing was predominantly used to test learning rather than an approach used during learning.
4. Students report that they are not using approaches taught to them by teachers. It has been shown that learners incorrectly predict suboptimal methods as superior to evidence-based approaches. We suggest that evidence-based study approaches are explicitly emphasised and embedded within courses.
5. We recommend to senior managers with learning and teaching remits (Directors of Learning and Teaching, Pro Vice-Chancellors for Education and Student Experience) that faculty staff are informed about evidence-based learning approaches from cognitive

science and increase metacognitive awareness in their teaching.

Keywords

Undergraduate students, study habits, metacognition, self-regulation

Introduction

Study habits and approaches to study are critical in higher education particularly considering the emphasis on independent adult learning and continued professional development. Self-directed learning affords agency to the learner and developing competencies in various disciplines is a vital skill and outcome. Heutagogy is the study of self-determined learning (Hase & Kenyon, 2000) and the role of the learner in learning frames this article. Heutagogy includes aspects of reflection with double-loop learning where learners reflect back on their experience and develop capabilities centred on self-efficacy, knowing how to learn and transferring their competencies in unfamiliar and novel situations. This goes beyond simply learning knowledge and with the necessity to adapt, innovate and the constant pace of change in the workplace, knowing how to learn is a fundamental skill in the 21st century. The approach to learning can be described in terms of the distinction between deep learning and surface learning approaches (Biggs, 1987; Marton & Säljö, 1976). Deep learning involves an active interaction with a purposeful intention to develop understanding and link ideas together. Surface learning is more passive, focusing on reproducing content as required. A third strategic learning approach combines aspects of both surface and deep learning. Although approaches to learning were described decades ago, there is a need to revisit study habits and approaches to learning in relation to research knowledge from cognitive science.

This paper reports on a survey study to determine the study strategies and habits across three different levels of study: Year 1 (Y1), Year 2 (Y2) and Year 3 (Y3) on a single programme of study (Pharmacy). Previous research on effective study strategies is outlined to illustrate the evidence-based approaches endorsed from cognitive science. A survey was utilised based on previous research with introductory courses where most participants were first- and second-year undergraduate students (Geller et al., 2018; Hartwig & Dunlosky, 2012). This allows for a comparison of results with previous research data and findings in the discussion section. There are some implications highlighted for faculty and researchers based on the findings from this study.

Literature Review

There is a growing research base from cognitive science that supports effective study strategies with much evidence on distributed practice and retrieval practice (Dunlosky et al., 2013). The use of desirable difficulties to enhance learning focuses on creating conditions that lead to more durable and flexible learning (Bjork & Bjork, 2011). Retrieval of information (or the testing effect) produces large gains in long-term retention relative to rereading and restudying of material (Roediger & Butler, 2011; Stewart et al., 2014). A study by Roediger and Karpicke (2006) using general scientific material found that students in the repeated-testing condition recalled more after a week compared to students in the repeated-study condition (61% vs 40%). The repeated-study condition group read the material 14.2 times compared to 3.4 times in the repeated-testing condition group. Retrieval practice has also been compared to active learning tasks such as concept mapping. Concept mapping requires learners to construct a diagram that links and connects relationships among concepts (Novak & Cañas, 2006). This encoding of meaningful relationships among concepts within an organised knowledge structure is a recommended elaborative learning task. Retrieval practice has shown greater gains (by one standard deviation) in conceptual learning of science topics than elaborative approaches using concept maps (Karpicke, 2011). Distributed practice (or the spacing effect) where study periods are spaced out over time showed enhanced learning as opposed to cramming study in a single session (Cepeda et al., 2006). Distributed practice involves distinctive retrieval episodes, and it has been shown to help in the discrimination of different problem types e.g., a study by Kornell et al. (2010) found that spacing provided an advantage when learning visually complex paintings in both young and older adults. Interleaving, where exposure to different concepts is mixed up rather than grouping and presenting each concept as a block helps learners to distinguish between similar concepts (Rohrer, 2012). For example, a recent study found interleaving mathematics problems, resulted in a higher score than the blocked group, 61% vs. 38%, d=0.83 in an unannounced test a month after the assignments (Rohrer et al., 2020). A third reported effective study strategy involves generative learning which states that learner-generated materials which involves reorganising and integrating new learning with prior knowledge will be more easily remembered and applied in new situations that instructor-provided materials (Fiorella & Mayer, 2015). Examples of generative learning strategies include summarising, drawing, imagining, self-testing, self-explaining, teaching and role play. A study by Ponce and Mayer (2014) used eye-tracking technology with students reading only, taking notes, or completing a graphic organiser during the reading of a passage on steamboats presented online. Compared to the note-taking group, the graphic organiser group displayed more eye movements (between the top and bottom of the passage and between the text and writing window) and

scored higher on a comprehension test afterwards (d=1.17). The reading only group tended to use a linear strategy where their eyes followed the text in order compared to the generative learning strategy displayed by the graphic organiser group whose eyes searched for connections across the passage.

Despite the effectiveness of retrieval practice and self-testing, students do not implement these strategies when self-studying (Hagemeier & Mason, 2011; Karpicke et al., 2009). Research on the study strategies of US college students found that testing, rereading, and cramming are commonly reported study strategies with higher performing students more likely to choose effective study strategies and have greater awareness on the benefits of self-testing (Geller et al., 2018; Hartwig & Dunlosky, 2012; McAndrew et al., 2016). In addition, Geller et al. (2018) found that avoidance goals (e.g., fear of failure) coincided with increased cramming and students were more influenced by impending deadlines than by a planned study schedule. A study survey that considered the study strategies, hours of study and distribution of study over time found that initially, intentions to use effective strategies were evident but during the semester, students relied on relatively ineffective strategies and crammed studying ahead of an exam (Blasiman et al., 2017). In populations where no academic deadlines exist, similar study habits were displayed where retrieval practice and self-testing are mostly unappreciated (Yan et al., 2014). Metacognitive awareness in relation to the benefits of retrieval practice and distributed practice confirms that students are not necessarily implementing such effective study approaches (Karpicke et al., 2009). The research evidence suggests that students can overpredict their learning and discontinue studying and succumb to 'stability bias' (Kornell & Bjork, 2009). Self-directed learning requires the learner's ability to accurately monitor their understanding. Metacognition is the act of thinking about one's own thinking. Metacognitive monitoring is measured in two ways: resolution and calibration. Metacognitive resolution is the ability to evaluate correct answers from incorrect answers whereas metacognitive calibration is the prediction of performance. Poor resolution can lead to the prioritization of wrong items; poor calibration with overconfidence can lead to limited studying (Kornell & Bjork, 2008). The Dunning-Kruger effect reflects these metacognitive errors where poor performers overestimate their expertise and knowledge (Dunning, 2011).

