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Metacognitive awareness in relation to university students' learning profiles

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Abstract
The present study aims to deepen our understanding of the relationship between metacognitive awareness and approaches to learning in a multidisciplinary context of higher education using a person-oriented approach. The participants in the present study were 462 third year students of humanities, social sciences and theology. The students filled in a HowULearn questionnaire which included 18 items related to metacognitive awareness and 12 to approaches to learning. Exploratory and confirmatory factor analyses were conducted to explore the factor structure of the instruments. The data were analyzed using Pearson's correlation, K-means cluster analysis and One-way ANOVA. The results showed that two dimensions of metacognitive awareness, namely knowledge about cognition and regulation of cognition, emerged from the data. Knowledge about cognition was evaluated higher than regulation of cognition. The results showed that both dimensions of metacognitive awareness were statistically significantly related to a deep approach to learning and organized studying and negatively to an unreflective approach. Furthermore, three learning profiles were identified and they differed in both of these dimensions of metacognitive awareness. More precisely, students representing *organized students* applying a deep approach had higher scores on knowledge about cognition as well as on regulation of cognition compared with the students representing *unorganized studentsapplying a deep approach* or those with a *dissonant profile*. In addition, students representing the *dissonant profile* had statistically significantly lower scores on knowledge about cognition than those students representing *unorganized students applying a deep approach*. The present study implies that students with different study profiles need different types of support for the metacognitive awareness of their own learning processes.

Keywords Metacognitive awareness · Approaches to learning · Learning profiles · Person-oriented approach · Higher education

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Introduction

Recent research has shown that successful study at university requires the ability to regulate one's own studying and evaluate one's own learning and deep study processes (Räisänen et al., 2020; Tuononen et al., 2019). The results of these studies imply that metacognitive awareness has an important role in learning and studying because it can be defined as the students' ability to identify their strengths and weaknesses and deepen their knowledge of strategies as well as understanding how, when and why to use such strategies (Harrison & Vallin, 2018; Schraw & Dennison, 1994). Thus, it highly resembles students' ability to reflect on their own learning, which has also been shown to be related to the academic competences of university students (Tuononen et al., 2017). There is also some evidence that metacognitive awareness is related to students' learning processes (Beccaria et al., 2014; Magno, 2009) and to better academic achievement (Sawhney & Bansal, 2015; Vosniadou et al., 2021; Young & Fry, 2008). However, the relationship between metacognitive awareness and student learning is still under-examined in the multidisciplinary context of higher education. Studies concerning metacognitive awareness in higher education have been mainly conducted in the field of teacher education (e.g., Kallio et al., 2018; Kallio, Virta, Kallio, Virta, Hjardemaal & Sandve, 2017). Moreover, there are contradictory results of the relations between student learning and metacognitive awareness (Magno, 2009). This indicates the need for new methodological approaches, for example person-oriented methods to examine these relations (Veenman et al., 2006). Interestingly, to our knowledge, there is no previous study that has explored these relations using a person-oriented approach. Previous studies have identified student profiles based on student learning, regulation of learning or metacognition, but not specifically metacognitive awareness including both knowledge about cognition and regulation of cognition and approaches to learning (Fryer & Vermunt, 2018; Millenos et al. 2021; Räisänen et al., 2016).

Furthermore, evidence shows that many students have difficulties in reflecting on their learning, which indicates a lack of metacognitive skills and problems in regulating their learning (Räisänen et al., 2020; Smith et al., 2007; Tuononen et al., 2017). Thus, the present study aims to explore higher education students' metacognitive awareness and the relationship between metacognitive awareness and approaches to learning in a multidisciplinary context.

Metacognitive awareness

Metacognitive awareness can be defined as students' awareness of their own learning strategies and also of how, when and why to successfully apply them (Harrison & Vallin, 2018; Schraw & Dennison, 1994). It has been said to comprise two dimensions: *knowledge about cognition* and *regulation of cognition* (Schraw & Dennison, 1994; Kallio et al., 2018).

