At the heart of learning: navigating towards educational neuroscience in health professions education

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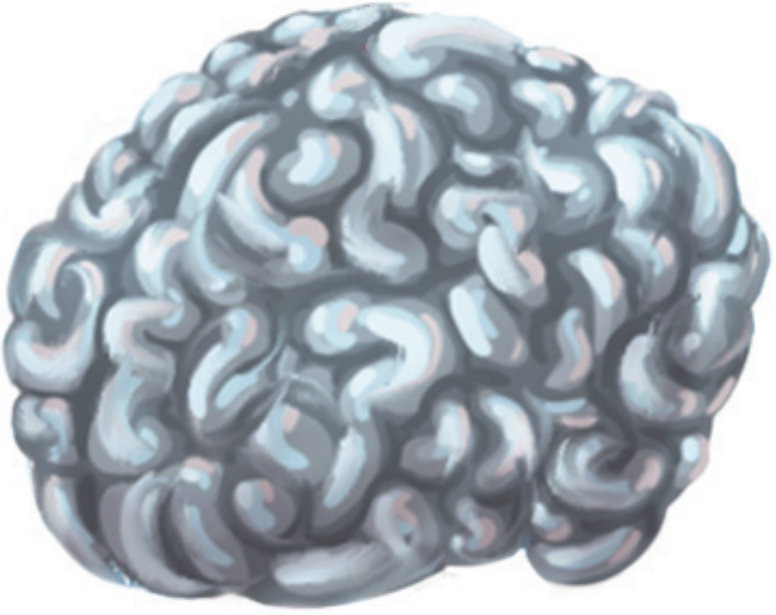
Chapter 10



What were you thinking? Medical students' metacognition and perceptions of self-regulated learning

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Submitted.

Abstract

Purpose

A metacognitive habit of mind is essential for healthcare professionals. This study identified metacognitive competencies of medical students as they completed a conceptual learning task, and provided insight in students' perceptions of self-regulated learning in their curriculum.

Methods

A qualitative study was conducted including a thinking aloud assignment and a semi-structured interview. Eleven third-year medical students from a Dutch University were purposively sampled. The data was transcribed verbatim and analysed iteratively using a template analysis.

Results

Students differed in their use of metacognitive skills, with an overall focus on monitoring and to a lesser extent on planning and evaluation. Additionally, differences were found in students' metacognitive knowledge and metacognitive experiences. There was apparent use of inefficient superficial predictive cues. Regarding perceptions of self-regulated learning skills, some students felt no need for developing such skills as they perceived medical education as an exercise in memorising facts. Others emphasised the need for more insight in their actual level of knowledge and competence.

Conclusion

Undergraduate medical students require explicit teaching of metacognitive skills to facilitate self-regulated learning. Educators should aim to integrate metacognition in the everyday discourse of the classroom to foster an environment in which students discuss their own learning.

Introduction

Self-regulated learning is a necessary skill for healthcare professionals to develop. However, explicit teaching of the required metacognitive competencies for self-regulation appears to be scarce in medical education (Sandars & Cleary, 2011; Artino et al., 2012). Medical students often struggle to acquire an adequate level of metacognition (Lucieer et al., 2016; de Bruin et al., 2017). In this study, we investigated undergraduates' metacognitive competencies and their associated perceptions on self-regulated learning.

Although self-regulation is recognised by the medical education community as an important prerequisite for effective learning, it is a common incorrect assumption that such a skill is implicitly acquired (Bjork et al., 2013). Researchers have suggested that medical schools should specifically emphasise self-regulated learning, since development of self-regulation is a shared responsibility between both students and educators (Sandars & Cleary, 2011; Brydges et al., 2015). Sophisticated self-regulated learners are capable of reflecting on their own performance and modifying their approach for future attempts (Zimmerman, 2000; Sandars, 2013). In essence, self-regulated learners are the captains of their own learning. David Sackett pleads for more captains by advising: "Half of what you'll learn in medical school will be shown to be either dead wrong or out of date within five years of your graduation; the trouble is that nobody can tell you which half—so the most important thing to learn is how to learn on your own." (Smith, 2003). Moreover, not only being able to learn lifelong but also to do it effectively, by setting realistic goals and evaluating one's outcomes, will help students to become better healthcare professionals in the long-term. Multiple studies have reported on benefits associated with adequate self-regulated learning, including enhanced academic achievement, safer and more effective practice, and obtainment of a lifelong learning attitude (Langendyk, 2006; Brydges & Butler, 2012; Zimmerman and Schunk 2013). Self-regulated learning can thus be considered a necessity to all practicing healthcare professionals who have a societal obligation to continuously develop their knowledge.