Theoretical Framework

Learners are central to the process of self-directed learning. Their prior knowledge, preconceptions and experiences shape their interactions within learning contexts. New learning is constructed and assimilated into a pre-existing framework of understanding. This constructivist perspective assumes that knowledge is constructed in the mind of the learner (Bodner et al., 2001). The subjectivity of the learner needs to be considered in relation to constructivism and meaningful learning. A framework to characterize meaningful learning is Novak's Theory of Human Constructivism (Bretz, 2001; Novak, 2002; Novak et al., 1984). Meaningful learning requires three conditions:

1. The material to be learned must be presented in a clear manner using concepts and language that relates to the learner's prior knowledge.

2. The learner must possess relevant prior knowledge.

3. The learner must choose to learn meaningfully by attempting to incorporate new meanings into their prior knowledge rather than simply rote learning the material.

Learners' prior knowledge, content to be learned and the approach to learning are three factors required for meaningful learning to take place. It is the approach to learning component that is the focus within this research article.

Previous studies on specific study habits have focused on psychology (Hartwig & Dunlosky, 2012; Kornell & Bjork, 2007; Morehead et al., 2016), biology (Geller et al., 2018) and dentistry courses (McAndrew et al., 2016). Recent research on chemistry courses in two distinct locations (UK and Spain) confirmed that the use of suboptimal study strategies is a general phenomenon observed across multiple geographical locations (Fergus et al., 2021). It was of interest here to explore the reported study strategies and habits among students on a single programme of study (Pharmacy) across three different levels of study: Year 1 (Y1), Year 2 (Y2) and Year 3 (Y3). This would emphasise the reported study habits at different levels of study to examine any shifts in approaches to learning. Perhaps learners report more evidence-based approaches in Y3 compared to Y1? The pharmacy professional programme incorporates scientific (biology, chemistry, pharmaceutics, and

pharmacology) and clinical components (pharmacy practice and legal regulations) and the breath of disciplines captured in this programme help to make the findings more widely applicable. To contribute to the research knowledge on effective study approaches from cognitive science and habits within a programme of study, a survey study with first-, second- and third-year pharmacy students was proposed.

Research Question:

To what extent are undergraduate students (Y1, Y2 and Y3) adopting evidence-based study approaches at different levels of study within a programme of study?

Method

A survey of 11 questions was administered as a paper-based survey during class sessions to Y1, Y2 and Y3 undergraduate pharmacy students at the University of Hertfordshire, UK. The survey questions from previously reported study surveys (Geller et al., 2018; Hartwig & Dunlosky, 2012) were utilised so that general comparisons from this study could be evaluated. A face validity check was carried out by two academics and following this Q7 was modified as it referred to and specified psychology.

The time window of the survey during 2019/2020 took place between October 2019- January 2020 and prior to the pivot to online learning and delivery due to the COVID-19 pandemic in March 2020. The course modality across all three years included face-to-face lectures, tutorials, clinical sessions, and laboratory practicals. The paper-based survey was distributed during a classroom teaching session where attendance is generally good. The sample of students were as follows: Y1 (n=92), Y2 (n=49) and Y3 (n=51). Demographic data questions for gender and age were also included in the survey instrument. As data were categorical, associations between year of study were investigated using the chi-squared test and Fisher's exact test (where the expected number is less than 5 in more than 20% of the cells); analyses were performed using SPSS v26. The research project was approved by the ethics board at the University of Hertfordshire (protocol number: cLMS/CL/UH/05054).

Results and Discussion

A total of 192 first-, second- and third-year undergraduate students (Y1, Y2, and Y3) in the UK were surveyed on their study approaches. The response rates for each cohort (based on course enrolment) were Y1 (79.3%); Y2 (66.2%) and Y3 (60.7%). Of the 192 students, 70.8% (n=136) were female, 20.8% (n=40) male and 8.3% (n=16) did not specify. The ages reported ranged from 18 to over 25; 13.5% (n=26) were 18 years, 59.9% (n=115) ranged between 19-21 years, 18.2% (n=35) were between 22-25 years and 8.3% (n=16) reported to be over the age of 25. The results were evaluated comparing the cohorts in Y1, Y2 and Y3.

The results have been broken into three distinct sections (Learners' study decisions, Strategies in studying and Timing patterns of studying) followed by a discussion for each section's theme. This is then followed by a discussion on the implications for practice and future research.

Learners' study decisions

Table 1 shows the survey results for Q1-3 which focused on the decisions learners make in relation to their study approaches.

Table 1:

Study approaches questionnaire (Q1-3) on decisions learners make and percentage responses for students in Y1, Y2 and Y3 of a pharmacy programme of study.