Knowledge about cognition includes declarative, procedural and conditional knowledge of cognition (Sperling et al., 2002). Declarative knowledge refers to "knowing about things", procedural knowledge to "knowing how to do things" and conditional knowledge to "knowing why and when to do things" (De Jong & Ferguson-Hessler, 2010; Schraw & Moshman, 1995; Nousiainen et al., 2019). Declarative knowledge can be characterized as knowledge about the contents of learning and especially the strategies that can be applied to increase the performance of task completion (Harrison & Vallin, 2018; Schraw & Moshman,

1995). Procedural knowledge is knowledge about how a person uses learning strategies to complete a task. Conditional knowledge is knowledge about when and why strategies can be used in order to accomplish tasks (Schraw, 2001), as well as understanding and applying strategies to enhance learning (Schunk & Zimmerman, 2012). Students who have high conditional knowledge can monitor their own learning progress and implement learning strategies effectively for context specific situations (Schraw, Crippen, & Hartle, 2006).

Regulation of cognition refers to students' ability to plan, implement, monitor, and evaluate learning processes (Schraw & Dennison, 1994). It comprises three main phases, namely, 1) task analysis, goal setting, and strategic planning before taking any action, (2) using a range of methods/strategies, monitoring, observing learning during the performance/action and controlling learning during studying, and (3) evaluating and reflecting on learning during and/or after the action (Harrison & Vallin, 2018; Kallio et al., 2017; Usher & Schunk, 2018; Zimmerman, 2000). These different phases have been found to be cyclical in nature and tightly intertwined so that students go back and forth between the phases when they complete learning tasks (Hyytinen et al., 2021; Rogat & Linnenbrink-Garcia, 2011; Pintrich, 2004; Zimmerman, 2000). Regulation of cognition involves a continuous evaluation of what is known and what still needs to be learned (Brown, 1987; Flavell, 1979).

Previous research has shown that there is a large variation in higher education students' regulation of cognition (e.g. Donche & Van Petegem 2009; Donche et al., 2010; Heikkilä, Lonka, Niemivirta, & Nieminen, 2012; Lindblom-Ylänne, Saariaho, Koivuniemi et al., 2017; Pintrich, 2000). Some students regulate their own learning without difficulty but others experience major challenges when doing so (Lindblom-Ylänne et al., 2017; Räisänen et al., 2020; Young & Fry, 2008). For example, some students have difficulties in setting realistic goals that could be divided into manageable tasks (McCardle et al., 2017; Young & Fry, 2008) found that undergraduates and graduate students did not differ in their knowledge about cognition but they did differ in the regulation of cognition, with graduates gaining higher scores than undergraduates.

Knowledge about cognition and regulation of cognition are closely related to each other (e.g., Brown 1987; Flavell, 1987; Winne, 2018). As an example, regulation of cognition makes it possible to monitor knowledge about cognition (Harrison & Vallin, 2018; Schunk & Greene, 2018; Zimmerman & Schunk, 2012). Knowledge about cognition plays an especially important role at the beginning of studying when new study practices are being learned or when completing complex tasks (Hyytinen et al., 2021; Winne, 2018). There is evidence that metacognitively-aware students are able to set realistic goals for their learning and they are also able to use effective strategies and make changes when needed more successfully than unaware students (Pintrich, 2000; Schraw & Dennison, 1994).

Approaches to learning and metacognitive awareness

Student learning has been examined extensively with a focus on study processes and the strategies students use when studying. These processes and strategies represent the students' approaches to learning and they reflect qualitatively different ways of going about learning and studying (Asikainen & Gijbels, 2017; Biggs, 2003; Entwistle, 2009; Entwistle et al., 2006; Lonka et al., 2004). A *deep approach* refers to the intention to understand information through comprehending the bigger picture by relating ideas and searching for evidence. A *surface approach* has been characterized as having its focus on learning things by heart,

which often results in a fragmented knowledge-base where information is seen as unrelated bits and pieces (Entwistle, 2009). However, recent research has suggested that instead of the memorization and repetition of knowledge, the core of the surface approach is unreflective studying and the experience of fragmented knowledge and thus the surface approach should be better labelled as the *unreflective approach* (Lindblom-Ylänne et al., 2019). Recent research indicates that high scores on an unreflective approach suggest the inability to relate ideas, and thus difficulties emerge in understanding the content (Parpala et al., 2021).

