Instructions for authors, subscriptions and further details:

http://ijep.hipatiapress.com

Modelling the Components of Metacognitive Awareness

Heli Kallio,[1] Kalle Virta,[1] Manne Kallio[2]

1) University of Turku

2) University of Helsinki

Date of publication: June 24th, 2018
Edition period: June 2018 - October 2018

To cite this article: Kallio, H.; Virta, K. & Kallio, M. (2018). Modelling the Components of Metacognitive Awareness. *International Journal of Educational Psychology*, *7*(2), 94-122. doi: 10.17583/ijep.2018.2789

To link this article: http://dx.doi.org/10.17583/ijep.2018.2789

IJEP – International Journal of Educational Psychology, Vol. 7 No. 2
June 2018 pp. 94-122

Modelling the Components of Metacognitive Awareness

Heli Kallio
University of Turku
Manne Kallio
University of Helsinki
Kalle Virta
University of Turku

Abstract

Metacognitive awareness consists of two components, i.e. regulation of cognition and knowledge of cognition. In earlier studies self-evaluation is aligned as a sub-component of regulation of cognition. However, in this study we point out that self-evaluation does not actually regulate the ongoing or forthcoming process but it is a tool used to reflect both knowledge and regulation. This alignment is modelled to assess to what extend self-evaluation can be predicted by the other components of the metacognitive awareness. The model is tested empirically among vocational education students (N= 578) using the Metacognitive Awareness Inventory (MAI). The results of SEM concludes that the conditions and goals appointed by the learner predict the selection of contents and strategies towards self-evaluation of one's own learning. In other words, by measuring planning or conditional knowledge we could predict other components of knowledge or regulation and, especially, self-evaluation. The findings of this study extensively confirm that planning and knowledge of conditions predict success through the learning process. The results encourage teachers to support students in improving their metacognitive awareness, i.e. expect them to set goals for their own learning.

Keywords: metacognitive awareness, knowledge of cognition, regulation of cognition, self-evaluation, Metacognitive Awareness Inventory MAI

2018 Hipatia Press
ISSN: 2014-3591
DOI: 10.17583/ijep.2018.2789

IJEP – International Journal of Educational Psychology, Vol. 7 No. 2 June 2018 pp. 94-122

Configurando los Componentes de las Habilidades Metacognitivas

Heli Kallio
University of Turku
Manne Kallio
University of Helsinki
Kalle Virta
University of Turku

Resumen

La conciencia metacognitiva consiste en dos componentes, a saber: la regulación de la cognición y el conocimiento de la cognición. En estudios previos la autoevaluación se alinea como un subcomponente de la regulación de la cognición. Sin embargo, en este estudio señalamos que la autoevaluación no regula realmente el proceso actual o futuro, sino que es una herramienta utilizada para reflejar tanto el conocimiento como la regulación. Esta alineación se modela para valorar hasta qué punto la autoevaluación puede ser predicha por los otros componentes de la conciencia metacognitiva. El modelo es probado empíricamente entre los estudiantes de formación profesional (N = 578) utilizando el Metacognitive Awareness Inventory MAI (Inventario de Habilidades Metacognitivas). Los resultados de SEM concluyen que las condiciones y metas señaladas por el alumno predicen la selección de contenidos y estrategias para la autoevaluación del propio aprendizaje. En otras palabras, midiendo la planificación o el conocimiento condicional podríamos predecir otros componentes del conocimiento o la regulación y, especialmente, la autoevaluación.

Palabras clave: conocimiento metacognitivo, conocimiento de la cognición, regulación de la cognición, autoevaluación, Metacognitive Awareness Inventory MAI (Inventario de Habilidades Metacognitivas)

2018 Hipatia Press
ISSN: 2014-3591
DOI: 10.17583/ijep.2018.2789

Hipatia Press
www.hipatiapress.com

The aim of this study was to explore the components of metacognitive awareness. The earlier models delineating metacognitive awareness are divided into two main components: knowledge of cognition and regulation of cognition (Brown, 1987; Schraw & Dennisson, 1994). Consequently, we assume that self-evaluation is a link between the knowledge of cognition and the regulation of cognition. However in earlier studies it is only a sub-component for the regulation of cognition. In the present study, the components are modeled and tested empirically using the Metacognitive Awareness Inventory, MAI (Schraw & Dennisson, 1994) among vocational education and training. The research topic is of high relevance, hence learners' responsibility is highlighted in the current reorganizations of the field.

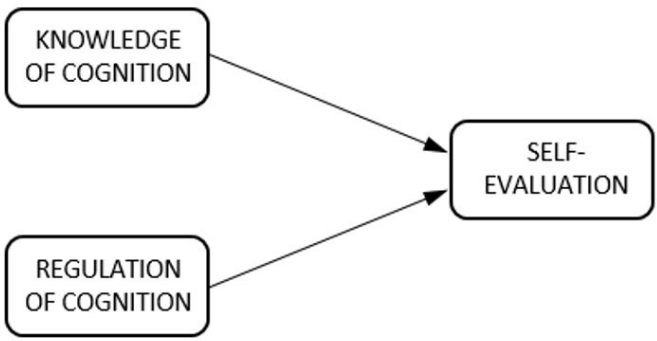

Figure 1. The framework of the components of metacognitive awareness in the present study.

Metacognition has been studied for over three decades from different perspectives and a variety of areas (see, e.g., Efklides, 2008; Bryce, Whitebread, & Szűcs, 2015). Research is mainly focused on identifying what people know about their own cognition (knowledge of cognition) and how people monitor and control their cognition (regulation of cognition). There are different characters of metacognition and its components, such as: self-regulation and Metacognitive knowledge; metacognitive experiences and metacognitive skills (Efklides, 2008); metacognitive beliefs (Kornell, 2014) and metacognitive awareness, including knowledge and regulation of cognition (Bryce, Whitebread, & Szűcs, 2015). Each one features slight theoretical variations and different terminology (Bryce, Whitebread, & Szűcs, 2015; see also Efklides, 2008). In the present study, we explored the perceived understanding of knowledge of cognition and regulation of cognition of individuals. Hence, we use the concept "metacognitive awareness" to describe the perceived understanding and conscious thinking of one's own learning, including both the knowledge of cognition and the regulation of cognition (cf. Ormrod, 2004; Young & Fry, 2012).