Self-regulated learning is a cyclical process during which a learner plans one's activities prior to a task, monitors these during a task, and evaluates the outcome after a task (Zimmerman, 2002). The cycle of self-regulated learning is guided by three interrelated components: cognition, metacognition and motivation (Schraw et al., 2006). While most studies in the medical education context focus on cognition (Young et al., 2014) and motivation (ten Cate et al., 2011), research on metacognition is relatively limited.

In the field of social-cognitive sciences, researchers have been studying

metacognition for several decades. Flavell and others have described three major components of metacognition, which may inform metacognitive teaching practices in the classroom (Flavell, 1979; Hartman, 2001; Pintrich, 2002; Zohar & Barzilai, 2013). Firstly, one may explicitly teach students about metacognitive knowledge; e.g. educators should help students to make accurate judgements of their learning, so students are aware of what they know and do not know. Secondly, one may explicitly teach metacognitive skills; e.g. educators should provide students with effective strategies for learning so students can use them when studying. Thirdly, one may explicitly teach students about metacognitive experiences; e.g. students' feelings related to the learning task such as a feeling of puzzlement or an aha-experience. Metacognitive experiences are often used by learners as heuristic superficial cues which form the basis for their judgements of learning (Koriat, 1997; de Bruin et al., 2017). For instance, a medical student may judge her/his chances of making the right diagnosis based on the speed with which this diagnosis came to mind. However, fast thinking does not necessarily mean that the student's response is correct. Rather, comprehension-based cues that are formed by causal reasoning are more predictive of correct responses (Thiede et al., 2010).

In undergraduate medical education, we are generally unaware whether and how students use their metacognitive knowledge, skills, and experiences to regulate their learning. Namely, the current focus of research in medical education is on investigating self-regulated learning in the clinical context (Berkhout et al., 2015; van Houten-Schat et al., 2018; Bransen et al., 2019). However, one may argue that metacognition and self-regulated learning should play an important role already at the start of a student's medical training. More research is needed to investigate undergraduates' current level of metacognition and their perceptions on self-regulated learning in the curriculum, in order to develop effective teaching programs.

In this study, we investigated third-year medical students' metacognitive knowledge, skills, and experiences in order to identify the barriers in acquiring an adequate level of metacognition. To put this into perspective, we also asked students about their perceptions of self-regulated learning in the medical curriculum. Ultimately, these findings may support educators in their quest to effectively teach self-regulated learning.

Methods

Context

This study was conducted at Leiden University Medical Center (LUMC), the Netherlands. The LUMC offers a six-year medical training program; undergraduate

years 1-3 are pre-clinical and graduate years 4-6 consist of clerkships. The Framework for Undergraduate Medical Education in the Netherlands describes the learning outcomes that medical students should achieve in their training to effectively meet the standards of health care. One of the learning outcomes is that undergraduates should possess metacognitive competencies that are necessary to handle a high level of autonomy (Herwaarden et al., 2009). However, in the current LUMC curriculum, formal teaching of such skills is limited. This study was conducted during the third year of the pre-clinical phase. We used this specific population of third-year students as they are expected to have sufficient metacognitive competencies in order to be successful in their clerkships that start after this year.

Participants

During January-April 2019, the first author (MV) approached third-year students by e-mail. Participants were purposively sampled to ensure all were in their final year of pre-clinical studies. Additionally, we aimed for a variety in gender that would reflect the medical student population in the Netherlands (30% male, 70% female). A total of 11 students participated in the current study. Due to anonymity we cannot include more potentially identifying information about the participant. Students gave a verbal consent to the audio-recording before the session and signed an informed consent form afterwards. They were given a free lunch worth €7.50 in compensation for their effort. This study was approved by the Institutional Educational Review Board of the LUMC, reference number: OEC/ERRB/20181009/1.