A third approach, *organized studying*, concerns students' time and effort management. It is therefore considered to be more of an approach to studying than to learning (Entwistle, 2009; Entwistle & McCune, 2004) but in the present study we use the concept of approaches to learning to include deep and surface approaches and organized studying.

There is usually a strong negative correlation between the deep and surface approaches to learning (e.g., Entwistle et al., 2000) and a strong theoretical positive linkage between the deep approach to learning and organized studying (e.g. Richardson 2000). However, person-oriented studies have revealed different combinations of approaches to learning among university students (Asikainen et al., 2020; Parpala et al., 2010, 2021). For example, based on their research in an Asian context, Fryer & Vermunt (2018) suggest that Asian students are able to use both surface and deep approaches to learning together or in a series. This result indicates that the deep and surface approaches to learning could be described as intermediate positions on a spectrum measuring student approaches to learning (Kember, 1996). Furthermore, the deep approach has been related to both high and low scores on organized studying (Parpala et al., 2010, 2021). Interestingly, in the fields of law and of veterinary medicine, the profile of deep and unorganized studying was found to characterize groups of students with the poorest academic achievement (Haarala-Muhonen et al., 2017; Ruohoniemi et al., 2010). Person-oriented methods are required in order to detect these different combinations of approaches to learning.

There is evidence that metacognitive awareness and a deep approach to learning are positively related to each other (Beccaria et al., 2014; Magno, 2009; Tuononen et al., 2019). In line with this, Leung & Kember (2003) found that students' ability to reflect on learning is positively related to a deep approach to learning. Moreover, students who applied a deep approach to learning were able to plan, monitor and evaluate their own learning (Räisänen et al., 2016). However, Magno (2009) found that, among Asian students, the surface approach was also positively related to metacognitive awareness. Furthermore, students using a deep approach displayed more cognitive self-appraisal and regulatory control of the learning process through ongoing reflective thinking, whereas students using a surface approach engaged in less self-monitoring and self-assessment (Chin & Brown, 2000). Thus, the difference between the students using a deep approach and those using a surface approach was less due to the amount of content knowledge they possessed than it was to the strategies they used (Chin & Brown, 2000). This previous research, also with contradictory results, imply that in order to understand the relations between metacognitive awareness and student approaches to learning in detail, person-oriented methods are needed (Veenman et al., 2006).

Aims

The present study aims to explore the metacognitive awareness of higher education students and the relationship between metacognitive awareness and approaches to learning. The research questions are:

1) What dimensions of metacognitive awareness emerge among university students?
2) What kind of learning profiles can be identified?
3) How are learning profiles related to metacognitive awareness?

Methodology

Participants

The participants in the present study were 462 students in the fields of humanities, social sciences and theology. The students filled in a HowULearn questionnaire (Parpala & Lindblom-Ylänne, 2012) in the Unihow system, which is a digital reflection tool and feedback system used in a research-intensive university in Scandinavia. All final stage bachelor's students in the present university are asked to fill the questionnaire as a part of their studies. The questionnaire was sent electronically to the students and the system provided them with not only their own mean scores on each scale but, for comparison, the mean scores of the whole cohort, as well as individual feedback based on their approaches to learning. The students were asked for permission to use the data for research, and only the responses of those who gave permission were used in the present study. The data of two academic years were combined: 2019 (n = 243) and 2020 (n = 219). All students were at the end of their bachelor's studies when they answered the questionnaire. Thus, they represent third year students at the same level of knowledge. In 2019 and 2020, a total of approximately 1084 students started their studies in these fields, and thus the response rate was about 43%.

Materials

The HowULearn questionnaire (Parpala & Lindblom-Ylänne, 2012) consists of different research instruments measuring the students' learning and their experiences of the teaching-learning environment. The analysis in the present study was carried out on two sections of the questionnaire, i.e., students' metacognitive awareness and approaches to learning.