Some controversies exist in how metacognitive awareness is defined in different studies. Marton and Blooth (2009) describes the metacognitive awareness as a phenomenon which is manifested in the variations of ways in which people experience situations and phenomena in their life and their worlds. According to Garner and Alexander (1989), metacognitively aware learners are more strategic and perform better than unaware learners (see also Pressley & Ghatala, 1990). Metacognitive awareness allows individuals to plan, sequence and monitor his or her learning so that the improvements can be seen directly in performances (Schraw & Dennisson, 1994). As in metacognition, the distinction in metacognitive awareness is generally made between knowledge of cognition (i.e. metacognitive knowledge) and regulation of cognition (i.e. metacognitive regulation) (Schraw & Dennisson, 1994; Schraw, Crippen, & Hartley, 2006). This two-component model of metacognitive awareness is well-documented. Hence, this two-component model is applied in the present study, as well.

Knowledge of cognition includes three sub-components: conditional knowledge (i.e., knowledge about when and why to learn), declarative knowledge (knowledge about what are the contents of learning), and procedural knowledge (i.e., knowledge about how the person uses the learning strategies) (Schraw, Crippen, & Hartley, 2006). Regulation of cognition, includes five sub-components facilitating the process aspect: planning, information management strategies, monitoring the comprehension, debugging strategies and evaluating (Schraw & Dennisson, 1994; Baker, 1989).

Knowledge of Cognition and Regulation of Cognition

Flavell (1977) divides metacognitive knowledge into person-related variables, task-related variables, and strategy-focused variables (see also Brown, Bransford, Ferrara, & Campione, 1983; Bråten, 2006; Veenman, van Hout-Wolters, & Afflerbach, 2006). Knowledge of person variables refers to general knowledge about how human beings learn and process information, as well as individual knowledge of one's own learning processes. Knowledge of task variables includes knowledge about the nature of the task as well as the type of processing demands that it will place upon the individual. Knowledge about strategy variables includes knowledge about cognitive and metacognitive strategies, as well as conditional knowledge about when and where it is appropriate to use (Bråten, 2006). Conditional knowledge refers to the learners' knowledge about why and when she / he is learning. Declarative knowledge refers to the learners' knowledge about what she / he is learning. Procedural knowledge refers to the learners' knowledge about how she / he uses the strategies when studying. In the present study, knowledge of cognition is also used as one component of metacognitive awareness.

Regulation of cognition refers to exerting control over one's own cognitive processing, for example, the flexible employment of different processing activities, depending on circumstances and on interim learning outcomes. The regulation activities conceive planning before a certain course or assignment and monitoring as well as using information management strategies during a learning task (Vermunt & Verloop, 1999; Pintrich, 2004). Regulation of cognition refers to the steps that learners take to regulate and modify the progress of their cognitive activity. These steps develop initially as by-products in the context of domain-specific learning, and self-correcting activities may be seen as its early precursors (von Wright, 1992). Regulation of cognition includes predicting an action or an event, monitoring ongoing activity, checking the results of actions, reality testing, and a variety of other behavioral patterns for coordinating and controlling deliberate attempts to learn and solve problems (Brown & DeLoache, 1983). Veenman, Wilhelm, and Beishuizen (2004) argue that regulation of cognition appears to be highly interdependent. Deep orientation, systematic orderliness, accuracy, evaluation and elaboration may be regarded as skillfulness in regulation of cognition (Veenman, Prins, & Elshout, 2002). Furthermore, Veenman, Wilhelm & Beishuizen (2004) found that with some limitations, this kind of skillfulness is a general, person-related characteristic across age groups, rather than being domain specific (Veenman, Wilhelm, & Beishuizen, 2004).

Self-evaluation

Self-evaluation is generally considered to be one of the activities on one's own learning at the end of the learning task or a course (Schraw & Dennisson, 1994; Vermetten, Vermunt, & Lodewijks, 1999). According to a hypothetical model shown below, both the knowledge of cognition and the regulation of cognition predict the self-evaluation. The term "evaluation" can be understood in different ways. In this study, the "concept evaluation" refers to self-evaluation, the pupil's own objectives, and it is directed at the general level for the learning effort. We use this concept to avoid any misunderstanding that might arise in mixing it with the original term "evaluation" that has been used in the original MAI questionnaire. Previous research aligns self-evaluation with the regulation of metacognition (Jacobs & Paris, 1987; Schraw & Dennison, 1994; Balcikanli, 2011). According to von Wright (1992), evaluating pertains to judging the extent to which the final learning outcomes are in agreement with the goals that were planned. It also pertains to the degree to which the learning process has proceeded, as imagined beforehand. Hence, the self-evaluation of one's own learning is the central component in metacognitive awareness.

In the theoretical model of the present study, self-evaluation acts as the reference component of the knowledge of cognition and regulation of cognition. Previously, self-evaluation has been described as a sub-component of regulation (e.g., Vermetten, Vermunt, & Lodewijks, 1999). However, in this study we assume that both knowledge of cognition and regulation of cognition predict self-evaluation.

We assume that the self-evaluation is not a component of regulation, as such, as it does not regulate the ongoing or forthcoming process. It is a tool used to reflect both the knowledge and the regulation. Hence, the sub-components of knowledge of cognition (i.e., conditional, declarative and procedural knowledge) and self-evaluation were explored in a conjoined model. Similarly, the sub-components of regulation of cognition (i.e., planning, monitoring, information management strategies, and debugging strategies) and self-evaluation were explored in another conjoined model.

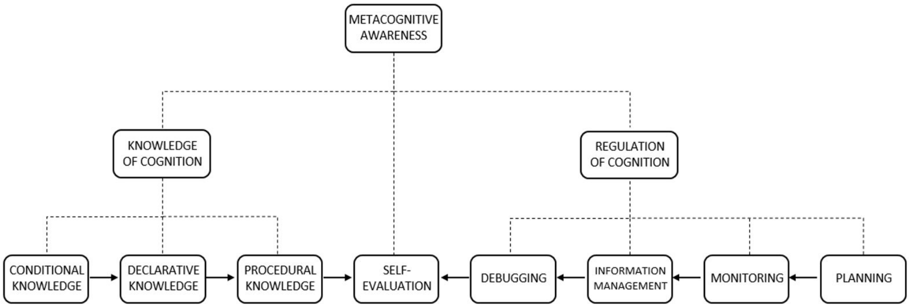

Figure 2. The components of metacognitive awareness.

The research task is to explore, to what extent self-evaluation can be explained by the knowledge of cognition and regulation of cognition. The research questions are:

1. How do the components of the knowledge of cognition predict self-evaluation?
2. How do the components of the regulation of cognition predict self-evaluation?

Methods

Participants and Data

Strict ethical norms and practices has been followed throughout the research project. The management of the participating institutions were informed about the rationale, objectives and ethical issues of the project. The data gathering sessions were held in groups. In the beginning of each sessions, the participants were informed of the purpose of the study, the use of the data and that participation was strictly voluntary. The students were explained how the data was encoded to protect the anonymity of the participants, and finally short instructions were given on how to fill in the questionnaires using pen and paper. All researchers and teachers, who were involved in gathering or handling the data, agreed the norms of handling the data and confidentiality of the participants. No personal identification information were gathered from the participants. The group codes were used in analysis and the names of the participated institutions, for example, were stored separately from the main data.