Data collection

As little is known about students' metacognitive competencies and their associated perceptions of self-regulated learning in the undergraduate medical curriculum, we designed an explorative qualitative study in which we used a template analysis based on metacognitive theory (Flavell, 1979; Schraw & Moshman, 1995). Accordingly, we conducted a thinking aloud procedure followed by a semi-structured interview to gain insight into students' metacognitive knowledge, skills and experiences. Also, during the interview participants shared their perceptions of self-regulated learning in the medical curriculum. The first author (MV) was present during the thinking aloud sessions and conducted the interviews afterwards.

The thinking aloud assignment and interviews were audio-recorded and transcribed verbatim by the first author (MV). At the start of the assignment, participants were asked to think aloud while solving four exercises on medical physiology. These exercises were designed by an expert physiologist (PS) and

aimed to activate participants' scientific reasoning and conceptual thinking. Factual knowledge was presented on an information sheet, so students mainly had to focus on application and integration of the information. After each exercise, students were prompted to evaluate their conclusions by asking how sure they were of their provided answer. If participants were silent for more than three seconds, they were asked to continue to think aloud. Prior to the physiology questions, participants received two practice questions to practice thinking aloud.

The thinking aloud procedure was also used as a prompt for the subsequent semi-structured interview. The interview guide was developed by MV, GB, BO and MW (see Supplementary M). The interview guide was designed and structured based on theoretical concepts of metacognition (Flavell, 1979; Schraw & Moshman, 1995; Pintrich, 2002; Zimmerman, 2002; Zohar & Barzilai, 2013). This guide included questions about goal-setting, learning strategies, and reflective activities. Other issues that were pursued during the interview concerned participants' perceptions of self-regulated learning in the medical curriculum. These questions focused on the value of knowing what you do (not) know and how learning activities could enhance this. Each session, consisting of a thinking aloud procedure and interview, lasted on average 45 minutes. Saturation was reached after eight interviews, after which we conducted three additional interviews to see if saturation was indeed reached.

Data analysis

Data analysis and collection proceeded in an iterative fashion. The data was coded, analysed and interpreted by MV, GB and MW using template analysis (Brooks et al., 2015), allowing a-priori themes to be used in developing the initial version of a coding template. Metacognitive theory was used to construct the initial template. MV and GB performed open coding on transcripts 1-3 independently. These codes were used to inform the first template. After these three transcripts this process of cross-checking coding, codes and template continued until consensus was reached. As the number of interviews grew, we kept refining the conceptual coding template. The coding template was compared and discussed by MV and GB throughout the data collection period. MV used the template to code transcripts 4-5 and 7-11, continuously refining the template by discussing the findings with GB. Transcript 6 was independently coded by GB. Further refinement of the template through collaborative analysis among the research team led to template consensus (see Supplementary N).

Reflexivity

The team consisted of researchers with varied backgrounds and expertise in

qualitative research to facilitate interpretation of our findings using multiple perspectives. The first author (MV) is a PhD candidate in medical education with a background in neurobiology and has a particular interest in metacognition and conceptual thinking. All other authors are active in the field of medical education research and have different backgrounds, including medical anthropology and sociology (GB), pedagogical sciences (BO), educational sciences (MW), medicine (AJdB) and physics (PS).

Results

Whereas students were mainly concerned with obtaining a good score, i.e. their cognitive performance, we focused on investigating their metacognitive performance. Firstly, we identified the metacognitive skills that students displayed during problem-solving. With our template we were able to identify if difficulties occurred for specific subtypes of metacognitive skills.

Planning

Planning occurs prior to the problem-solving process and includes setting goals, selecting appropriate strategies, making predictions, strategy sequences and allocating resources (Schraw & Moshman, 1995). All these themes were found in this study. During the thinking aloud assignment, some students showed planning behaviour by creating an overview of the important characteristics of the exercise, either by highlighting, summarising or visualising. In the interview, students would often recognise their ability to create overview.

> "Well, I think I am good at creating an overview. I will not start problem solving before creating an overview. Generally, I write down all the information and highlight the important information to clarify things before I start problem-solving." (P9)

Furthermore, some students specified that their strategy is to first identify the problem, before doing anything else. However, this was rarely done explicitly during the thinking aloud assignment.

> "Usually, I read the questions first and quickly after that I move on to what is really been asked from me, before reading all the text. However, I did not really do it now [during the exercise]." (P3)

Generally, little time was devoted to planning prior to problem-solving. For

instance, explicit goal-setting beforehand by identifying the exact problem and allocation of resources that students would need to solve the question was not observed. Additionally, students would sometimes miss out on information to solve the question because they did not accurately record which information they had at their disposal.