Question	*Answer Options*	*Number of students Y1/number responding to item (%)*	*Number of students Y2/number responding to item (%)*	*Number of students Y3/number responding to item (%)*	*p-value**
Q1. Would you say that you study the way you do because a teacher (or	Yes No	19/89 (21.3) 70/89 (78.7)	5/49 (10.2) 44/49 (89.8)	6/51 (11.8) 45/51 (88.2)	0.148

teachers) taught you to study that way?					
Q2. How do you decide wha to study next?	Whatever's due soonest/overdue	42/92 (45.7)	43/49 (87.8)	36/51 (70.6)	<0.001
	Whatever I haven't studied for the longest time	8/92 (8.7)	1/49 (2.0)	1/51 (2.0)	0.184#
	Whatever I find interesting	5/92 (5.4)	3/49 (6.1)	3/51 (5.9)	0.985
	Whatever I feel like I'm doing the worst in	31/92 (33.7)	6/49 (12.2)	4/51 (7.8)	<0.001
	I plan my study schedule ahead of time, and I study whatever I've scheduled	18/92 (19.6)	5/49 (10.2)	7/51 (13.7)	0.314
Q3. Do you usually return to course material to review it after a course has ended?	Yes	60/92 (65.2)	16/48 (33.3)	7/51 (13.7)	<0.001#
	No	32/92 (34.8)	32/48 (66.6)	43/51 (84.3)	

Key for Table 1: *Chi-squared test, #Fisher's exact test.

Students in all year groups, Y1 (78.7%), Y2 (89.8%) and Y3 (88.2%) reported that the study approaches they use are not because a teacher (or teachers) taught them to study in that way. This raises a valid question about where and how students are informed about effective study approaches. Heutagogy promotes that the control of learning shifts to the learner. This is a similar result reported previously (Kornell & Bjork, 2007; Hartwig & Dunlosky, 2012; Morehead et al., 2016) and is somewhat surprising given the focus on examination preparation in high schools. A recent publication by Tus (2020) pertaining to study habits of senior high school students in the Philippines suggested input from teachers to "monitor and provide the needed support and guidance in improving their study attitudes and study habits". Perhaps students omit to translate effective learning strategies in the classroom and homework exercises to their own independent study habits at university? There is an identified gap here in relation to a key influence on studying for university students. There is also a need to educate and share these strategies with instructors and teachers particularly to debunk pervasive myths such as learning styles (Newton & Salvi, 2020; Pashler et al., 2009). A survey of 70 college instructors found that they endorsed several effective study skills but there was only a small difference between the instructors and students in relation to knowledge of effective study skills (Morehead et al., 2016).

In relation to organization of study and what to study next (Q2), all years of study indicated to prioritize their study around upcoming deadlines and whatever is due soonest. There was clear evidence of a difference across the Y1, Y2 and Y3 cohorts for prioritizing study around deadlines ($p<0.001$) and whatever feel doing worst in ($p<0.001$) but no evidence of a difference for interest levels in topic ($p=0.985$), whatever has not been studied for the longest time ($p=0.184$) and planning with a schedule ($p=0.314$). All years of study have summative assessments throughout the year (progress test, laboratory reports, clinical dispensing, assignments) and a final exam at the end of the year (contributing 50%). The Y1 students have many formative assessments in the first semester to support the transition to higher education. They have not met the same number of summative assessments when they completed the survey instrument compared to Y2 and Y3 students and this could account for the differences in their decisions on what to study next. Research shows that a significant proportion of students' study decisions largely tend to be influenced by upcoming deadlines (Geller et al., 2018; Hartwig & Dunlosky, 2012; Kornell & Bjork, 2007). It is important that 'an assessment landscape' is transparent to students, so they have an overarching schedule outlining all deadlines well in advance. This will ensure that deadlines are appropriately placed across the academic year and provide students with a tool to support the development of their time management and planning skills.

Returning to review course material (Q3) was not the predominant strategy reported by Y2 and Y3 students in contrast to Y1 students and there was evidence of a difference across the years of study ($p<0.001$). From previous studies, it was found that just 23% of biology students, 14% of dental students and 22% of psychology students reviewed course material. (Geller et al., 2018; Hartwig & Dunlosky, 2012; McAndrew et al., 2016). The pharmacy programme of study is integrated where aspects of learning are taught and contextualised to other topics both across a year of study and between years of study in a spiral curriculum (Harden, 1999). This focus aims to support a deeper approach to learning where concepts are developed in a more complex manner, facilitating integrative learning of course content throughout the undergraduate degree. It is not clear if the design of the curriculum facilitates reviewing of content rather than students independently choosing to review as a study strategy. It is important that returning to review content is emphasized and explained to students, so they appreciate why reviewing is essential to learning.

Strategies in studying

The survey questions (Q4-7 and Q11) focused on the strategies learners take when studying and are displayed in Table 2.

Table 2:

Study approaches questionnaire (Q4-7& Q11) on strategies in studying and percentage responses for students in Y1, Y2 and Y3 of a pharmacy programme of study.

Question	*Answer Options*	*Number of students Y1/number responding to item (%)*	*Number of students Y2/number responding to item (%)*	*Number of students Y3/number responding to item (%)*	*p-value**
Q4. All other things being equal, what do you study more for?	Essay/short answer exams	28/92 (30.4)	15/48 (31.3)	21/50 (42.0)	0.624#
	Multiple-choice exams	8/92 (8.7)	4/48 (8.3)	2/50 (4.0)	
	About the same	56/92 (60.9)	29/48 (60.4)	27/50 (54.0)	
Q5. When you study, do you typically read a textbook/article/other source material more than once?	Yes, I re-read whole chapters/articles	29/92 (31.5)	11/49 (22.4)	7/51 (13.7)	<0.001
	Yes, I re-read sections that I under-lined/highlighted/ marked	54/92 (58.7)	22/49 (44.9)	16/51 (31.4)	
	Not usually	9/92 (9.8)	16/49 (32.7)	28/51 (54.9)	
Q6. If you quiz yourself while you study (either using a quiz at the end of a chapter, or a practice quiz, or flashcards, or something else), why do you do so?	I learn more that way than I would through rereading	24/92 (26.1)	12/49 (24.5)	12/50 (24.0)	0.956
	To figure out how well I have learned the information I'm studying	56/92 (60.9)	27/49 (55.1)	25/50 (50.0)	0.446
	I find quizzing more enjoyable than reading	7/92 (7.6)	3/49 (6.1)	6/50 (12.0)	0.590#
	I usually do not quiz myself	15/92 (16.3)	9/49 (18.4)	8/50 (16.0)	0.939