The data (N = 578) was gathered from ten units of vocational education institutions in 2015 and in the spring of 2016. 41.2 percent of the participants were men and 58.8 percent were women. 72.8 percent of the participants were 15 to 18 years old, while 27.2 percent were 19 or older.

The main aim of vocational education and training in Finland, where the present study took place, is to improve the skills of the work force, to respond to skills needs in the world of work and to support lifelong learning. The qualification is 120 credits, which takes three years of full-time study, unless prior learning can be counted towards the qualification (Ministry of Education and Culture Finland, 2015). The present study was chosen to take place in Finland, because "learning to learn" has been emphasized in curriculums on all levels of the Finnish educational system already for decades.

Vocational education is currently under re-organization in many European countries. For example, in Finland, authorization to provide education will be re-considered by the Ministry of Culture and Education. At the same time, funding will be reduced up to 200 million euros. Hence, for the research of students' metacognitive awareness, the field of vocational education is highly actual as the reform leads to a reduction in lessons, less direct teaching, and more responsibility shifted onto students' self-regulation and application of modern learning styles. For teachers, this means more of a supportive role, which in turn requires knowledge of cognition, regulation of cognition, and self-evaluation from the students themselves. Furthermore, metacognitive awareness is required in knowledge-intensive work and lifelong learning. Although the metacognition itself and self-regulation of learning have been highlighted in educational research and educational policy, the role of metacognitive awareness in vocational education is studied less.

Measures

Using self-report instruments can help learners to incorporate strategies that will improve their metacognitive awareness (Mokhtari & Sheorey, 2002). The students who are successful in their metacognitive self-assessment and, therefore, aware of their abilities, get through their studies better than those, who are unaware both strategically and in practice (Rivers, 2002; Schraw & Dennison 1994). Schellings, van Hout-Wolters, Veenman, and Meijer (2013) state that self-report questionnaires are not assessing metacognition and self-regulation widely enough. Veenman (2011) suggests using thinking-aloud measures, since students are not perhaps totally aware of the processes going on. Significantly, this lack of awareness may ultimately affect the verbalization of these processes in self-reports. Winne and Jamieson-Noel (2002) noted that the report itself does not necessarily specify exactly what students are doing while they are studying. However, according to Sperling, Howard, Miller, and Murphy (2002), self-report inventories as measures of metacognitive processing are perhaps, in some ways, the least problematic technique. In terms of their benefits, these inventories are easily administered and scored, which makes them useful large-scale assessment tools for determining which learners may need interventions in metacognition, strategy use, or superordinate self-regulation. Self-report inventories may also be helpful for use in theoretical research. For instance, research has demonstrated that both the knowledge and regulation components of metacognition can be measured via self-report inventories (Pereira-Laird & Deane, 1997; Schraw & Dennison, 1994).

In vocational education, students' metacognitive awareness has not been studied in more detail. Some elements of metacognition have been studied, though. According to Vermunt and Vermetten (2004) there has been a need for conceptualizations of student-learning components and to link metacognitive aspects of student learning. They used the Inventory of Learning Styles (ILS) for measuring components of learning, including metacognitive regulation strategies as one of the elements. They found four factors, one of which represents an application-directed learning pattern with high loadings of "concrete processing," "use of knowledge" as a conception of learning, and a "vocational learning orientation." Also, Slaats, Lodewijks and Van der Sanden (1999) studied the learning styles of students in secondary vocational education. They found two different learning patterns: reproduction-directed and meaning directed learning. The Metacognitive Awareness Inventory for Adults (MAI) developed by Schraw and Denisson (1994) is based on the theoretical structure of two main components: the knowledge of cognition and the regulation of cognition, which fit the theoretical framework of the present study. Hence, the MAI was chosen for this study. Earlier research reports indicate that the MAI produce structurally valid and internally congruent results as a whole. Furthermore, structurally valid and internally congruent results have been produced according to the division of the two main components. Earlier research reports (e.g., Pintrich, Wolters, & Baxter, 2000) indicate, however, that these components are quite close to each other.

The MAI is a 52-item self-report instrument of adolescent and adult metacognitive awareness. The questionnaire was set out to confirm the theoretical existence of two components: knowledge of cognition and regulation of cognition, which were quite close to each other. The final factor structure was best represented by dividing the factors into eight subcomponents: conditional knowledge, declarative knowledge, procedural knowledge, planning, monitoring, information management strategies, debugging strategies, and evaluation of learning, respectively. This structure was also confirmed by the results of Sperling et al. (2004).

The MAI has been denoted to have high internal consistency of the two factors, knowledge of cognition, and regulation of cognition. Internal consistency statistics range from r = .90-.95 (Dennison, 1997). It has firm predictive validity for self-monitoring and test performance in academic processes. Subsequent studies with the MAI have supported these findings (Hammann, 2005). It is considered a reliable initial test of metacognitive awareness (Schraw & Dennison, 1994, p. 472; Scott & Levy, 2013). In the Turkish version of the MAI, the internal consistencies of the instrument were .95 for the entire scale, and for the subscales .93-.98. (Akin, Abaci, & Çetin, 2007, p. 675). According to Young and Fry (2012), who studied the relationship between metacognitive awareness and academic achievement in college students, the results provide support for the validity of the MAI as it relates to academic measures. Zhang (2010) confirmed the reliability and validity of the MAI. The aim of the study was to investigate the predictability in metacognition when self-rated abilities were taken into account. Panaoura and Philippou (2003) used the idea of the MAI inventory in their study that was a part of a larger research on the development of young pupils' metacognitive ability in mathematics, where the original state of an instrument development and the examination of its construct validity was presented. The existence of a second-order structure representing metacognition was confirmed by a confirmatory factor analysis, as well as two basic first-order factors indicating knowledge of cognition and regulation of cognition.

Several researchers have used the MAI to study knowledge of cognition and regulation of cognition. Hammann and Stevens (1998) investigated the self-regulated learning of 90 college students. The component "knowledge of cognition" from the MAI was correlated with predictions of test performance, test scores, and online measures of exactness of responses. The "regulation of cognition" was related to intrinsic goals orientation and task value. The MAI has been used to study students' strategy use and understanding (Hartley, 2001; Lee, 2013; Mair, 2012), and to obtain scores for individual areas of metacognition (Coutinho, 2007). It has also been used as an instrument in studying academic achievement in college and for studying confidence in academic achievement (Amzil & Stine-Morrow, 2013). Moreover, the MAI has been used to discover how to support college students' self-monitoring and problem-solving skills (Kauffman, Ge, Xie, & Chen, 2008; Lee, Teo, & Bergin, 2009). Finally, Pang (2010) studied activity-based learning and metacognitive-based activities using the MAI.

