Is Metacognition a Single Variable?

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Abstract

The paper reports some of the findings of the study that has been conducted to see nature of metacognition. It was survey study. Schraw & Dennison (1994) metacognitve awareness inventory was used in the study as instrument. The instrument was administered on students of grade X. The age group of the students ranges between 15-16 years. The data analysis indicated that metacognition is not a single variable but is highly multivariate. This approach was considered as factor analysis of the response patterns of the students which showed no underlying structure at all. This undermines the claims of the original authors of the inventory but, more importantly, suggests that metacognition is not a single variable or even the eight variables that were derived from the original survey. The study recommended that there is a need to explore the nature of metacognition through further research.

Key words: Metacognition, Measurement of Metacognitive awareness, Metacognitive inventory

Introduction

Metacognition has been defined as "thinking about thinking" and is a complex form of higher-order thinking. Metacognition involves the ability to think about own cognitions, and to know how to analyze, to draw conclusions, to learn from, and to put into practice what has been learned (King, 1999). Metacognition was originally referred to as the knowledge about and regulation of one's cognitive activities. Under this inclusive definition, a series of metacognitive terms have been presented through the years. These have included: metacognitive beliefs, metacognitive awareness, metacognitive experiences, metacognitive knowledge, feeling of knowing, judgment of learning, theory of mind, meta-memory, metacognitive skills, executive skills, higher-order skills, meta-components, comprehension monitoring, meta-learning, learning strategies, heuristic strategies, and self-regulation. Indeed, there are far too many terms commonly associated with metacognition, leaving the whole area somewhat confused (King, 1999).

Metacognition has been defined in many ways and encompasses various dimensions. That is why metacognition has been considered as a fuzzy concept (Flavell, 1981, p37; Wellmann ,1981 as cited by Brown, 1987, p. 106) as it is related to different disciplines (cognitive psychology, developmental psychology, philosophy of mind), and thus has been examined for various purposes from various standpoints. These viewpoints are discussed in below paragraphs: Hudgins, Phye, Schau, Theisen & Ames (1983, pp. 68-73) described that metacognition is a cognitive skill which involves not only memory monitoring but also the monitoring of comprehension, problem solving and other cognitive skills. Howard, McGee, Shia & Hong (2000) found that metacognitive awareness and regulatory skills comprised of five independent factors: knowledge of cognition, objectivity, problem representation, sub-task monitoring and evaluation.

Many researchers stress that metacognition is best defined by recognizing that it is both knowledge about, and control over, thinking processes (Allen & Armour-Thomas, 1991). Vadhan and Stander (1993) clearly distinguish between ordinary thinking and awareness and understanding of thinking. However, Hacker (1998) divided metacognition into metacognitive knowledge, metacognitive skill and metacognitive experience. Nelson (1992) on the other hand, divided metacognition into two broad categories: knowledge of cognition and regulation of knowledge. Collin (1994) described metacognition as thinking about thinking. Pressley (1995, p .27) on other hand, defines metacognition as, "it is knowledge of thinking processes, both knowledge of the thinking occurring in the here and now." Child (1995, p.136) defined metacognition as, "*The concept of a person self consciously examining his/her mental processes, becoming aware of problems and adjusting accordingly in order to improve effectiveness."* While Shimamura (2000) referring it to, "*evaluation and control of one's cognitive processes. In this way, metacognition often suggests conscious control of thoughts, memories, and actions*." Luca & McMahon (2004) stated that, "*metacognition is widely considered integral to effective learning. However environments that support metacognition can be difficult to develop."*

Darling-Hammond *et al* (1998) identified two aspects of metacognition: reflection and self-regulation. Hunt and Ellis (2004, pp. 234-235) described that 'Meta' can refer to any aspect of cognition, such as meta-language (cognition about language) and meta- comprehension (cognition about comprehension). They described three aspects of metacognition: knowledge, monitoring and control. Similarly, Ashman & Conway (1997, pp. 51-52) described a model of metacognition given by Borkowski (1989). The model consisted of three strategy components: general strategy knowledge (awareness of the importance of being strategic); specific strategy knowledge (organization, verbal elaboration); and relational strategy knowledge (based on shared properties). Similar to Flavell, Paris & Parecki (1993) divided metacognition into self-appraisal and self-management. Peters (2000) defined metacognition as quoted by Imel (2002, p.1): "*It refers to the ability of the learners to be aware of and monitor their learning processes.*" Hartman (2001) underlined the following points of metacognition**:**