Q7. Imagine that in the course of studying, you become convinced that you know the answer to a certain question (e.g., the definition of a term). What would you do?	Make sure to study (or test yourself on) it again later	66/91 (72.5)	31/49 (63.3)	28/51 (54.9)	0.099
	Put it aside and focus on other material	25/91 (27.5)	18/49 (36.7)	23/51 (45.1)	
Q11. Which of the following study strategies do you use regularly? (Please check off all that apply).	Test yourself with questions or practice problems	71/92 (77.2)	33/48 (68.8)	29/49 (59.2)	0.080
	Use flashcards	37/92 (40.2)	11/48 (22.9)	10/49 (20.4)	0.021
	Recopy your notes	36/92 (39.1)	30/48 (62.5)	21/49 (42.9)	0.027
	Reread chapters, articles, notes, etc.	58/92 (63.0)	24/48 (50.0)	20/49 (40.8)	0.034
	Make outlines	13/92 (14.1)	13/48 (27.1)	13/49 (26.5)	0.098
	Underline or highlight while reading	55/92 (59.8)	22/48 (45.8)	26/49 (53.1)	0.282
	Make diagrams, charts, or pictures	39/92 (42.4)	20/48 (41.7)	12/49 (24.5)	0.089
	Study with friends	33/92 (35.9)	18/48 (37.5)	16/49 (32.7)	0.877
	"Cram" lots of information the night before the test	25/92 (27.2)	19/48 (39.6)	26/49 (53.1)	0.009
	Ask questions or verbally participate during class	11/92 (12.0)	8/48 (16.7)	6/49 (12.2)	0.717
	Other Please describe:	4.3 watch videos condense notes/checklist speak out loud to myself watch videos	2.0 watch videos	9.8 ask friends to test make condensed information sheets skype with friends use a whiteboard write out notes to test myself	

Key for Table 1: *Chi-squared test, #Fisher's exact test.

From the highest reported responses (Q7) on returning to material (e.g., the definition of a term), the key strategies of distributed practice and retrieval practice were incorporated by students. This differs to previous research where most students put it aside and focused on other material (Hartwig & Dunlosky, 2012). Kornell and Bjork (2008) suggested a "stability bias" in human memory where an assumption is made that one's memory will remain accessible and relatively stable over time. As highlighted previously, it is important that students understand why returning to review material supports learning so that they adopt this approach consistently.

The highest reported study strategy across all years of study was testing with questions or practice problems. Over half of the cohorts reported this strategy (Q6) to figure out how well they have learned the information. However, while the majority did self-test, 16.0%-18.4% of students reported that they did not usually test themselves. Research with US undergraduate students reported testing as a method to evaluate what they have learned (Geller et al., 2018; Hartwig & Dunlosky, 2012 McAndrew et al., 2016). Higher achieving undergraduate psychology students (GPA>3.6) reported using self-testing (Hartwig & Dunlosky, 2012). Higher performing undergraduate biology students endorsed self-testing, crammed less, and planned out their studying (Geller et al., 2018). Although students in this study are testing their learning, they are not using self-testing to replace suboptimal study habits. This highlights a need to reinforce that testing (retrieval practice) is not limited to being a post-learning activity.

Students across all years of study reported rereading their notes. Students are recommended textbooks for reading and the lecture slides are available to view and download via an online portal. Rereading was reported by 80% of second-year dental students and 66% of psychology students as a regular study habit (Hartwig & Dunlosky, 2012; McAndrew et al., 2016). Rereading has been found to be more time-consuming and less effective than self-testing (Uner & Roediger, 2018). Roediger and Butler (2011) found that testing enhanced students' recall after reading a text and feedback on incorrect answers promoted greater effects on longer-term recall with delayed feedback shown to enhance this effect. Recopying notes is evident across all years with a higher percentage (62.5%) of Y2 students adopting this strategy. The rereading and recopying of notes (particularly verbatim) will require time and effort and unfortunately the return on investment would be better supported using other evidence-based strategies. It has been reported that students rated and predicted strategies such as retrieval practice more effortful and less effective than restudying. (Carpenter et al., 2020; Karpicke & Blunt, 2011). This prediction error in performance was demonstrated for example, using concept mapping and retrieval practice; learners reflected on their experience with both strategies and perceived retrieval practice as less optimal whereas performance data demonstrated the opposite (Karpicke & Blunt, 2011). Helping learners to make effective study strategy choices in different contexts is critical to developing metacognitive awareness.

Learning strategies such as using flashcards ($p=0.021$) was highest reported by Y1 students. It may be that this study strategy is more familiar to Y1 students from their previous learning activities and the emphasis on application and evaluation of knowledge in Y2 and Y3 causes students to adopt other strategies. There was evidence of a difference using cramming between the years of study ($p=0.009$) with a higher percentage of Y3 students reporting this strategy. Y1 students were the lowest group that reported cramming the night before. The curriculum at Y1 overlaps to some extent with prior knowledge from high school. As discussed previously, the Y1 students have many formative assessments compared to summative assessments in the first semester which could account for this difference. For Y2 and Y3 students, all content is new and integrates with concepts from the previous levels of study. Fewer students indicated to ask questions and verbally participate in class. A survey study by Bowers (1986) found that 70% of students reported having the experience of classroom communication apprehension. There are several reasons that have been shown to contribute to non-participation in class; logistics (class size, timings), intimidation and communication apprehension, personality traits of students and instructor/classroom climate (Rocca, 2010; Weaver & Qi, 2005). Instructors can influence the classroom environment and using anonymous online polling tools allows an inclusive and enhanced engagement (Vallely & Gibson, 2018).