Procedure of the Analysis

As the MAI was originally in English, it was translated into Finnish for this research project in a three-step procedure. At first, three researchers, all native Finnish speakers, made their own version of each item of both inventories, and then the versions were integrated together. Furthermore, the items were checked by a native Finnish-speaking lecturer. In the second step, the new Finnish questionnaire was translated back into English, once more, by an experienced translator in order to ensure that the concepts and phrases are translatable both from English into Finnish, and vice versa. The final version was concluded, once certain modifications based on the translator's and the native Finnish-speaking lecturer's suggestions were taken into account. The third step of the procedure was to test the inventory questionnaires by a pilot group of students ($n = 28$) in a vocational education institute. The respondents were asked to rate each item on a 1-to-5 response scale, where the numbers presented the following opinions: 1 "never"; 2 "seldom"; 3 "sometimes"; 4 "often"; and 5 "always". The students were presented with the research project similarly as when the main data was collected later. Moreover, the pilot group was asked to pay special attention to possible unfamiliar concepts or unclear statements. The students were asked to present their questions or notes instantly, or to write them onto the questionnaire form. There were no noticeable notes found when the questionnaire was pre-tested by the students.

The analysis was done in two steps. At first, the components were composed following the theoretical structure of the items. Moreover, the structure of the factors was confirmed with Confirmatory Factor Analysis and the reliability was analyzed by calculating Cronbach's Alphas. Secondly, the theoretical path model of the components was tested using Mplus Structural Equation Modelling software.

First Step: Composing the Components

In the beginning, we calculated the Pearson's correlations between the items within each sub-component. The items with non-significant correlations ($p > .05$) with other items within a sub-component were removed. In this way, the "knowledge of cognition" component consisted of 13 items and the "regulation of cognition" component consisted of 24 items (Appendix 1).

Next, the internal consistency of both components was explored to conclude the reliability by calculating Cronbach's (1951) alphas. As in the earlier studies using the MAI-scale, the internal consistency was found to be good for the entire questionnaire (α = .93), and for both of the components (Regulation of Cognition, α = .91 and Knowledge of Cognition, α = .81). To ensure that the matrix was suitable for the analysis using parametric methods, the descriptive statistics were calculated (Appendix 1). As both skewness and kurtosis had values between -1 to 1 revealing the normality of the items we continued on to further analysis.

The theoretical structure of the components was confirmed using confirmatory factor analysis. The analysis took place within regulation of cognition and knowledge of cognition, separately. Knowledge of cognition consisted of three factors: conditional knowledge, declarative knowledge and procedural knowledge. The fit of the model was acceptable/good (χ^2/df (59) = 2.16; CFI = .93; TLI = .91; RMSEA = .05; Probability <= .05 = .55; SRMR = .04). As in the original factor structure of the MAI, self-evaluation was analyzed within regulation of cognition. Hence, it consisted of five factors: planning, monitoring, information management, debugging, and self-evaluation. The analysis also confirmed the theoretical factor structure (χ^2/df (240) = 1.72; CFI = .92; TLI = .91; RMSEA = .04; Probability <= .05 = .99; SRMR = .05) All factor loadings of the items were statistically significant ($p < .001$). The confirmatory factor analyses revealed that the components were composed without difficulties.

Second Step: Structural Equation Modeling

Next, thus constituted, the components, based on the confirmed factor structures, were used in path analysis. To explore the fit of the measurement models and the path model in more detail, it is recommended that the models are analyzed separately (McDonald & Ho, 2002). Since the measurement models are analyzed above, the components were constituted as manifest variables for further analysis. However, the advantage of using a structural equation analysis compared to traditional analysis by regression or path modeling would have been that statistics could have been applied on latent variable structures (Kline, 2011; MacCallum & Austin, 2000).

In the methods of structural equation modeling, the fit of the model and the data can be verified with several indexes. Chi Square (χ^2) describes the difference between the theoretical and measured covariance matrix. The interpretation of the χ^2 value is ambiguous and depends on sample size. This was noticed in this study, as well, since the significance levels (*p* values) of the test remained low. Therefore, model fit needed to be assessed using other indexes as well (Hair, Black, Babin, & Anderson, 2010; West, Taylor & Wu, 2012; Ullman, 2001; McDonald & Ho, 2002). The Comparative Fit Index (CFI) and Tucker–Lewis Indexes (TLI) compare model fit with the independence model. In this study, the cut-off value of acceptable model fit for both CFI and TLI is .90 while .95 indicates good fit (Tucker & Lewis, 1973; Hu & Bentler, 1999; Hoyle, 1995; Bentler, 1990). Root Mean Square Error of Approximation (RMSEA) indicates model fit in comparison with the degree of freedom of the model (Steiger, 1990). A cut-off value of .05 indicates good fit of the model (Byrne, 2012; Hoe, 2008; Steiger, 2000). Standardized Root Mean Square Residual (SRMR) indicates the model fit by comparing the averages of standardized residuals of the observed and predicted covariance matrixes. A cut-off value of close to .08 indicates good model fit (Hu & Bentler, 1999). (See also Little, Lindenberger, & Nesselroade, 1999; West et al., 2012.)

Results

Knowledge of Cognition

At first, conditional knowledge was set as the predictor for self-evaluation. Moreover, declarative and procedural knowledge were set as interveners in a path. The fit indexes suggested rejecting the model ($\chi^2/df = 44.60$ $p < .001$, CFI = .87, TLI = .61, RMSEA = .28). Based on a high modification index (79.88), a path from conditional knowledge also to procedural knowledge was added into the model.

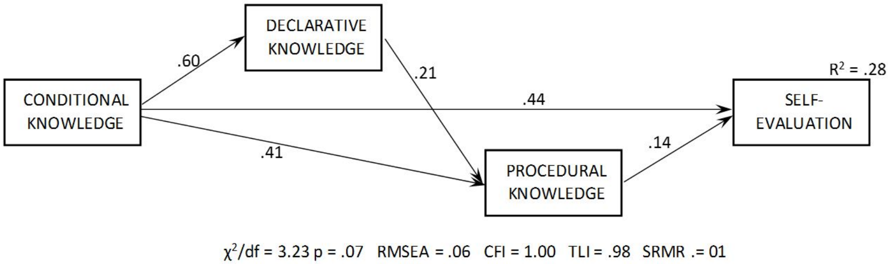

Figure 3. A model of the knowledge of cognition.