(a) Metacognition is thinking about thinking.
(b) It enables awareness and control over how teachers think about teaching.
(c) It enables them to self-regulate teaching activities with respect to students, goals and situation.
(d) Some metacognition is domain-specific and some is domain-general
(e) Two general types of metacognition are: executive management strategies that help to plan, monitor and evaluate/revise thinking processes and products, and strategic knowledge about information/strategies/ skills you have, when, why and how to use them.

On the other hand, Anderson's (2001) model of metacognition consists of four aspects:

(a) Preparing and planning for effective learning
(b) Evaluating strategy use and learning various strategies
(c) Monitoring strategy use
(d) Selecting and using particular strategies

It is evident that different fields and researchers have defined metacognition differently. Metacognition is the study of memory-monitoring and self-regulation, meta-reasoning, awareness and auto-consciousness. These capacities are used to regulate own cognition, to maximize thinking process and to evaluate ethical/moral rules. Although metacognition has been a part of discussion of educational psychologists for more than twenty years, but a clear definition of metacognition, is still not agreed upon. However, researchers agreed to divide it into two constructs: metacognitive knowledge and metacognitive control and regulation.

Research of Metacognition

Research on metacognition started in the early 1960s. Two renowned psychologists, Hart (1965) and Flavell (1979), have presented two parallel theories. To some extent, these two approaches have remained largely separate. Recently, however, attempts were made to bring these two tracks in metacognition closer together. Each track has something to add to the advancement toward an applied metacognition (Timothy; Bennett & Schwartz, (2002). Hart (1965, 1967) was interested in the accuracy of judgments people made about memory. Hart assumed that adults have conscious experiences such as "*feelings of knowing*". What was important to discover was whether they were valid predictors of behavior? He devised a paradigm, dubbed the RJR procedure, to test meta-memory judgments. Firstly, he gave people a recall test (R) related to newly learned information. If the participant was unsuccessful at recall, the participant was asked to make a feeling-of-knowing judgment (J), predicting the answer would be recognized in a multiple-choice format. In Hart's (1965) first study, participants simply indicated yes – they had a feeling of knowing – or no – they did not. In the second experiment, Hart (1965) used a six-point scale for feeling of knowing with points 1–3 corresponding to feeling of knowing, and 4–6 corresponding to feeling of not knowing (Timothy, Bennett & Schwartz, 2002).

Subsequent studies introduced more conventional Likert-scale measurements (Nelson, 1988). Finally, the participant received the recognition test (R). Hart (1965) showed that feeling-of-knowing judgments indeed predicted the likelihood of correct recognition for general knowledge materials; an observation replicated many times (Nelson, 1988; Schwartz, 1994). Hart (1967) later extended this technique to episodic memory. The RJR technique mostly lay dormant until the 1980s when it was revised by Thomas Nelson and his colleagues (Timothy, Bennett & Schwartz, 2002). On the other hand, develop-mentalists were also interested in metacognition but chose a different way of investigation. Flavell (1979) was interested in finding out if the improvement in children's memory abilities was a function of greater conscious understanding of the rules that govern memory and cognition (Timothy, Bennett & Schwartz, 2002). Thus, his studies trace the development of metacognitive thinking. Unfortunately, not yet fully armed with the ideas of monitoring and control (Nelson and Narens, 1990), Flavell's research agenda did not show any strong correlations between metacognitive thinking and improvements in memory.

Nonetheless, Flavell's approach has had a strong influence on the development of meta-memory in a number of domains (Timothy; Bennett & Schwartz, 2002). In recent years, there has been a union of the two "schools" of metacognition. Developmentalists have begun to use the tools developed by Hart, Nelson, and others to investigate the questions that Flavell originally tried to answer. This interaction has led to new understanding of how metacognition develops in children (Timothy; Bennett & Schwartz, 2002). Metacognition received a major support from "everyday memory" movement (e.g. Neisser, 1978). Early pioneers in the everyday memory movement studied meta-memory phenomena, particularly the feeling of knowing. Since 2002, metacognition has emerged as an important sub-field of cognitive psychology. Emergence of metacognition into the mainstream reflects the greater focus of cognitive psychologists on the experiential aspects of memory (Tulving, 1985 as quoted by Timothy, Bennett & Schwartz, 2002).