Students' metacognitive awareness in the questionnaire is measured using the Metacognitive Awareness Inventory (MAI; Schraw & Dennison 1994; Harrison & Vallin, 2018; Kallio et al., 2017, Kallio et al., 2018, Kallio et al., 2020). The original MAI consists of 52 items (Schraw & Dennison, 1994; Harrison & Vallin, 2018). However, in this study, a shortened 18-item version of the instrument was used to measure two major components of metacognitive awareness: 1) knowledge about cognition (nine items e.g. 'I am a good judge of how well I understand something') and (2) regulation of cognition (nine items e.g. 'I set specific goals before I begin a task'; see Appendix 1). This shortened version has been translated into Finnish, tested and found to be a reliable instrument for measuring in-service teachers' and teacher education students' metacognitive awareness (Kallio et al., 2017, 2018). However,

further research is needed to confirm the theoretical structure of the MAI in a multidisciplinary higher education context (e.g. Harrison & Vallin 2018).

The other section from the HowULearn questionnaire applied in the present study measures students' approaches to learning, using 12 items in which students are asked to think about their studying in general. The items measuring students' approaches to learning were taken and modified for HowULearn from the Approaches to Learning and Studying Inventory (ALSI, Entwistle & McCune 2004) and the Learning and Teaching Questionnaire (LSQ, Entwistle et al., 2003). In addition, two items from the Revised Learning Process Questionnaire (R-LPQ9, Biggs, Kember & Leung, 2001) were modified and added. The three scales included are the *deep approach* (e.g. 'I try to relate new material, as I am reading it, to what I already know on that topic'), the *unreflective approach* (prev. surface approach; e.g. 'Much of what I learn is incoherent, which means that I cannot connect it to a greater picture') and *organized studying* (e.g. 'I organize my study time carefully to make the best use of it'; see Appendix 2), each measured by four items. The HowULearn items measuring the unreflective approach focus on fragmented knowledge and difficulties in relating ideas, and therefore, the emphasis is not on the elements of the previous surface approach to learning (memorization and repetition of knowledge). The part measuring the approaches to learning in the HowULearn questionnaire has been widely used and validated in different contexts (e.g. Herrmann et al., 2017; Ruohoniemi et al., 2017; Tuononen et al., 2016) and the reliabilities for the deep and unreflective approach (prev. surface) scales were generally above 0.70 and above 0.80 for the organized studying scale (Postareff et al., 2018). A 5-point Likert scale (1 = totally disagree, 5 = totally agree) was used to measure both metacognitive awareness and approaches to learning.

Analysis

First, we conducted an exploratory factor analysis (maximum likelihood) with direct oblimin rotation on the items describing metacognitive awareness. The MAI has been added to the HowULearn questionnaire recently and its internal reliability has not yet been tested in this new context. Therefore, the exploratory factor analysis was chosen to test how the MAI functions among Finnish higher education students and to determine the number of factors that could be identified in the data. In addition to communalities and factor loadings, a parallel analysis and Velicer's minimum average partial (MAP) test were conducted to determine the most appropriate factor structure for a set of measured variables (Costello & Osborne, 2005; Fabrigar et al., 1999; Goretzko et al., 2019; O'Connor, 2000). Both the parallel analysis and the MAP test indicated a two-factor solution, which is in line with previous studies (Harrison & Vallin, 2018; Schraw & Dennison, 1994). All loadings were above the desired 0.32 mark (Tabachnick & Fidell, 2014). Communalities varied from moderate to low and a few items remained below the desired 0.40 (Costello & Osborne, 2005; see Appendix 1).

Acknowledging the findings of the exploratory factor analysis and the theory behind the assessment, we further tested a two-factor solution with confirmatory factor analysis (CFA; Barlow, & King, 2006; Hu & Bentler 1999; Schreiber, Nora, Stage, Schumacker & Lomax 2016). The fit indexes were 0.855 for the CFI, 0.82 for the TLI and 0.083 for the RMSEA. The value of the RMSEA indicated an acceptable fit between the model and the observed data. However, the values of the CFI and the TLI remained modest. Cronbach's alphas were 0.83 for the knowledge of cognition and 0.84 for regulation of cognition.