Conditional knowledge is the first predictor for self-evaluation. It predicts evaluation directly (r = .44) and via the interveners. Declarative knowledge does not predict self-evaluation directly but acts, rather, as an intervener. The fit indexes suggested rejecting the model, if the path from declarative knowledge to self-evaluation was not turned via procedural knowledge, but added straight to self-evaluation ($\chi^2/df = 24.33$, $p < .001$, RMSEA = .20, TLI = .79). Procedural knowledge acts as an intervener for both conditional knowledge and declarative knowledge. This final model is theoretically meaningful and fit the data. The model explained 28% of the variance of self-evaluation, and the fit indexes suggested good fit between the model and the data (Table 2).

Next, the fit of the model was tested within genders. The fit indexes revealed an excellent model fit for women, as Chi-square test and RMSEA-index suggested rejecting the model for men. However, all other indexes indicated a good fit for men, as well. To explore whether or not there were some differences between age-groups, especially within that of men, we composed the sub-sample of young students (those studying for their basic vocational degree are between 15 and 18 years old).

Table 1.
The fit indexes for a model of the knowledge of cognition.

	n	*χ^2/df (p)*	*CFI*	*TLI*	*RMSEA (Probability ≤ .05)*	*SRMR*	*R^2 (self-evaluation)*
All	578	3.23 (.07)	1.00	.98	.06 (.28)	.01	.28
Men	238	6.16 (.01)	1.00	1.02	.15 (.04)	.03	.23
Women	340	.13 (.72)	1.00	1.01	.01 (.81)	.01	.32
≥19yo.	157	.50 (.48)	1.00	1.03	.01 (.56)	.01	.22
≤ 18 yo.	421	2.51 (.11)	1.00	.98	.06 (.29)	.01	.29
Men ≤ 18yo.	189	7.87 (.01)	.97	.81	.19 (.02)	.04	.22
Men ≥19yo.	49	.50 (.48)	1.00	1.08	.01 (.51)	.02	.27
Women ≤ 18 yo.	232	.28 (.59)	1.00	1.01	.01 (.69)	.01	.35

Further analysis within young (≤ 18) and older (≥ 19) students, separately, revealed that the model fits better for older rather than younger students. The findings within men and young students encouraged us to analyze young men and young women separately. Finally, it was found that the fit of the model is good or even excellent, but not within the category of young men.

Regulation of Cognition

Following the theoretical background, the component of planning was set as the first predictor for self-evaluation while monitoring was set as an intervener. Moreover, the components of information management and debugging were set as interveners for both planning and monitoring. However, the fit indexes suggested rejecting the model (χ^2/df = 19.45, p < .001; TLI = .87; RMSEA = .18). Following a high modification index (33.39), the path from information management to debugging was added. The final model is supported by the theoretical background and has excellent fit indexes.

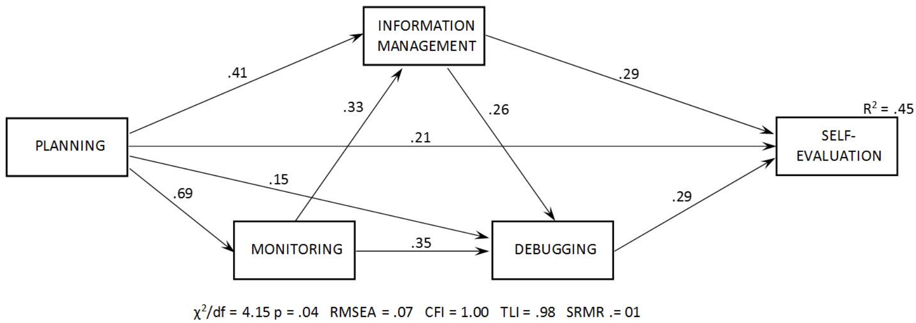

Figure 4. A model of the regulation of cognition.

Planning is the general predictor for the other components of the regulation of cognition; however, the direct effect to self-evaluation is relatively low (r = .21). Hence, the interveners play an important role in the model. With the intervening components, the model is able to explain as much as 45% of the variance of self-evaluation. The fit indexes suggested good fit between the model and the data (Table 3).

Again, the fit of the model was tested within genders. As the model of knowledge of cognition, the model of regulation of cognition fit excellently for women, but not for men. Once more, the model was tested within sub-samples of young and older students, separately.

Table 2.
The fit indexes for a model of the regulation of cognition.

	n	χ^2/df *(p)*	*CFI*	*TLI*	*RMSEA (Probability ≤ .05)*	*SRMR*	R^2 *(self-evaluation)*
All	578	4.15 (.04)	1.00	.98	.07 (.18)	.01	.45
Men	238	6.23 (.01)	.99	.90	.15 (.04)	.02	.43
Women	340	.51 (.47)	1.00	1.01	.01 (.63)	.01	.47
≥19yo.	157	.45 (.50)	1.00	1.02	.01 (.58)	.01	.42
≤ 18 yo.	421	4.44 (.04)	1.00	.97	.09 (.14)	.01	.46
Men ≤ 18yo.	189	9.66 (.01)	.98	.81	.19 (.02)	.03	.45
Men ≥19yo.	49	1.59 (.21)	.99	.94	.11 (.24)	.02	.33
Women ≤ 18 yo.	232	.04 (.85)	1.00	1.02	.01 (.89)	.01	.47

The same results, as we saw when testing the model of knowledge of cognition, were found: the fit of the model is good or even excellent, but not within the category of young men.

Discussion

The aim of the study was to explore the components of metacognitive awareness. A theoretical model, in which the components of knowledge of cognition and regulation of cognition predict self-evaluation, is presented and tested empirically among vocational education students (N= 578). The results revealed that students' metacognitive awareness can be measured using the MAI and modeled following the theoretical framework. Our hypothesis, in which we assumed that the self-evaluation acts as a reference component between knowledge and regulation of cognition, was confirmed. Both models (the path of knowledge of cognition and the path of regulation of cognition) fit the data. The main findings and conclusions are:

1. Self-evaluation is predicted by conditional knowledge, directly, and via declarative knowledge and, secondly, procedural knowledge. The path of the components indicates that the contents of learning and then the learning strategies are selected in order to achieve the learning goals described as conditional knowledge.

2. Planning is predicting the other components of regulation. Direct effect to self-evaluation is significant statistically, but relatively low; in consequence, the interveners are important components in the regulation process. This is logical, since one cannot evaluate learning once not implemented any.

3. Knowledge of cognition and regulation of cognition can refer to each other using self-evaluation as a reference component. Referring the paths reveal that planning is related to conditional knowledge, when setting the learning goals, on which the contents and strategies are based. Conditional knowledge, appointed by the learner for his / her own learning, and the planning of his / her own learning are directing the activities towards self-evaluation of one's own learning. In other words, by measuring planning or conditional knowledge we could predict other components of knowledge or regulation and, especially, self-evaluation.