Now a new category of metacognitive research has appeared which advocated not only theoretical aspects of metacognition but it equally focuses on its educational application. Researchers moved their interest from the theoretical to the practical, from the laboratory to the classroom. For example, Borkowski and Muthukrishna (1992) stated that, "*metacognitive theory has considerable potential for aiding teachers as they try to create classroom environments that focus on strategic learning that is both flexible and creative*".

It may be summed that the development of new approach in research on metacognition highlighted its importance in the educational process. However, the researches indicated that measurement of metacognition is not an easy task as mentioned in the following discussion:

Measurement of Metacognition

One of the basic problems of the study in the field of metacognition is to develop and use valid tasks for measuring metacognitive ability. Although several methods of measuring metacognition are used, however each method has advantages and limitations. For example, one of a very popular approach for assessing both metacognitive knowledge and control is to ask students directly about what they learn (Panaoura, 2004). Various problems were identified with the measurement of metacognition. Today, the methods for measuring metacognition still have some serious problems of reliability and validity. Referring to the measurement problem and solutions, Schraw and colleagues (2000, pp.297-322) suggested to:

i. Take observations of metacognitive abilities, to obtain information about strategies, metacognition and motivation in academic tasks.
ii. Select proper cognitive tasks for emergence of metacognitive abilities. Use an instrument that measures metacognition with psychometric properties on various populations.
iii. Use a variety of qualitative and quantitative methods with each student.

According to Collins et al (2004) the commonly used measures include self-talk, self-report, and questionnaires. However, these measures often lack reliability (Brown, 1987) and therefore complicate interpretation of findings. Similarly questionnaires also have limitations. When answering questionnaires about imaginary problem-solving situations, readers may fail to show it in real problem-solving situations relevant (Whitehead, cited in Palincsar & Brown, 1989).

The questions used to elicit self-talk, self-reports, and questionnaires also have measurement inconsistencies. General questions are slightly explained responses closely linked to the cognitive processes (Ericsson & Simon, cited in Brown, 1987). Therefore to provide valid information, questions should be specific to the task. For example, more valid information can be obtained by presenting students with actual passages containing main ideas and asking them to identify main ideas. Interactions between context and a student's previous training also confuse the measurement of metacognition. Individuals do not show the same metacognitive skill in every situation (Meltzer, 1993). Performance on metacognitive tools depends upon the complexity of the task and may be greatly influenced by a student's prior experience with the task and familiarity with the task (Torgesen, 1994). It is therefore important to look into measures, tasks, and familiarity of information before making research conclusions. Van Zile Tamsen (1996) discussed the following assessment issues in the measurement of metacognition:

i. Behavioral rules are seldom useful as metacognitive activity occurs in the mind and may not involve observable behavior.

ii. Self report inventories are used to measure metacognitive activity (e.g; Pintrich, Smith, Garcia; & Mc Keachie, 1991), although such inventories are easy to administer and analyze; they are limited in a number of ways:

a. Students may support items they understand to be desirable, regardless of whether they actually engage in the cognitive activity.
b. Different students may interpret the items differently, making comparison difficult.

c. Students may engage in metacognitive activities other than reported in the inventory; therefore the understanding of metacognitive processes is limited to activities represented on the inventory.

iii. Interviews and verbal reports are more popular methods of assessing metacognitive activity. Although such assessment tools overcome the difficulties presented by the inventory, there is still the concern that participants may not be aware of their mental processing, and/or may not be able to express these processes to the researcher. In addition, expression may impede with the processing.

In summary, the points of difference in definition, theory, and measurement with respect to metacognition research suggest care in interpreting findings of the study. New fields of research study such as metacognition also hold great opportunity for misinterpretation and over generalization. Therefore, components and measures of metacognitive studies require close analysis before making conclusions regarding implications for different people.