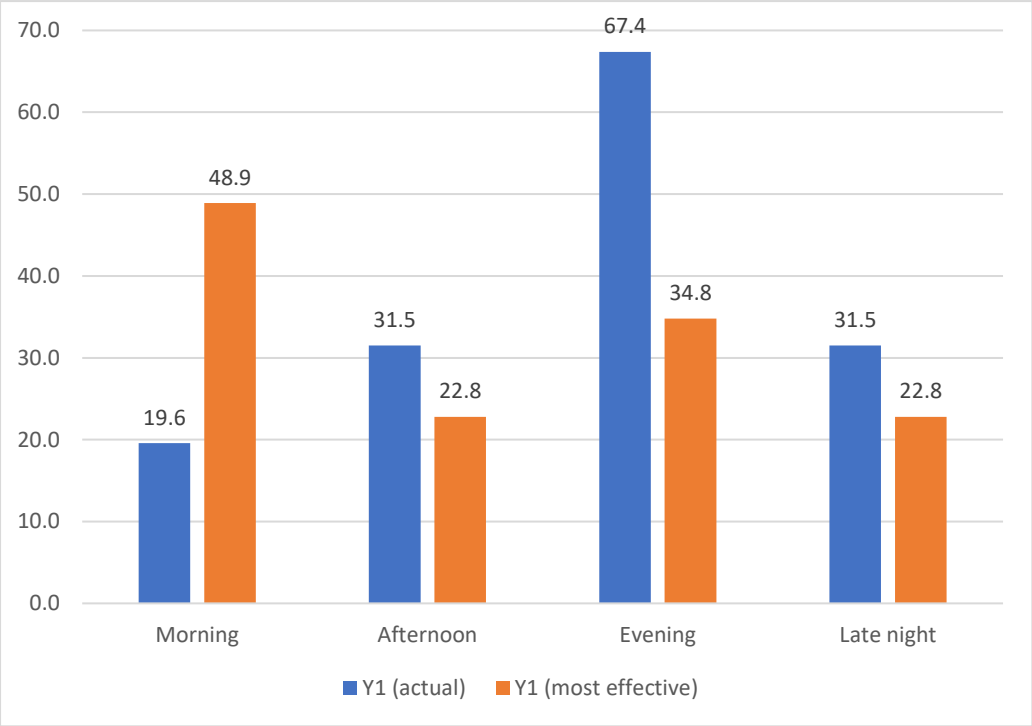
Although evidence-based study habits are adopted by students, their strategic incorporation is not evident. Students are engaged randomly with certain study habits such as using flashcards (in Y1) and using practice questions to test learning rather than as a learning tool. This demonstrates that in this study, the extent of undergraduate students using evidence-based study approaches is inconsistent. There is no evidence of a linear progression from Y1 to Y3.

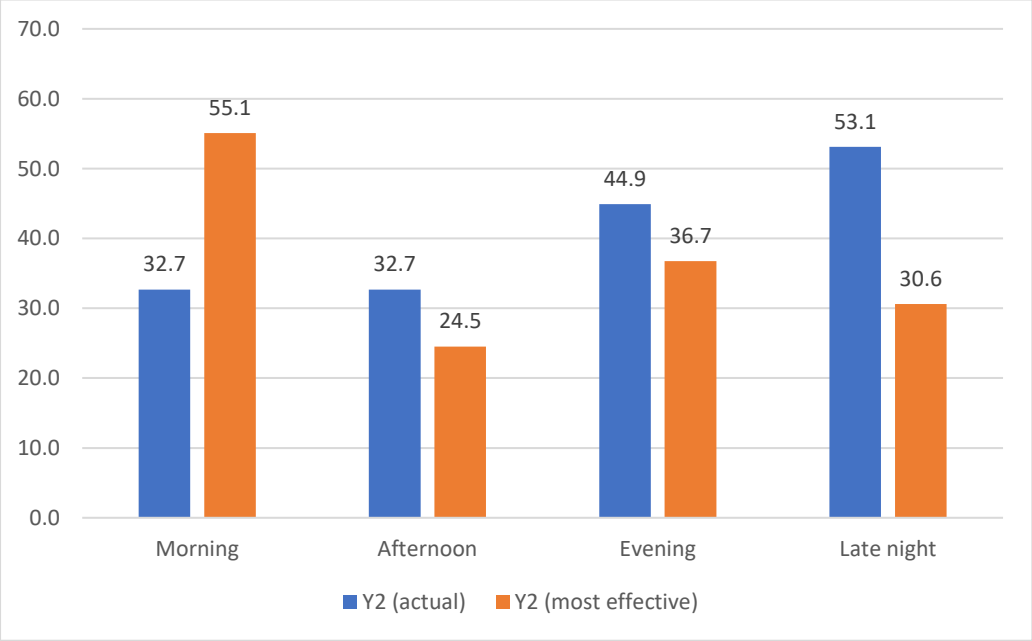
Timing patterns of studying

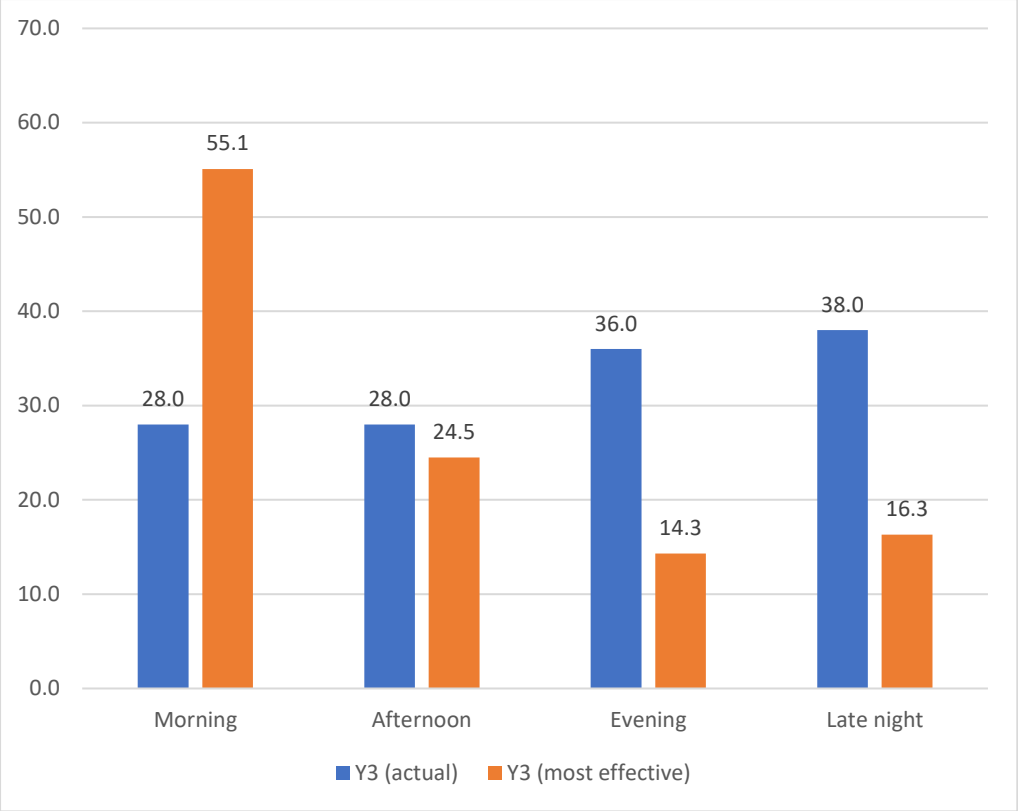
When students study most often and students' beliefs about the most effective time of day illustrated some differences that are identified in Figure 1.