The composed models fit in both genders and ages. However, the fit of the models are not as suitable among young men as in other observed groups. This is an issue for further study to explore more deeply. One possible explanation could lie in developmental psychology: cognitive abilities develop earlier among girls. According to Forsthuber, Horvath, and Motiejunaite (2009), all recent international assessment studies agree that girls tend to have a higher reading achievement than boys. The gender gap emerges early and maintained with age. Niemivirta found (2004, p. 45) that, among the students of the last class of the comprehensive school and of vocational educational, there were more girls than the expectation value predicted among the group of academic-orientated students. Moreover, there were fewer girls in the group of practice-orientated students. Among the students of the upper secondary school, women represent, to a large extent, the group of academic-orientated students. Secondly, young men might not be focused on the questionnaire. A third explanation might lie in the different study programs. The case might be that study programs differ on the way vocational subjects are taught and learned. For example, automotive technology and the building trade support more practical than academic skills. Moreover, the study programs are gender separated: most of the students in automotive technology are men, as most of the students in hairdressing and day-care work are women. Hence, this makes it difficult to point out how much a study program explains the difference. Also, it is unclear whether the gender explains differences in the selection of the training program, or is the training program an explanatory factor itself?

A number of studies have demonstrated the importance of teaching and learning metacognitive skills to enhance lifelong learning. It was found in this study, as well, that metacognitive awareness is required in order to regulate one's own learning, when aiming for success in learning outcomes in further studies and in employment. Teacher education could be improved to promote trainees' readiness in promoting learners' self-regulation. Supporting metacognitive awareness and self-regulative learning is a principal feature in lifelong learning. To achieve learning results, students should be able to regulate their learning within different subject areas, and not just to learn subject-specific skills or information. This kind of setting requires a change in the teachers' role. The key pedagogical element is to what extent the teacher is able to support students in improving their metacognitive awareness.

This study contributes to the existing body of research on students in vocational education. The study joins the discussion in developing new learner-centered culture in the area of more traditional pedagogical culture. The subjects in vocational education appear to be more practical than academic. Teaching certain predetermined contents or processes have been central for vocational education. Until now studies consisted of many contact lessons; however, nowadays the students' responsibility for their own learning is on the increase, once the number of lessons are reduced. In the future, when the reform of vocational education is carried out to its full extent, even the vocational degree must provide the wider skills for learning to learn. Highly relevant discussion in the field is whether and to what extent the students of practical subjects are able to regulate their learning independently.

The findings of this study show that the vocational students' knowledge and regulation of cognition follow the theoretical assumptions of metacognitive awareness. These results do not report the extent to which vocational students are aware of their metacognition, compared to, for example, more academically oriented students. But these results encourage an even more learner-centered culture, in which the students are expected to set goals for their own learning. The findings of this study extensively confirm that planning and knowledge of conditions predict success through the learning process.

References

Akin, A., Abaci, R., & Çetin, B. (2007). The validity and reliability of the Turkish version of the metacognitive awareness inventory. *Educational Sciences: Theory & Practice*, *7*(2), 671–678.

Amzil, A., & Stine-Morrow, E. A. (2013). Metacognition: Components and Relation to Academic Achievement in College. *Arab World English Journal*, *4*(4)

Balcikanli, C. (2011). Metacognitive Awareness inventory for teachers (MAIT). *Electronic Journal of Research in Educational Psychology*, *9*(25), 1309–1332. doi: 10.25115/ejrep.v9i25.1620

Bentler, P. (1990). Comparative fit index in structural models. *Psychological bulletin, 107*, 238–246.

Brown, A. (1987). Metacognition, executive control, Self-Regulation, and other more mysterious mechanisms. In F.E. Weinert & R.H. Kluwe (Eds.), *Metacognition, motivation, and understanding* (pp. 65–116). Hillsdale, NJ: Lawrence Erlbaum, Publishers.

Brown, A. L., Bransford, J. D., Ferrara, R. A., & Campione, J. C. (1983). Learning, remembering, and understanding. In P. H. Mussen (Ed.), *Handbook of child psychology* (4th edition) Vol.3 Cognitive development (pp. 77–166). New York: Wiley.

Brown, A. L. & DeLoache, J. S. (1983). Metacognitive skills. In M. Donaldson, R. Grieve & C. Pratt (Eds.), *Early childhood development and education*. Oxford: Blackwell.

Bryce, D., Whitebread, D., & Szűcs, D. (2015). The relationships among executive functions, metacognitive skills and educational achievement in 5 and 7 year-old children. *Metacognition Learning 10*, 181–198. doi: 10.1007/s11409-014-9120-4

Bråten, I. (2006). Vygotsky as a precursor to metacognitive theory: The concept of metacognition and its roots. *Scandinavian Journal of Educational Research* 35(3), 179–192. doi: 10.1080/0031383910350302

Byrne, B. (2012) *Structural Equation Modeling With Mplus. Basic Concepts, Applications, and Programming.* Routledge.

Coutinho, S. A. (2007). The relationship between goals, metacognition, and academic success. *Educate~*, *7*(1), 39–47.

Cronbach, L. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika, 16,* 297–334. doi:10.1007/BF02310555

Dennison, R. S. (1997). Relationships among measures of metacognitive monitoring. In *Proceedings of the annual meeting of the American Educational Association, Chicago, IL*.

Efklides, A. (2008). Metacognition: Defining its facets and levels of functioning in relation to self-regulation and co-regulation. *European Psychologist, 13*(4), 277–287. doi:10.1027/1016-9040.13.4.277

Flavell, J. H. (1976). Metacognitive aspects of problem solving. In L. B. Resnick (Ed.), *The nature of intelligence* (pp. 231–235). Hillsdale, NJ: Erlbaum.

Forsthuber, B., Horvath, A., & Motiejunaite, A. (2009). *Gender Differences in Educational Outcomes: Study on the Measures Taken and the Current Situation in Europe*. Education, Audiovisual and Culture Executive Agency (EACEA P9 Eurydice).

Garner, R., & Alexander, P. A. (1989). Metacognition: Answered and unanswered questions. *Educational psychologist*, *24*(2), 143–158. doi:10.1207/s15326985ep2402_2

Hair, J., Black, W., Babin, B., & Anderson, R. (2010). *Multivariate data analysis* (6th edition) Pearson Education, Upper Saddle River.

Hammann, L. (2005). Self-regulation in academic writing tasks. *International journal of teaching and learning in higher education*, *17*(1), 15–26.