Method of the Study

It was survey study. Two hundred students of grade X participated in the study. The age group of the students ranges between 15-16 years. Male and female students equally participated in the sample. Schraw and Dennison (1994) Inventory was used as instrument in the study because it is claimed to be a reliable and valid instrument. The inventory represents two factors of metacognition, i.e. knowledge of cognition and regulation of cognition. Knowledge of cognition or metacognitive knowledge refers to knowledge about yourself and about learning strategies as well as knowledge about when, why and how to use these strategies. Within the knowledge component were statements of declarative knowledge (knowledge about self and strategies), procedural knowledge (knowledge about strategy use), and conditional knowledge (when and why to use strategies).

The regulation of cognition refers to the control aspect of learning such as planning (goal setting), management strategies (organizing), comprehension monitoring, debugging strategies and evaluation (analysis of performance and strategy effectiveness). The inventory consisted of 52 items representing these components. First in a meeting with school science teachers, the objectives of the study and application procedure was discussed. The directions were administered in oral format by the researcher. The researcher personally administered the instrument to the students. Before giving instruments, a brief introduction about the research was provided to the respondents. The respondents were asked to read the statements carefully and indicate their response by tick marking the appropriate box. They were told that there are no right and wrong answers to the statement in the inventory. They were further asked to rate themselves on use of metacognition as accurately and honestly as they could. Average completion time for the inventory was fifteen minutes.

Data Analysis

The traditional way in psychology to assess attitudes often involves the gathering of a very large number of questions, pre-testing them in various ways and selecting a few for which there is clear evidence that they are measuring the same underlying variable. The problem is that attitudes are usually very multi-variable in nature, a point noted by Gardner (1995, 1996). It is assumed that, if inter-item correlations are reasonably high, then the questions are measuring similar things. However, inter-question correlation can be very misleading in this regard as correlation does not guarantee this at all. First of all, there is a need with the 52 questions in this survey to explore whether they are measuring one variable or, indeed, the eight variables as suggested. This is easily checked using factor analysis by loading each question separately. Factor analysis looks at the patterns of correlations between measurements and explores whether there are any underlying factors which can explain these patterns. Factor analysis cannot say what the underlying factors are. It can only identify their presence and their number.

SPSS was used and principal components analysis using varimax rotation was applied. In this, the factors are known as ‘components’. The statistical analysis seeks to impose a set of multi-dimensional coordinate axes onto the data in order to minimize and maximize the angles between the measurements made by each of the 52 questions with the axes. The cosine of the angle is shown as a loading and this can be seen as the correlation coefficient between the component and what the question is measuring. Because this works in hyperspace, it is impossible to draw but Reid (2006) offers some background to the nature of correlation. More details about factor analysis were given in the table 1. For data for the sample (N=200) were analyzed using the principal components method of factor analysis. Using varimax rotation, 19 factors were found with Eigen values above 1 and these accounted for 70% of the variance. However, the inventory should have come up with 8 factors. A factor analysis was re-run, setting the number of factors as eight. This only accounted for 42% of the variance, which is far too low.

The loadings are shown in annexure. Ideally, loadings should be very high or very low. If there is an underlying structure, then every question should load onto at least one factor very strongly (with a high loading). In this study, only loadings above 0.6 are shown. This is not a very strict condition at all in that the angle between what the question is measuring and what the factor (or component) is still large (the angle whose cosine is 0.6 is about 53˚). Even with this non-rigorous limit, there is no clear pattern in the loadings and many questions simply do not load at all. Table 1 show the loadings of the whole set of questions on to the eight components. Each component represents one underlying factor which accounts for the correlation pattern. It can be seen that many questions do not load onto any of the components. What should have happened is that all the questions in one area will load highly onto one component and not onto any other component.

In fact, the loadings do ***not*** relate in any way to the supposed eight areas in the original survey. In the eight (evaluation), there is some consistency of loading for 2, 3 and 4 questions.Thus, the outcomes from the principal components analysis do not support the coherency of the eight groups in any way, other than the evaluation group of questions. Thus, there is no underlying structure at all as indicated in the Table. However, the average age of the students was about 15-16 year and, at this age, they are much less accurately self-aware, often seeing themselves as they would like to be rather than as they really are. Clearly, the lower level of accurate self-awareness of students has made the data less precise (see Hindal, 2007).