Table 1 Means and standard deviations of metacognitive awareness and approaches to learning

	Mean (scale 1–5)	Standard deviation
Metacognitive awareness		
Knowledge about cognition	3.75	0.58
Regulation of cognition	3.12	0.67
Approaches to learning		
Deep approach	3.89	0.67
Unreflective approach	2.54	0.77
Organized studying	3.67	0.80

Next, the confirmatory factor analysis was conducted to explore the factor structure of the approaches to learning inventory. The three-factor model, namely (1) deep approach, (2) unreflective approach, and (3) organized studying, was based on the scales that replicate across studies (Parpala et al., 2010, 2021; Tuononen et al., 2016). The fit indexes indicated an acceptable fit for the CFI and the RMSEA and modest first for the TLI between the model and the observed data (CFI=0.92, TLI=0.89, RMSEA=0.077; cf. Schreiber et al., 2006). Cronbach's Alphas were 0.80 for the deep approach, 0.76 for the unreflective approach, and 0.71 for organized studying. The scales and items are presented in Appendix 2. Exploratory and confirmatory factor analyses were conducted with SPSS and Amos 25.

The relation between metacognitive awareness and approaches to learning was measured using Pearson's correlation. Student learning profiles were identified with K-means cluster analysis and the differences in metacognitive awareness between the learning profiles were explored using One-Way ANOVA.

Results

The results showed that the students scored high on knowledge about cognition and relatively high on regulation of cognition (Table 1). Regarding the approaches to learning, the students scored highest on the deep approach, rather high on the organized studying and lowest on the unreflective approach.

Pearson's correlations between metacognitive awareness and approaches to learning were statistically significant (Table 2). The results showed that both the dimensions of metacognitive awareness (knowledge about cognition and regulation of cognition) correlated positively and statistically significantly with a deep approach to learning and organized studying and negatively to an unreflective approach.

Next, we explored what kind of learning profiles could be found. Three clusters emerged from the data (Table 3). The first, *Organized students applying a deep approach*, included students who scored the highest on the deep approach and organized studying and lowest on the unreflective approach. The second profile, *Unorganized students applying a deep approach*, included students who scored high on deep approach but the lowest on organized studying. The third, *Dissonant profile*, comprised students who scored high on all approaches.

Next, the differences in the dimensions of metacognitive awareness between the profiles were explored using ANOVA. The results showed significant differences in *knowledge about cognition* and *regulation of cognition* (Table 4). Bonferroni's post hoc tests revealed

Table 2 Pearson's correlations between metacognitive awareness and approaches to learning

	1	2	3	4	5
1. Knowledge about cognition	1				
2. Regulation of cognition	0.497**	1			
3. Deep approach	0.527**	0.552**	1		
4. Unreflective approach	−0.541**	−0.223**	−0.371**	1	
5. Organized studying	0.434**	0.478**	0.293**	−0.189**	1

** Correlation is significant at the level 0.001

Table 3 Learning profiles

Profiles	Organized students applying a deep approach (n = 230) Mean (SD)	Unorganized students applying a deep approach (n = 113) Mean (SD)	Dissonant profile (n = 119) Mean (SD)
Deep approach	4.21 (0.49)	3.74 (0.64)	3.41 (0.66)
Unreflective approach	2.10 (0.51)	2.45 (0.53)	3.46 (0.54)
Organized studying	3.86 (0.49)	2.42 (0.50)	3.32 (0.66)

Table 4 The differences in metacognitive awareness between the learning profiles

Learning profiles	Knowledge about cognition Mean (SD)	Regulation of cognition Mean (SD)
1. Organized students applying a deep approach	4.05 (0.44)	3.41 (0.60)
2.Unorganized students applying a deep approach	3.56 (0.53)	2.75 (0.58)
3. Dissonant profile	3.35 (0.56)	2.93 (0.65)
F	87.85	52.28
p	< 0.001	< 0.001

Bonferroni's test. Knowledge about cognition 1 > 2, 3,** 2 > 3*. Regulation of cognition 1 > 2, 3. * p < 0.05. ** p < 0.001

that students representing the profile *Organized students applying a deep approach* had higher scores on knowledge about cognition than the students representing other profiles. In addition, students belonging to *Dissonant profile* had statistically significantly lower scores on knowledge about cognition than those representing *Unorganized students applying a deep approach*. Regarding the regulation of cognition, the results showed that students representing the profile *Organized students applying a deep approach* had higher scores than the students in other profiles. There was no statistically significant difference in the regulation of cognition between the students in the profile *Unorganized students applying a deep approach* and the *dissonant profile*.