Hammann, L. A., & Stevens, R. J. (1998). Metacognitive Awareness Assessment in Self-Regulated Learning and Performance Measures in an Introductory Educational Psychology Course. In *Proceedings of the annual meeting of the American Educational Research Association, San Diego, CA.*

Hartley, K. (2001). Learning strategies and hypermedia instruction. *Journal of Educational Multimedia and Hypermedia, 10*(3), 285–305.

Hoe, S. (2008). Issues and Procedures in Adapting Structural Equation Modeling Technique. Quantitative Methods Inquires, *Journal of Applied Quantitative Methods 3* (1), 76–83.

Hoyle, R. (1995). The structural equation modeling approach: Basic concepts and fundamental issues. In R. Hoyle (Ed.), *Structural Equation Modeling: Concepts, Issues, and Applications* (pp. 1–15). Thousand Oaks, Sage.

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives, *Structural Equation Modeling, 6* (1), 1–55. doi:10.1080/10705519909540118

Kauffman, D. F., Ge, X., Xie, K., & Chen, C. H. (2008). Prompting in web-based environments: Supporting self-monitoring and problem solving skills in college students. *Journal of Educational Computing Research*, *38*(2), 115–137. doi:10.2190/EC.38.2.a

Kline, R. (2011). *Principles and Practice of Structural Equation Modeling* (3rd edition). New York & London: The Guilford Press.

Kornell, N. (2014). If it is stored in my memory I will surely retrieve it: anatomy of a metacognitive belief. *Metacognition Learning, 10*, 279–292. doi:10.1007/s11409-014-9125-z

Lee, C. B. (2013). Examining intentional knowing among secondary school students: Through the lens of Metacognition. *The Asia-Pacific Education Researcher, 22*(1), 79–90. doi: 10.1007/s40299-012-0028-y

Lee, C. B., Teo, T., & Bergin, D. (2009). Children's use of Metacognition in solving everyday problems: An initial study from an Asian context.

The Australian Educational Researcher, *36*(3), 89-102. doi: 10.1007/BF03216907

Liebler, R. A. (2000). Assessing for Metacognition Competencies in an Adult Degree Completion Program. In K. Lee. (Ed.) *Access to Quality and Success: Applying Principles of Good Practice. AHEA 2000 Conference Proceedings*. Chicago, Illinois.

Little, T. D., Lindenberger, U., & Nesselroade, J. R. (1999). On Selecting Indicators for Multivariate Measurement and Modeling With Latent Variables: When “Good” Indicators Are Bad and “Bad” Indicators Are Good. *Psychological Methods, 4*(2), 192–211. doi: 10.1037/1082-989X.4.2.192

MacCallum, R., & Austin, J. (2000). Applications of Structural Equation Modeling in psychological research. *Annual Reviews of Psychology, 51*, 201–226. doi: 10.1146/annurev.psych.51.1.201

Mair, C. (2012). Helping Students Succeed through Using Reflective Practice to Enhance Metacognition and Create Realistic Predictions. *Psychology Teaching Review*, *18*(2), 42–46.

Marton F., & Booth S. (1997). *Learning and awareness*. Mahwah, New Jersey: Lawrence Erlbaum Associates, Publishers.

McDonald, R., & Ho, R. (2002). Principles and Practises in Reporting Structural Equation Analyses. *Psychological Methods, 7,* 64–82. doi: 10.1037/1082-989X.7.1.64

Ministry of Education and Culture. (2015). *Finnish VET in a nutshell*. Espoo: Grano Oy.

Mokhtari, K., & Sheorey, R. (2002). Measuring ESL students' awareness of reading strategies. *Journal of developmental education, 25*(3).

Mäkinen, J. (2003). *University students’ general study orientations. Theoretical background, measurements and practical implications*. Annales Universitatis Turkuensis B: 262. Turku: Painosalama Oy.

Niemivirta, M. (2004). Tyttöjen ja poikien väliset erot oppimismotivaatiossa. In T. Gordon, E. Lahelma, H. Lyytinen, M. Niemivirta, P. Scheinin & M. Siimes. *Koulu – sukupuoli – oppimistulokset*. Finnish National Board of Education.

Ormrod, J. E. (2004). *Human Learning* (pp. 401–424). Upper Saddle River, NJ: Pearson Education.

Panaoura, A., & Philippou, G. (2003). The Construct Validity of an Inventory for the Measurement of Young Pupils' Metacognitive Abilities in Mathematics. *International Group for the Psychology of Mathematics Education*, *3*, 437–444.
Pang, K. (2010). Creating stimulating learning and thinking using new models of activity-based learning and metacognitive-based activities. *Journal of College Teaching and Learning*, *7*(4), 29. doi: 10.19030/tlc.v7i4.112
Pereira-Laird, J. A., & Deane, F. P. (1997). Development and Validation of a Self-Report Measure of Reading Strategy Use. *Reading Psychology: An International Quarterly*, *18*(3), 185–235. doi: 10.1080/0270271970180301
Pintrich, P. R. (2004). A conceptual framework for assessing motivation and self-regulated learning in college students. *Educational psychology review*, *16*(4), 385–407. doi: 10.1007/s10648-004-0006-x
Pintrich, P. R., Wolters, C. A., & Baxter, G. P. (2000). 2. Assessing Metacognition and Self-Regulated Learning. In G. Schraw & J. C. Impara (Eds.), *Issues in the Measurement of Metacognition*. Lincoln, NE: Buros Institute of Mental Measurements.
Pressley, M., & Ghatala, E. S. (1990). Self-regulated learning: Monitoring learning from text. *Educational Psychologist*, *25*(1), 19–33. doi: 10.1207/s15326985ep2501_3
Rivers, W. P. (2002). Autonomy at All Costs: An Ethnography of Metacognitive Self-Assessment and Self-Management among Experienced Language Learners. *The modern language journal*, *85*(2), 279–290. doi: 10.1111/0026-7902.00109
Schellings, G. L., van Hout-Wolters, B. H., Veenman, M. V., & Meijer, J. (2013). Assessing metacognitive activities: the in-depth comparison of a task-specific questionnaire with think-aloud protocols. *European journal of psychology of education*, *28*(3), 963–990. doi: 10.1007/s10212-012-0149-y
Schraw, G., & Dennison, R. S. (1994). Assessing Metacognitive Awareness, *Contemporary Educational Psychology, 19,* 460–475. doi: 10.1006/ceps.

Schraw, G., Crippen, K. J., & Hartley, K. (2006). Promoting self-regulation in science education: Metacognition as part of a broader perspective on learning. *Research in science education*, *36*(1–2), 111–139. doi: 10.1007/s11165-005-3917-8

Scott, B. M., & Levy, M. G. (2013). Metacognition: Examining the components of a fuzzy concept. *Educational Research eJournal*, *2*(2), 120–131. doi: 10.5838/erej.2013.22.04.