Conclusion

It may be concluded that there is no underlying structure at all. Indeed, the eight component analyses give inconsistent results, suggesting that students may be responding in a way which sees the questions differently; although part of the difference might be explain by the fact that some of the questions are different.
In the original study (Schraw & Dennison, 1994), it was proposed that there were eight areas:

(1) Procedural knowledge PK
(2) Declarative knowledge DK
(3) Conditional knowledge CK
(4) Planning PL
(5) Management strategies MS
(6) Comprehension monitoring CM
(7) Debugging Strategies DS
(8) Evaluation EV

If this was, indeed, the correct underlying structure of variables being tested, then the factor analyses would have come up with eight factors, accounting for at least 70% of the variance and every question would have loaded strongly (preferably much better than 0.6) with one factor. It is now absolutely clear that the allocation of the questions to these eight areas is not supported. It is more likely that each of these supposed areas is, in fact, multi-dimensional. This casts serious doubt on the procedure commonly used where responses to the questions are coded and added. It is not valid to add things which are NOT the same. The only legitimate way to move forward is to analyze each question on its own.

Discussion

The present study has explored to examine the nature of metacognition. The study used Schraw & Dennison, (1994) metacognitve inventory for this purpose. In the data analysis, the assumption that all the 52 questions were measuring one latent construct was challenged on the basis of evidence from factor analysis and each question was then analyzed separately. The data analysis indicated that metacognition is not a single variable but is highly multivariate. This approach was considered as factor analysis of the response patterns of the students which showed no underlying structure at all. This undermines the claims of the original authors of the inventory but, more importantly, suggests that metacognition is not a single variable or even the eight variables which were derived from the original survey.

This study has revealed the very complex nature of metacognition. The literature has often presented metacognition in overly precise terms and this study offers a welcome antidote to such spurious simplicity. It is difficult to argue that metacognition is a key element in generating greater student success. However, it is obvious that thinking about thinking is a useful skill in its own right and its development as an integral part of the whole process of learning may be very important. This study has offered some insights, guidelines and caveats for that future research. Perhaps the most important finding is that metacognition is not a single variable nor even a simply collation of a small number of variables. There is a need to explore the nature of metacognition much further. Using factor analysis and a re-designed survey, the aim would be to examine the nature of metacognition much further and to seek to describe operationally any key factors within the concept.

References

Anderson, M; & Oates, T. (2005). *Metacognition in computation.* A paper presented at 2005 AAAI spring symposium.USA:

Anderson, N. J. (2002). *The role of metacognition in second language teaching and learning*. ERIC digest No ED463659. Retrieved on July 25,2006 from www.eric.ed.gov

Ashman, A.F & Conway, R.N.F. (1997). *An introduction to cognitive education. Theory and application.* London: Rutledge.

Brown, A. (1987). *Metacognition, executive control, self regulation and other more mysterious mechanisms.* In F. weinert & R. Kluwe (Eds) Metacognition, Motivation and Understanding. Hillsdale, NY: Erlbaum.

Collins, N. (1994). *Metacognition and reading to learn*. ERIC Digest No ED376427. Retrieved on September 24, 2006, from http://128.104.40.21//step/kw/TheoreticalPerspectives/CognitiveTheory/Metacognition

Child, D. (1995). *Psychology and the teacher*. (5th ed). New York: Holt, Rinehart & Winston.

Collins, V. L: Dickson, S,V; Simmons, D. C; & Kameenui, E. J. (2004). *Metacognition and its relation to reading comprehension: A synthesis of the research.* USA: US office of special education program. Retrieved on December 19,2006 from http://www.metacogsyn.html

Darling-Hammond, L; Austin, K; Cheung, M; & Martin, D. (2003*). Thinking about thinking: metacognition.* Stanford University School of Education.Stanford:

Flavell, J. H; Miller, P. H; & Miller, S. A. (1993). *Cognitive development*.(3rd ed). Englewood cliffs, NJ: Prentice hall.

Gardner, P. L. (1995) Measuring attitudes to science: unidimensionality and internal consistency revisited, *Research in Science Education,* 25(3), 283–289.