Figure 1:

Responses for Y1, Y2 and Y3 students on time of day in relation to actual study time and beliefs on most effective study time







The survey results for Q8-10 which focused on the timing patterns of studying are shown in Table 3. There was evidence of a difference between the years of study in relation to actual time of study for evening (p=0.001) and most effective time for studying in the evening (p= 0.020). There is a suggestion of a difference for late night studying (0.044).

Table 3:

Study approaches questionnaire (Q8-10) on the timing patterns of studying and percentage responses for students in Y1, Y2 and Y3 of a pharmacy programme of study.

Question	*Answer Options*	*Number of students Y1/number responding to item (%)*	*Number of students Y2/number responding to item (%)*	*Number of students Y3/number responding to item (%)*	*p-value**
Q8. What time of day do you most often do your studying?	Morning	18/92 (19.6)	16/49 (32.7)	14/50 (28.0)	0.201
	Afternoon	29/92 (31.5)	16/49 (32.7)	14/50 (28.0)	0.868
	Evening	62/92 (67.4)	22/49 (44.9)	18/50 (36.0)	0.001
	Late night	29/92 (31.5)	26/49 (53.1)	19/50 (38.0)	0.044
Q9. During what time of day do you believe your studying is (or would be) most effective?	Morning	45/92 (48.9)	27/49 (55.1)	27/49 (55.1)	0.695
	Afternoon	21/92 (22.8)	12/49 (24.5)	12/49 (24.5)	0.964
	Evening	32/92 (34.8)	18/49 (36.7)	7/49 (14.3)	0.020
	Late night	21/92 (22.8)	15/49 (30.6)	8/49 (16.3)	0.244

Q10. Which of the following best describes your pattern of study?	I most often space out my study sessions over multiple days/weeks	56/90 (62.2)	25/45 (55.6)	24/48 (50.0)	0.366#
	I most often do my studying in a couple of sessions before the test	25/90 (27.8)	18/45 (40.0)	18/48 (37.5)	
	I most often do my studying in one session before the test	9/90 (10.0)	2/45 (4.4)	6/48 (12.5)	

Key for Table 1: *Chi-squared test, #Fisher's exact test.

Time management differences were also evident in terms of the time of day for studying. Variations between the cohorts may be due to individual differences and scheduling differences. It is not uncommon now for students to have external employment commitments and other responsibilities such as caring duties that can impact on their schedules. There is some flexibility for students due to the varied schedules each day including some days with fewer scheduled activities or gaps between scheduled activities. Although there is no optimal study time, sleep quality is linked with cognitive function (Lowry et al., 2010; Medeiros et al., 2001). The sleep-wake cycle is controlled by the circadian pacemaker. Students pulling "all-nighters" to complete assignments, manage competing responsibilities and work schedules could impact on their sleep quantity and academic performance. The responses for (Q10) which focused on study sessions before a test contradicted the results for cramming lots of information (Q11). It could be that some students best describe their studying as spaced out before a test reported in Q10 and yet they also cram the night before reported in Q11. Identifying a pattern of study that works for each individual learner is more important than specifying a time of day. The pattern should incorporate distribute practice where learning is revisited and avoid cramming lots of information in single sessions.

Future Research

Although this study was executed pre COVID-19 pandemic, the utilisation of suboptimal study habits will continue to impact learners. The pivot to online delivery of teaching and assessment during COVID-19 increased the extent of independent study. Asynchronous online resources provided greater flexibility for learners to manage and schedule activities around their own preferences. One of the challenges with video lectures for learners is mind wandering where there is a shift of thoughts from the task activity to unrelated thoughts. The extent and rate of mind wandering for university students has been found to be 40-45% (Kane et al., 2017; Szpunar et al., 2013). If students postpone their engagement with recorded lecture videos and stack them (as opposed to distributed practice) to catch up like binge watching a boxset, this will contribute to negative student outcomes. It will be important to evaluate learners' responses to the varied challenges with online delivery. With different delivery and assessment formats, it is not evident if students consequently changed their study habits. A lack of metacognitive awareness would create uncertainty about what approaches to learning are best suited to different situations, contexts, and assessment formats.

Direction and Implications, Limitations, and Conclusion

This survey study explored the extent that undergraduate pharmacy students across three distinct year groups (Y1, Y2 and Y3) adopted evidence-based study approaches. There was some evidence of metacognitive awareness in relation to methods such as self-testing (retrieval practice) and spacing out study sessions (distributed practice). However, the specific strategies indicated by all years of study illustrated much use of suboptimal study strategies such as rereading, recopying notes, and cramming lots of information the day prior to a test. It is demonstrated that students are not maximising their study efforts during their independent study time. There are some limitations within this study to note. Some findings would need to be investigated further

using a larger sample size and this would help determine any differences in study habits and approaches based on gender and age. The survey study provides a useful snapshot of reported study habits at a point in time; further analysis using interviews and focus groups would help the reported results to be understood in more depth.