Monitoring

Monitoring is the online awareness of comprehension and performance and thus takes place during the actual problem-solving (Schraw & Moshman, 1995). Students used various forms of monitoring, i.e. strategies, during the thinking aloud assignment. Regularly used strategies included rereading, goal-checking, visualising the situation, and eliminating answer options to get to the correct solution. Students rarely switched between different strategies. Generally, they started to use a different approach only when their initial outcome did not align with one of the answer options. Some students admitted that they did not consciously use specific metacognitive strategies during the thinking aloud assignment.

> "I do not really have specific strategies, that I think wow, I should do this or that. I use the strategy to sometimes just read it again. And sometimes you will encounter things during the test that may help you. So yes.. basically like that." (P9)

A large variety in awareness of student's strategy use was found. The excerpt illustrates one end of a spectrum, which encompassed students who did not use any specific strategies at all and were unable to come up with potential strategies they might have used. At the other end of the spectrum were students who were clearly aware of their strengths and weaknesses, and used specific strategies to solve the questions. In the middle of the spectrum, there were students who admitted that, although they knew they should use certain strategies to solve the questions, they did not use them during the task.

The majority of students admitted that they found the questions rather difficult, as they found analytical thinking difficult.

> "I think we are trained in medical school to learn factual knowledge, and this [exercise] is a different skill than learning facts, or connecting facts, so... this is really a different skill, so I think that is always difficult, but it requires quite some brainpower." (P2)

In general, students felt that analytical reasoning is a competency which is not actively taught during medical training.

Evaluation

Evaluation refers to appraising the outcomes and regulatory processes after problem-solving. This includes, for example, evaluating one's goals and conclusions (Schraw & Moshman, 1995). During the thinking aloud assignment, few students evaluated their goals and conclusions after marking one of the answer options. We prompted the students to evaluate by asking how sure they were of their provided answer. Despite this prompt, students spent little time evaluating their answers. Most students would answer the question 'How confident are you that your given answer is correct?' without explicitly elaborating on their feeling of confidence or without checking their answer. During the interviews, most students described that a 'feeling of logic' would determine their level of comprehension.

> "Yes, if my feelings tell me that it [the answer] is not right but according to the formula it would be right, then I think, this is not right so I will doubt. Like, when it is not in accordance with each other, and if I cannot solve it with the formula and with my feelings, then I am not sure." (P6)

Other cues for comprehension included; time spent on task, familiarity with the learning material, and the ease of reasoning.

> "I always notice that the longer I think about it, the more I start doubting." (P1)

> "Yes, but you also think I really have known this [learning material]. I have really studied this and known this. I didn't know then if I was good at it, but yeah." (P2)

> "I am sure when; this is how I reasoned and then I get to the right answer, then this seems the right answer to me." (P5)

Interestingly, the feeling of logic and familiarity with the learning material were often mentioned, whereas these cues generally are not good predictors for the level of comprehension (Thiede et al., 2010; de Bruin et al., 2017). Rather, the ease of reasoning is well associated with one's actual level of comprehension but this cue was mentioned to a much lesser extent.

Perceptions on self-regulated learning in the medical curriculum

During the interviews, the thinking aloud data was enriched by asking students to reflect on the role of 'knowing what you (do not) know' in the curriculum. Students said they valued the ability to accurately estimate their knowledge and skills so they know what they are (not yet) competent at. Most students outsourced this ability to external assessment tools. For example, they would mention both formative and summative exams, study assignments, and e-learnings as tools to estimate their level of knowledge or skills.

> "Yes, you have mostly study assignments and practice exams of course which have a diagnostic value in terms of what knowledge you actually already possess." (P8)

A few students described the ability to accurately estimate one's knowledge as an internal, personal ability that could be developed by specific strategies, such as self-explaining, explaining to a peer, and consulting a teacher or other sources. The word 'reflection' was rarely mentioned, and if it was, students indicated that focus on this competency during their medical training was insufficient.