Gardner, P. L. (1996) The dimensionality of attitude scales, *International Journal of Science Educatiion,* 18(8), 913–919.

Hacker, D. J. (1998). *Definitions and empirical foundation*. In D. Hacker; J. Dunlosky; & A. Graesser (Eds). Metacognition in Educational Theory and Practice. Mahwah, NY: Erlbaum.

Hartman, H. E. (2001). *Metacognition in learning and instruction: Theory, research and practice.* Netherland: Kluwer Academic.

Howard, B. C; Mc Gee, S; Shia, R & Hong, N. S.(April 2000). *Metacognitive self regulation and problem solving: Expanding the theory base through factor analysis.* Paper presented at the annual meeting of the American Research Association, New Orleans; LA:

Hudgins, B. B; Phye, G. D; Schau, C. G; Theisen,G.L; Ames, C; & Ames, R. (1983). *Educational psychology*. Illinois: F.E. Peacock.

Hunt, R. R.& Ellis, H. C. (2004). *Fundamentals of cognitive psychology.* (7th ed). New York: Steve Rutter.

Imel, S. (2002). *Metacognitive skills for adult learning*. In Trends and Issues Alert No 39.US: ERIC Document.Retrieved on March 13,2006 from www.eric.edu.com

King, K. (1999). *Metacognition in the composition classroom*. Idaho State University. Idaho:

Luca, J. & McMahon, M. (2004). *Promoting metacognition through negotiated assessment.* In R. Atkinson, C. McBeath, D. Jonas-Dwyer & R. Phillips (Eds), Beyond the Comfort Zone: Proceedings of the 21st ASCILITE Conference (pp. 562-570). Perth, 5-8 December,2004.

Nelson, T.O & Narens, L (1992). *Meta-memory: A theoretical framework and new findings.* New York: Academic.

Palinesar, A.S; & Brown, A. L. (1989). *Instruction for self regulated reading*. In L. B. Resnick and L.E; Klopfer, (Eds); Towards the Thinking Curriculum: Current Cognitive Research. Alexandria, V. A: Association For Supervision And Curriculum Development Yearbook.

Panaoura, A. (2004). *Young pupils' metacognitive ability in maths*. (Master's thesis, Department of Education, University of Cyprus). Cyprus:

Pressley, M & Mc Cormick, C. (1995). *Advanced educational psychology for educator, researchers and policymakers.* New York: Harper Collins.

Reid,N. (2006). Thoughts on attitude measurement. In Research in science & Technological education , Vol 24, No 1 , pp.3-27.

Schraw, G. (2000). *Assessing metacognition: Implivstiond of the boros symposium.* In G. Schraw and J. Impara (Eds). Issues in the Measurement of Metacognition. Lincoln, NB: University of Nebraska Press.

Schraw, G; & Dennison, R. (1994). *Assessing metacognitive awareness. Contemporary Educational Psychology.19(4)*(pp460-475)

Shimamura, A. P. (2000). *Toward a cognitive neuroscience of metacognition.* University of California. Available on line at http://www.ideallibrary.com Retrieved on October 17, 2006.

Timothy, J; Bennett, P & Schwartz, L (2002). *Applied metacognition.* Cambridge: Cambridge University Press.

Van Zile-Tamsen, C.M.(1996). *Metacognitive self regulation and the daily academic activities of college students.* (Unpublished doctoral dissertation, State University of New York). Buffalo:

Table 1Factor Loadings of Students' Metacognitve Inventory

	Components							
N = 200	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***
DK1								
DK2								
DK3	.601							
DK4								
DK5								
DK6								
DK7								.685
DK8								
PK1								
PK2								
PK3								
PK4								
CK1								
CK2								
CK3								
CK4								
CK5								
P1								
P2						.875		
P3				.829				
P4								
P5								
P6						.875		
P7				.829				
IMS1								
IMS2								
IMS3								
IMS4								
IMS5								
IMS6								
IMS7								
IMS8								
IMS9								
IMS10								
DS1								
DS2								
DS3								
DS4								
DS5							.640	
CM1								
CM2			.681					
CM3			.763					
CM4							.627	
CM5							.703	
CM6			.814					
CM7							.608	
E1								
E2		.668						
E3		.663						
E4		.607						
E5								
E6								