Slaats, A., Lodewijks, H., and Van der Sanden, J. (1999). Learning styles in secondary vocational education: disciplinary differences. *Learn. Instr. 9*, 475–492. doi: 10.1016/S0959-4752(99)00007-9

Sperling, R.A., Howard, B.C., Miller, L.A. & Murphy, C. (2002). Measures of Children's Knowledge and Regulation of Cognition. *Contemporary Educational Psychology 27*, 51–79. doi: 10.1006/ceps.2001.1091

Sperling, R. A., Howard, B. C., Staley, R., & DuBois, N. (2004). Metacognition and Self-Regulated Learning constructs. *Educational Research and Evaluation*, *10*(2), 117–139. doi: 10.1076/edre.10.2.117.27905

Steiger, J. (1990). Structural model assessment and modification: An interval estimation approach. *Multivariate Behaviour Research, 25*, 173–180. doi: 10.5539/jel.v6n4p78

Steiger, J. (2000). Point estimation, hypothesis testing, and interval estimation using the RMSEA: Some comments and a reply to Hayduk and Glaser. *Structural Equation Modeling, 7*(2), 149–162. doi: 10.1207/S15328007SEM0702_1

Tucker, L. & Lewis, C. (1973). A reliability coefficient for maximum likelihood factor analysis. *Psychometrika, 38*, 1–10. doi: 10.1007/BF02291170

Ullman, J. (2001). Structural Equation Modeling. In B. Tabachnik & L. Fidell (Eds.), *Using Multivariate Statistics* (4th edition, pp. 653–771) Needham Heights: Allyn & Bacon.

Veenman, M. V. J., Van Hout-Wolters, B. H., & Afflerbach, P. (2006). Metacognition and learning: Conceptual and methodological considerations. *Metacognition and learning*, *1*(1), 3–14.

Veenman, M. V. J., Wilhelm, P., & Beishuizen, J. J. (2004). The relation between intellectual and metacognitive skills from a developmental perspective. *Learning and Instruction, 14,* 89–109. doi: 10.1016/j.learninstruc.2003.10.004

Veenman, M. V. J., Prins , F. J. & Elshout. J. J. (2002). Initial inductive learning in a complex computer simulated environment: the role of metacognitive skills and intellectual ability. *Computers in Human Behavior, 18*, 327–341. doi: 10.1016/S0747-5632(01)00038-3

Vermetten, Y. J., Vermunt, J. D., & Lodewijks, H. G. (1999). A longitudinal perspective on learning strategies in higher education-different view-points towards development. *British Journal of Educational Psychology*, *69*(2), 221–242. doi: 10.1348/000709999157699

Vermunt, J.D. (1996). Metacognitive, cognitive and affective aspects of learning styles and strategies: a phenomenographic analysis. *Higher Education, 31*, 25–50. doi: 10.1007/BF00129106

Vermunt, J.D., & Verloop, N. (1999). Congruence and friction between learning and teaching. *Learning and Instruction, 9*, 257–264. doi: 10.1016/S0959-4752(98)00028-0

Vermunt, J. D., & Vermetten, Y. J. (2004). Patterns in student learning: Relationships between earning strategies, conceptions of learning, and learning orientations. *Educational psychology review*, *16*(4), 359–384.

von Wright, J. (1992). Reflections on reflection. *Learning and Instruction, 2*, 59–68. doi: 10.1016/0959-4752(92)90005-7

West, S., Taylor, A. & Wu, W. (2012). Model Fit and Model Selection in Structural Equation Modeling, In R. Hoyle (Ed.), *Handbook of Structural Equation Modeling* (pp. 209–231). The Guilford Press.

Winne, P. H., & Jamieson-Noel, D. (2002). Exploring students' calibration of self reports about study tactics and achievement. *Contemporary Educational Psychology*, *27*(4), 551–572. doi: 10.1016/S0361-476X(02)00006-1

Young, A., & Fry, J. (2012). Metacognitive awareness and academic achievement in college students. *Journal of the Scholarship of Teaching and Learning*, *8*(2), 1–10. doi: 10.1016/j.sbspro.2015.01.707

Zhang, L. F. (2010). Do thinking styles contribute to metacognition beyond self-rated abilities? *Educational Psychology*, *30*(4), 481–494. doi: 10.1080/01443411003659986

Appendix 1. The descriptive statistics of the items and sub-components.

KNOWLEDGE OF COGNITION

	n	*χ^2/df (p)*	*CFI*	*TLI*	*RMSEA (Probability <= .05)*	*SRMR*	*R^2 (self-evaluation)*
All	578	3.23 (.07)	1.00	.98	.06 (.28)	.01	.28
Men	238	6.16 (.01)	1.00	1.02	.15 (.04)	.03	.23
Women	340	.13 (.72)	1.00	1.01	.01 (.81)	.01	.32
>18 yo.	157	.50 (.48)	1.00	1.03	.01 (.56)	.01	.22
<= 18 yo.	421	2.51 (.11)	1.00	.98	.06 (.29)	.01	.29
Men <= 18 yo.	189	7.87 (.01)	.97	.81	.19 (.02)	.04	.22
Men > 18 yo.	49	.50 (.48)	1.00	1.08	.01 (.51)	.02	.27
Women <= 18 yo.	232	.28 (.59)	1.00	1.01	.01 (.69)	.01	.35

REGULATION OF COGNITION

	n	*χ^2/df (p)*	*CFI*	*TLI*	*RMSEA (Probability <= .05)*	*SRMR*	*R^2 (self-evaluation)*
All	578	4.15 (.04)	1.00	.98	.07 (.18)	.01	.45
Men	238	6.23 (.01)	.99	.90	.15 (.04)	.02	.43
Women	340	.51 (.47)	1.00	1.01	.01 (.63)	.01	.47
>18 yo.	157	.45 (.50)	1.00	1.02	.01 (.58)	.01	.42
<= 18 yo.	421	4.44 (.04)	1.00	.97	.09 (.14)	.01	.46
Men <= 18 yo.	189	9.66 (.01)	.98	.81	.19 (.02)	.03	.45
Men > 18 yo.	49	1.59 (.21)	.99	.94	.11 (.24)	.02	.33
Women <= 18 yo.	232	.04 (.85)	1.00	1.02	.01 (.89)	.01	.47

Heli Kallio, MEd, is lecturer in the Faculty of Educational Sciences, University of Turku.

Kalle Virta, PhD, is senior lecturer at the Faculty of Educational Sciences, University of Turku.

Manne Kallio, PhD, is senior lecturer at the Faculty of Educational Sciences in the University of Helsinki.

Contact Address: Heli Kallio, University of Turku, Seminaarinkatu 1, 26100 Rauma Finland. Email: heli.kallio@utu.fi