The evidence from this study demonstrates that learners would require training on metacognitive awareness and evidence-based study strategies from cognitive science to enable their self-determined learning capabilities to evolve. The linear progression through a programme of study alone will not achieve this. McDaniel and Einstein (2020) proposed a theoretical framework called the knowledge, belief, commitment, and planning (KBCP) framework for guiding training to promote students' successful self-regulation of effective learning strategies. They outlined four essential components included in training: (a) acquiring knowledge about strategies, (b) belief that the strategy works, (c) commitment to using the strategy, and (d) planning of strategy implementation. The need for guidance on approaches to learning for students is even more pertinent with the wider adoption of blended delivery post-pandemic. There is an important call for senior managers with learning and teaching remits (Directors of Learning and Teaching, Pro Vice-Chancellors for Education and Student Experience) to help emphasise metacognitive awareness in teaching and embed evidence-based approaches to learning into curricula.

References

Biggs, J. B. (1987). Student Approaches to Learning and Studying. Research Monograph. Australian Council for Educational Research Ltd., Radford House, Frederick St., Hawthorn 3122, Australia.

Bjork, E. L., & Bjork, R. A. (2011). Making things hard on yourself, but in a good way: Creating desirable difficulties to enhance learning. *Psychology and the real world: Essays illustrating fundamental contributions to society*, 2(59-68).

Blasiman, R. N., Dunlosky, J., & Rawson, K. A. (2017). The what, how much, and when of study strategies: comparing intended versus actual study behaviour. *Memory*, 25(6), 784-792. https://doi.org/10.1080/09658211.2016.1221974

Bodner, G., Klobuchar, M., & Geelan, D. (2001). The many forms of constructivism. *Journal of Chemical Education*, 78(8), 1107. https://doi.org/10.1021/ed078p1107.4

Bowers, J. W. (1986). Classroom communication apprehension: A survey. *Communication Education*, 35(4), 372-378. https://doi.org/10.1080/03634528609388361

Bretz, S. L. (2001). Novak's theory of education: Human constructivism and meaningful learning. *Journal of Chemical Education*, 78(8), 1107 . https://doi.org/10.1021/ed078p1107.6

Carpenter, S. K., Endres, T., & Hui, L. (2020). Students' use of retrieval in self-regulated learning: Implications for monitoring and regulating effortful learning experiences. *Educational Psychology Review*, 1-26. https://doi.org/10.1007/s10648-020-09562-w

Cepeda, N. J., Pashler, H., Vul, E., Wixted, J. T., & Rohrer, D. (2006). Distributed practice in verbal recall tasks: A review and quantitative synthesis. *Psychological Bulletin*, 132(3), 354. https://doi.org/10.1037/0033-2909.132.3.354

Dunlosky, J., Rawson, K. A., Marsh, E. J., Nathan, M. J., & Willingham, D. T. (2013). Improving students' learning with effective learning techniques: Promising directions from cognitive and educational psychology. *Psychological Science in the Public Interest, Supplement*, 14(1), 4-58. https://doi.org/10.1177/1529100612453266

Dunning, D. (2011). The Dunning–Kruger effect: On being ignorant of one's own ignorance. In *Advances in experimental social psychology*, 44, 247-296 https://doi.org/10.1016/B978-0-12-385522-0.00005-6

Fergus, S., Heelan, A., Ibrahim, S., Oyman, H., Diaz-de-Mera, Y., & Notario, A. (2021). Insights into study strategies and habits: a study with undergraduate students in Spain and the UK. *Journal of Chemical Education*, 98(10), 3084–3089. https://doi.org/10.1021/acs.jchemed.1c00126

Fiorella, L., & Mayer, R. E. (2015). Learning as a generative activity: Eight learning strategies that promote understanding. *Educational Psychology Review*. https://doi.org/10.1007/s10648-015-9348-9.

Geller, J., Toftness, A. R., Armstrong, P. I., Carpenter, S. K., Manz, C. L., Coffman, C., & Lamm, M. H. (2018). Study strategies and beliefs about learning as a function of academic achievement and achievement goals. *Memory*, 26(5), 683-690. https://doi.org/10.1080/09658211.2017.1397175

Hagemeier, N. E., & Mason, H. L. (2011). Student pharmacists' perceptions of testing and study strategies. *American Journal of Pharmaceutical Education*, 75(2). https://doi.org/10.5688/ajpe75235

Hartwig, M. K., & Dunlosky, J. (2012). Study strategies of college students: Are self-testing and scheduling related to achievement? *Psychonomic Bulletin and Review*, 19(1), 126-134. https://doi.org/10.3758/s13423-011-0181-y

Harden, R. M. (1999). What is a spiral curriculum? *Medical Teacher*, 21(2), 141-143. https://doi.org/10.1080/01421599979752

Hase, S., & Kenyon, C. (2000). From andragogy to heutagogy. ultiBASE In-Site. http://pandora.nla.gov.au/nphwb/20010220130000/http://ultibase.rmit.edu.au/Articles/dec00/hase2.htm

Kane, M. J., Smeekens, B. A., Von Bastian, C. C., Lurquin, J. H., Carruth, N. P., & Miyake, A. (2017). A combined experimental and individual-differences investigation into mind wandering during a video lecture. *Journal of Experimental Psychology: General*, 146(11), 1649. https://doi.org/10.1037/xge0000362

Karpicke, J. D., & Blunt, J. R. (2011). Retrieval practice produces more learning than elaborative studying with concept mapping. *Science*, 331(6018), 772-775. https://doi.org/10.1126/science.1199327

Karpicke, J. D., Butler, A. C., & Roediger, H. L. (2009). Metacognitive strategies in student learning: do students practise retrieval when they study on their own? *Memory*, 17(4), 471-479. https://doi.org/10.1080/09658210802647009

Kornell, N., & Bjork, R. (2008). Optimising self-regulated study: The benefits-and costs-of dropping flashcards. *Memory*, 16(2), 125-136. https://doi.org/10.1080/09658210701763899