Discussion

The present study revealed that two expected dimensions of metacognitive awareness: knowledge about cognition and regulation of cognition, were identified among university students (see Harrison & Vallin, 2017; Craig et al., 2020; Schraw & Dennison, 1994). In addition, three learning profiles emerged, namely organized students applying a deep approach, unorganized students applying a deep approach and a dissonant profile. The results of the present study further revealed that the learning profiles were related to metacognitive awareness. This study provides new evidence of the relation between approaches to learning and metacognitive awareness by using a person-oriented approach. Next, the results are discussed in more detail.

The results showed that of the two dimensions of metacognitive awareness, namely knowledge about cognition and regulation of cognition, students struggle more on regulation of cognition than knowledge about cognition, which has also been found in previous studies (Magno, 2009; Sawhney & Bansal, 2015; Young & Fry, 2008). Thus, students might have knowledge about their learning and how they should study but they lack skills to study in that way. Similar gap between intention and action has been found also in other studies (Klingsieck, 2013; Steel, 2007; Räisänen et al., 2016). As expected, these two dimensions of metacognitive awareness strongly correlated with each other (Young & Fry, 2008; Winne, 2018).

The results of the present study showed a clear positive association between a deep approach to learning, organized studying and both dimensions of metacognitive awareness. We identified three different learning profiles: organized students applying a deep approach, unorganized students applying a deep approach and a dissonant profile. These profiles are similar to those found in previous studies (Asikainen et al., 2020; Parpala et al., 2010) even though small differences may be detected. In the present study, we identified only three learning profiles, whereas in earlier studies four profiles have been detected (e.g. Asikainen et al., 2020; Parpala et al., 2021; Vanthournout et al., 2013). In the third profile, named the *Dissonant profile*, students reported high deep approach, unreflective approach and organized studying. The profile is in line with the suggestion put forward by Fryer & Vermunt (2018) that students may use both deep and surface approaches together or in a series. Similarly, previous studies have identified students who score either low on all dimensions or high on all dimensions (Vanthournout et al., 2013). In addition, the dissonant profile is similar to a previously found profile in which an unreflective approach is emphasized (Parpala et al., 2021). One explanation might also be that these students have trouble reflecting on their own learning and thus score high on each dimension.

Our findings clearly show that students representing different learning profiles score differently in dimensions measuring metacognitive awareness. Although in previous studies the differences between the students have been detected, especially regarding the regulatory dimension (Fryer & Vermunt, 2018; Schraw & Dennison, 1994; Young & Fry, 2008), in our study we found differences between the profiles in both dimensions. The results showed that *organized students applying a deep approach* scored higher on both dimensions of metacognition, that is, knowledge about cognition and regulation of cognition, than the other two profiles. This was expected and is in line with previous studies suggesting a close relationship between metacognitive awareness and a deep approach to learning (Beccaria et al., 2014; Chin & Brown, 2000). The other two profiles differed from the first profile

in both dimensions of metacognition. The *Dissonant profile* scored the lowest of all three profiles on the knowledge about cognition. This indicates the negative association between an unreflective approach (prev. surface approach) and metacognitive awareness because unreflective approach is emphasized in this profile. This relation has not been found in previous studies and it provides an interesting insight into the relationship between learning processes and metacognitive awareness. It appears that students who have trouble mastering and understanding central knowledge and have a fragmented knowledge base also struggle with metacognitive awareness. The reason why this association has not been previously detected may also lie in the measures of the "older" surface approach which have emphasized rote learning and memorization instead of fragmented knowledge and difficulties in understanding, i.e. the core elements of an unreflective approach (Lindblom-Ylänne et al., 2019).