> "But at such a meta level not really I think. That we really reflect on ourselves in terms of how well we understand something? How well do we understand exercises, or how well do we understand how we have to handle knowledge and things. I think that should be an essential component of an educational program, especially of an academic education.. There is not enough attention paid to it [reflection] I think. We have to write reflection reports but you might as well just fill in three words, because the teacher is OK with it anyway. Yes, it is mainly just a fill in assignment, and not really that you, as a student, will take a look at yourself thinking what can I do better. And if you would take that maybe a little bit more seriously, also looking [as a teacher] what he [the student] actually does with it [the feedback], because that is being forgotten most of the time." (P8)

Students are in search of 'hard outcome measures', i.e. numbers, as they mention that they would appreciate having more insight into the status of their competences.

> "Uh... with those competences, so competency-based education, really the practice-based education, I would have to admit that I find it really difficult to monitor my progress and how I have developed myself. That

> of course is one of the subjects during the teacher-coach conversations, but it is not very tangible. How good of a communicator, how good of a team player have I become during the last three years? I do not really have a clue, and I do not have any numbers either." (P7)

All students offered ideas in response to one of the questions on how we could enhance one's insight into one's learning during the medical curriculum. Students mostly mentioned that having more of the currently existing assessment tools, e.g. low-stakes exams, study assignments and e-learnings, would provide more insight in one's knowledge deficiencies.

> "But maybe if, for example, the self-study assignments or e-learning assignment are designed like the exam, it would be.. but, then your learning is very exam-oriented maybe." (P2)

A few students elaborated on the benefits of intensifying feedback and reflection to facilitate personal continuous development.

> "Well, actually we were talking about this yesterday in an educational committee. Longitudinal assessment and improving yourself and such... that more attention should be paid to that. And that you maybe can ask the students themselves or assess if.. are they willing to improve themselves?" (P8)

Finally, some students mentioned that medical education is solely about learning medical facts.

> "To me, what I am learning is mostly about learning facts, and that is what's assessed really... I am not looking for any help [in learning facts], because it's things that I know or do not know. I don't think that anyone can help me to better learn things by heart, because I, that is one of my strengths, that I am good at learning things by heart. So, I don't really need help with that and I think that during my education that [learning facts] is what I mainly do for an exam, and in that sense, to a lesser extent understanding the material." (P7)

As illustrated by this excerpt, students felt that learning facts does not require any monitoring, e.g. help-seeking, indicating that developing metacognitive skills may not be necessary to succeed in medical school.

Discussion

Our study provided insight in medical students' metacognitive knowledge, skills and experiences. Additionally, we obtained students' perceptions on self-regulated learning in the medical curriculum.

Regarding metacognitive skills, students used various ways to monitor their learning process while problem-solving. For example, they visualised the situation to make the problem less abstract. Contrary to monitoring, less time was spent on planning and evaluating. Previous research on metacognitive skills in clinical reasoning also showed that students performed monitoring, but that planning occurred to a much lesser extent (Artino et al., 2014). Planning and evaluation are strong predictors of academic performance (Murad et al., 2010; Patel et al., 2015; Gandomkar et al., 2016). Importantly, these skills are modifiable and teachable, rather than fixed traits (Zimmerman, 2000). Tanner has provided examples of self-questions that learners may ask in training their metacognitive skills, either on the level of an assignment, a single class session, an exam, or a full course (Tanner, 2012). These questions are not only helpful for learners, but also serve as a tool for educators who aim to address metacognitive skills explicitly in their classrooms.

Regarding metacognitive knowledge, a large variety in awareness about one's learning process was found. For those students with little metacognitive knowledge about types of skills or how to use them, there is a need to teach this explicitly (Pintrich, 2002; Tanner, 2012). This includes teaching various strategies, various cognitive tasks, and accurate knowledge about themselves. Moreover, educators should be aware of students' prior knowledge about a subject before teaching them new information. For example, preassessments may be very valuable tools in encouraging students to examine their level of knowledge, and for educators as a diagnostic tool to gain insight in students' understanding (Versteeg et al., 2019). Educators should take responsibility, especially since we know from literature that students themselves are rather poor judges of their actual knowledge and competencies (Thiede et al., 2003; Versteeg et al., 2019).