Kornell, N., & Bjork, R. A. (2007). The promise and perils of self-regulated study. *Psychonomic Bulletin and Review*, 14(2), 219-224. https://doi.org/10.3758/BF03194055

Kornell, N., & Bjork, R. A. (2009). A Stability Bias in Human Memory: Overestimating Remembering and Underestimating Learning. *Journal of Experimental Psychology: General*, 138(4), 449-468. https://doi.org/10.1037/a0017350

Kornell, N., Castel, A. D., Eich, T. S., & Bjork, R. A. (2010). Spacing as the friend of both memory and induction in young and older adults. *Psychology and Aging*, 25(2), 498-503. https://doi.org/10.1037/a0017807

Lowry, M., Dean, K., & Manders, K. (2010). The link between sleep quantity and academic performance for the college student. *Sentience*, 3(2), 16-19. https://sites.oxy.edu/clint/physio/article/TheLinkBetweenSleepQuantityandAcademic.pdf

Marton, F., & Säljö, R. (1976). On qualitative differences in learning: I—Outcome and process. *British Journal of Educational Psychology*, 46(1), 4-11. https://doi.org/10.1111/j.2044-8279.1976.tb02980.x

McAndrew, M., Morrow, C. S., Atiyeh, L., & Pierre, G. C. (2016). Dental Student Study Strategies: Are Self-Testing and Scheduling Related to Academic Performance? *Journal of Dental Education*, 80(5), 542-552. https://doi.org/10.1002/j.0022-0337.2016.80.5.tb06114.x

McDaniel, M. A., & Einstein, G. O. (2020). Training learning strategies to promote self-regulation and transfer: The knowledge, belief, commitment, and planning framework. *Perspectives on Psychological Science*, 15(6), 1363-1381. https://doi.org/10.1177/1745691620920723

Medeiros, A. L. D., Mendes, D. B., Lima, P. F., & Araujo, J. F. (2001). The relationships between sleep-wake cycle and academic performance in medical students. *Biological rhythm research*, 32(2), 263-270. https://doi.org/10.1076/brhm.32.2.263.1359

Morehead, K., Rhodes, M. G., & DeLozier, S. (2016). Instructor and student knowledge of study strategies. *Memory*, 24(2), 257-271.https://doi.org/10.1080/09658211.2014.1001992

Newton, P., & Salvi, A. (2020). How Common is Belief in the Learning Styles Neuromyth, and Does it Matter? A Pragmatic Systematic Review. *Frontiers in Education*, 5:602451. https://doi.org/10.3389/feduc.2020.602451

Novak, J. D. (2002). Meaningful learning: The essential factor for conceptual change in limited or inappropriate propositional hierarchies leading to empowerment of learners. *Science Education*, 86(4), 548-571.

Novak, J. D., & Cañas, A. J. (2006). The theory underlying concept maps and how to construct them. *Florida Institute for Human and Machine Cognition*, 1(1), 1-31. http://cmap.ihmc.us/publications/researchpapers/TheoryUnderlyingConceptMaps.pdf

Novak, J. D., Gowin, D. B., & Bob, G. D. (1984). Learning how to learn: Cambridge University press.

Pashler, H., McDaniel, M., Rohrer, D., & Bjork, R. (2009). Learning styles concepts and evidence. *Psychological Science in the Public Interest, Supplement*, 9(3), 105-119. https://doi.org/10.1111/j.1539-6053.2009.01038.x

Ponce, H. R., & Mayer, R. E. (2014). Qualitatively different cognitive processing during online reading primed by different study activities. *Computers in Human Behavior*, 30, 121-130.

Rocca, K. A. (2010). Student participation in the college classroom: An extended multidisciplinary literature review. *Communication Education*, 59(2), 185-213. https://doi.org/10.1080/03634520903505936

Roediger, H. L., & Butler, A. C. (2011). The critical role of retrieval practice in long-term retention. *Trends in Cognitive Sciences*, 15(1), 20-27. https://doi.org/10.1016/j.tics.2010.09.003

Roediger, H. L., & Karpicke, J. D. (2006). Test-enhanced learning: Taking memory tests improves long-term retention. *Psychological Science*, 17(3), 249-255.

Rohrer, D. (2012). Interleaving Helps Students Distinguish among Similar Concepts. *Educational Psychology Review*, 24(3), 355-367.

Rohrer, D., Dedrick, R. F., Hartwig, M. K., & Cheung, C.-N. (2020). A randomized controlled trial of interleaved mathematics practice. *Journal of Educational Psychology*, 112(1), 40.

Stewart, D., Panus, P., Hagemeier, N., Thigpen, J., & Brooks, L. (2014). Pharmacy student self-testing as a predictor of examination performance. *American Journal of Pharmaceutical Education*, 78(2). https://doi.org/10.5688/ajpe78232

Szpunar, K. K., Moulton, S. T., & Schacter, D. L. (2013). Mind wandering and education: from the classroom to online learning. *Frontiers in Psychology*, 4, 495. https://doi.org/10.3389/fpsyg.2013.00495

Tus, J. (2020). The Influence of Study Attitudes and Study Habits on the Academic Performance of the Students, *International Journal of All Research Writings*, 2(4), 11-32.

Uner, O., & Roediger, H. L. (2018). The effect of question placement on learning from textbook chapters. *Journal of Applied Research in Memory and Cognition*, 7(1), 116-122. https://doi.org/10.1016/j.jarmac.2017.09.002

Weaver, R. R., & Qi, J. (2005). Classroom organization and participation: College students' perceptions. *The Journal of Higher Education*, 76(5), 570-601. https://doi.org/10.1080/00221546.2005.11772299

Vallely, K., & Gibson, P. (2018). Engaging students on their devices with Mentimeter. Compass: Journal of Learning and Teaching, 11(2), 1-6.

Yan, V. X., Thai, K. P., & Bjork, R. A. (2014). Habits and beliefs that guide self-regulated learning: Do they varywith mindset. *Journal of Applied Research in Memory and Cognition*, 3(3), 140-152. https://doi.org/10.1016/j.jarmac.2014.04.003