It appears that students who have trouble reflecting on their own learning processes and have a fragmented knowledge base also lack knowledge of their own strengths, weaknesses and the strategies they could use to improve their studying, let alone regulate their cognition. This is in line with previous studies suggesting that many students struggle with reflecting on and regulating their own learning (Smith et al., 2007; Räisänen et al., 2020; Tuononen et al., 2017). Even though the profile *Unorganized students applying a deep approach* scored a little higher on the knowledge about cognition than those representing the *Dissonant profile*, no differences were detected regarding the regulation of cognition. It appears that students in both these profiles might have challenges in the regulation of cognition. Previous research suggests that the ability to regulate and reflect on one's own learning and deep study processes are both crucial factors for student achievement (Magno, 2009) as well as for employability and later career success (e.g. Tuononen et al., 2019). These findings are central and a cause for concern in higher education. It is well justified to assume that lacking these skills might pose a risk of drop-out or later difficulties in employment.

Limitations and methodological reflections

The generalisability of these results is subject to certain limitations. Over 40% of students answered the questionnaire which can be considered a relatively high percentage. However, the situation of those students who either declined to participate or those who did not give their consent remains unknown.

As discussed above, our results confirm the theoretical structure of the two-component model of metacognitive awareness (Craig et al., 2020; Harrison & Vallin, 2018; Schraw & Dennison, 1994). However, this model differs from those obtained earlier in the context of Finnish teacher education. As an example, Kallio et al., (2017) have found a six-factor model in which both main components of metacognitive awareness are divided into three subcomponents. Furthermore, the CFA indicated some problematic issues with the MAI showing acceptable and modest fit indexes. Previous studies have also identified some challenges in the factor structure of the MAI (e.g. Harrison & Vallin 2018). Thus, further development of the MAI in the multidisciplinary higher education context would be important in the future.

Considering the complex and abstract nature of metacognitive awareness, the assessment of students' knowledge about cognition and regulation of cognition utilizing self-reports is not without challenges (Craig et al., 2020). It has been found that reporting these kinds of

conceptions is cognitively extremely demanding and requires high-level abstraction and deep reflection on the part of the students (Karabenick et al., 2007). Consequently, there is a need to investigate metacognitive awareness using other authentic methods, such as observation of learning or information-searching situations. Such methods could provide an opportunity to deepen the understanding of the contextual and situated elements of metacognition of learning.

Practical implications

The results of the present study highlight the entanglement of metacognitive awareness and approaches to learning. Thus, metacognitive awareness could also be supported by taking into account students' learning processes. These findings have some practical implications. Firstly, students should be provided with the time and place for reflection. Reflection helps students to raise the metacognitive awareness of their own learning processes. It has been suggested that students' metacognitive awareness and ways of self-monitoring their learning could also be enhanced by asking students to complete an inventory regarding their approaches to learning in order to acquaint them with their own study processes (Backhaus & Liff, 2007; Haarala-Muhonen et al., 2017; Parpala & Lindblom-Ylänne 2012).

Secondly, students need to practice regulation of cognition by planning, monitoring and evaluating their learning processes (Kallio et al., 2018; Usher & Schunk, 2018). Students could be given tasks that encourage them to set their own goals for learning and provide opportunities for monitoring and evaluating their learning process in order to achieve their goals (Hyytinen et al., 2021; Winne, 2018). These tasks would also help students in developing their deep approach to learning and organizing skills which, on the basis of this research, are essential in supporting metacognitive awareness. Furthermore, previous studies indicate that students' versatile feedback and support from their teachers and peers in order to develop their metacognitive awareness during studies (McCardle et al., 2017; Kallio et al., 2020; Räisänen et al., 2016). The present study revealed that students with different learning profiles may need different kinds of support for their learning (see also e.g., Lindblom-Ylänne et al., 2017). Some students need more support for regulation whereas others need more knowledge about their learning. Moreover, the present study emphasizes that the ability to relate various contents and ideas to a coherent whole, and knowledge and regulation of cognition should be developed hand in hand.