Regarding metacognitive experiences, most students estimated their performance based on a feeling of logic or a feeling of familiarity, and to a lesser extent on the ease of reasoning. The first two can be referred to as surface-related cues that operate automatically and unconsciously, and which are generally unreliable as predictive cues for performance (Koriat, 1997; Thiede et al., 2010). Importantly, learners can be trained to effectively use predictive cues such as comprehension-based cues, e.g. ease of reasoning (Begg et al., 1989; Koriat, 1997). Various examples of training methods include, generating key words

or summaries in case of learning factual knowledge, and completing diagrams in case of conceptual knowledge (Thiede & Anderson, 2003; van Loon et al., 2014). Teaching students explicitly to recognise and generate predictive cues in the classroom may eventually lead to enhancing predictive cue use during self-regulated learning outside of the classroom (de Bruin et al., 2017).

Facing the facts

During their medical training, students continuously have to prove themselves, resulting in their learning being driven by assessments (Wormald et al., 2009; Boulet & Durning, 2019). Our research confirms this as students describe the value they assign to assessment outcomes. They feel that assessments are the main indicators for performance. Regarding competency-based education specifically, students felt they have no insight in their level of competency as they cannot fall back on any numerical indicator of performance. The impact of assessments on medical students' motivation to study is profound and often leads to a surface approach to learning (Marton & S□lj□, 1976; Wormald et al., 2009; Cilliers, 2015). This surface approach is characterised, for example, by students' aim to memorise facts (Ramsden, 2003). Notably, our students underlined this statement by describing that the focus in undergraduate medical training is on learning factual knowledge. They felt this approach to learning comes at the cost of their reasoning abilities. Even clinical 'reasoning' is described by some students as a process of pattern recognition during which one has to merely recall factual knowledge. The medical education community has already suggested that one of the solutions to establish deep-learning might entail more integration of basic science and clinical learning, which would meet the students' needs for conceptual knowledge to better understand medical concepts (Kulasegaram et al., 2013). Additionally, since assessment drives learning, educators and faculty should better align assessments with the skill sets required for practice. Currently, there is a trend towards integrated longitudinal assessment programmes that facilitate a more continuous evaluation of student abilities, and which aim to produce competent lifelong learners. Moreover, we may consider rewarding students' metacognitive performances, such as their use of reflective journals (Tanner, 2012).

> "The point at which students have both learned metacognitive skills and have become aware of when to apply these strategies is hypothetically the point at which they have matured into lifelong learners within their disciplines." (Tanner, 2012).

Defining the necessary competencies allows for the integration of meaningful

assessments in medical education that help our students to become lifelong learning health professionals (Schuwirth & van der Vleuten, 2012; Boulet & Durning, 2019).

Strengths and limitations

A strength of our study lies in combining the thinking aloud assignment with an interview session. This approach allowed us to better grasp all three facets of students' metacognitive performance. It also functioned well as a prompt for students' thoughts about self-regulated learning on the curriculum level.

Some limitations must be taken into consideration. First, the study was conducted in a non-authentic setting, meaning that contextual factors from a real environment which may influence learning behaviour and performance were excluded. Second, metacognitive skills were measured without explicitly asking our students about these skills during the task. This is contrary to the use of microanalyses which are defined as "structured interview approaches that involve administering context-specific questions targeting multiple cyclical phase processes as trainees engage in authentic activities" (Cleary et al., 2016). These microanalyses are often used to measure self-regulated learning processes and prompt students to focus on strategic steps during problem-solving (Artino et al., 2014). However, such prompts may trigger students' awareness and induce 'artificial' use of metacognitive skills as they may not have used these skills in a non-prompted setting. Therefore, we feel that our approach leads to a more accurate image of students' use of metacognitive skills.

Our study was performed among final year pre-clinical medical students in one Dutch University. Despite this specific context, we feel that our findings are transferable within the Dutch educational context as all Dutch medical programs are based on the same blueprint as developed by the Dutch Federation of University Medical Centers (Herwaarden et al., 2009). Additionally, part of the context is transferable to the medical education community as a whole, since medical education programs worldwide consist of a preclinical and clinical phase.

Conclusion

This study revealed that medical students are in need of explicit training of metacognitive skills to facilitate self-regulated learning. This includes planning, monitoring and evaluation skills. Moreover, our findings showed that the level of metacognitive knowledge and metacognitive experiences highly varied among students. Educators and faculty should aim to integrate metacognition in the everyday discourse of the classroom to foster an environment in which students

discuss their own cognition and learning. This includes the use of novel assessment strategies that drive both cognitive and metacognitive learning in order to develop metacognitive habits of mind and stimulate lifelong learning.