Finally, it is important to describe metacognitive awareness explicitly to students, because it would help them connect new strategies to existing knowledge on learning processes (Pintrich, 2004; Winne, 2018). However, higher education teachers are not necessarily sufficiently prepared to teach this issue. Therefore, the fourth implication of this study is that teachers need both a clear understanding of the nature of metacognitive awareness (Kallio et al., 2020) as well as the pedagogical competencies to integrate the elements of metacognitive awareness in their teaching and assessment practices.

Conclusions

Our findings contribute to the current literature by indicating that, in a multidisciplinary higher education context, metacognitive awareness is essential and related to students'

approaches to learning. Additionally, it showed that a deep approach in itself is not something that supports metacognitive awareness but, alongside, it also needs time and effort management skills, i.e. organized studying. Thus, the present study suggests that students' learning profiles should be taken into account when supporting their metacognitive awareness. Therefore, when enhancing students' metacognitive awareness through study alone and with other students, the students' ability to relate ideas and understand the connections as well as their skills in organizing and managing their time and effort should be supported.

Appendix

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Compliance with Ethical Standards

Disclosure of potential conflicts of interest The authors have no financial or proprietary interests in any material discussed in this article.

Research involving human participants and/or animals Voluntary participation, informed consent, and anonymity of the participants were ensured in the research process. The research did not involve intervention in the physical integrity of the participants, deviation from informed consent, studying children under the age of 15 without parental consent, exposure to exceptionally strong stimuli, causing long-term mental harm beyond the risks of daily life, or risking participants' security (cf. Finnish Advisory Board on Research Ethics 2012; 2020). Consequently, the study did not require an ethics review in the Finnish context.

Informed consent The research team complies with The Ethical Principles of Research in the Humanities and Social and Behavioural Sciences by Finnish Advisory Board on Research Ethics (2020) in the different phases of the study, such as study design, data collection, treatment of the participants, analysis, and preparation of the manuscript. Participation to the research was voluntary. Particular care has been taken in protecting participants' privacy and Finnish legislation is followed.

Appendix 1 Factor loadings and communalities of the MAI questionnaire for a 2-factor solution.

Item	Factor 1 Knowledge about cognition	Factor 2 Regulation of cognition	Communalities
I can motivate myself to learn when I need to.	0.49		0.29
I use my intellectual strengths to compensate for my weaknesses.	0.57		0.40
I know when each strategy I use will be most effective.	0.71		0.48
I am good at organizing information.	0.63		0.51
I am good at remembering information.	0.54		0.33
I am a good judge of how well I understand something.	0.57		0.32
I try to use strategies that have worked in the past.	0.73		0.49
I am aware of what strategies I use when I study.	0.56		0.49
I find myself using helpful learning strategies automatically.	0.77		0.52
I think about what I really need to learn before I begin a task.		0.53	0.39
I set specific goals before I begin a task.		0.67	0.50
I organize my time to best accomplish my goals.		0.30	0.29
I change strategies when I fail to understand.		0.39	0.29
I ask myself if what I'm reading is related to what I already know.		0.35	0.35
I find myself analyzing the usefulness of strategies while I study.		0.49	0.28
I summarize what I've learned after I finish.		0.81	0.52
I ask myself how well I accomplish my goals once I'm finished.		0.80	0.52
I ask myself if I learned as much as I could have once I finish a task.		0.80	0.57

Appendix 2 Items of the scales of approaches to learning

Scale	Items
Deep approach	I consider ideas and perspectives presented in different texts (i.e., academic articles and teaching material). I look at evidence carefully to reach my own conclusion about what I'm studying. I try to relate new material, as I am reading it, to what I already know on that topic. I try to relate what I have learned in one course to what I learn in other courses.
Unreflective approach	It is often hard for me to make sense of things I need to learn. Much of what I learn is incoherent, which means that I cannot connect it to a greater picture. Topics are presented in such complicated ways I often can't see what is meant. Even though I study some things over and over again to remember them, they do not make sense to me.
Organized studying	I put a lot of effort into my studying. I am generally systematic and organized in my studies. I organize my study time carefully to make the best use of it. I have made a plan to ensure that I get through the entire curriculum during the semester.

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