Developing Students' Metacognitive Skills in a Data-Rich Environment

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Abstract

This paper examines the development of students' metacognitive skills in a data-rich environment. The study involves the development and use of a Metacognitive Inventory, which evaluates students' awareness of their cognitive processes as they approach and solve problems. This 26-item inventory is based on the Problem Solving Inventory and State Metacognitive Inventory, with modifications allowing it to be used in a variety of situations. The items cover the six categories of approach-avoidance, awareness, cognitive strategy, confidence, planning, and self-checking. Data was collected through the ***G***reen ***R***esearch for ***I***ncorporating ***D***ata in the ***C***lassroom ($GRID_C$), a National Science Foundation funded research project aimed at developing students' higher order thinking skills in a data-rich learning environment. The sample consists of 147 individuals from a variety of undergraduate and graduate courses at North Carolina State University and a course at Pitt Community College. Given the mix of community college students and university students enrolled in lower and upper level courses, subjects varied in age and class rank. The results indicate significant gains in metacognitive performance, as well as gains for specific items under five of the categories. Cronbach's alpha was used to check for internal consistency for each category. Alpha coefficients for the categories of awareness, cognitive strategy, planning, self-checking and approach/avoidance indicate a good scale.

Keywords: metacognition, critical thinking, survey reliability, renewable energy, STEM

This paper examines the development of students' metacognitive skills in a data-rich environment. The study made use of a Metacognitive Inventory (MI), designed to evaluate students' awareness of their cognitive processes as they approach and solve problems. Data was collected through the Green Research for Incorporating Data in the Classroom ($GRID_C$), a National Science Foundation funded research project aimed at developing students' higher order thinking skills in a data-rich learning environment.

The $GRID_C$ project develops curriculum to teach science, technology, engineering and mathematics (STEM) concepts using data collected from renewable energy technologies at the North Carolina Solar House (NC Solar House) located on the campus of North Carolina State University (NC State). This project enhances instruction and improves learning, while addressing a highly relevant social issue: renewable energy. The project gives teachers and their students the opportunity to study and evaluate the value of renewable energy systems through the use of real-time renewable energy data.

Throughout the years, researchers have shown the value of using real-world data to enhance instruction in mathematics, science and social studies (Drier, Dawson & Garofalo, 1999; Gordin, Polman & Pea, 1994). Curricula that are based on the performance data of renewable energy technologies provide students with valuable knowledge and skills that can be used for professional growth and decision-making.

Furthermore, research on technological problem solving, critical thinking, novice/expert performance and metacognition reveals that students must understand factual, conceptual and procedural knowledge, apply their knowledge to learn by doing, and then reflect on the process that led to the solution (Bransford, Brown & Cocking, 2000; Anderson, Krathwohl, Airasian, Cruikshank, Mayer, Raths, & Wittrock, 2001). The $GRID_C$ project team and participating instructors developed instructional units grounded in these concepts, while incorporating the use of the renewable energy data collected through $GRID_C$ resources in the units.

In order to assess student knowledge, application and reflection, three instruments were used (available upon request). Alternative versions of a multiple-choice test were developed by a panel of content experts to measure knowledge, specific activities were designed to measure the application of knowledge gained, rubrics were developed to measure student performance, and a metacognitive inventory was prepared to measure reflection.

Data Acquisition System

The core of the $GRID_C$ data acquisition system is located at the NC Solar House, on the NC State campus, and gathers renewable energy data from the house and other units (e.g., garage and research annex) on the grounds. The NC Solar House was first opened to the public in 1981, and today, is one of the most visible and visited solar buildings in the United States.

The monitoring system records, among its data, meteorological data (i.e., irradiance, ambient and module temperature, wind speed and direction, module temperature, relative humidity, rain gauge, barometric pressure), photovoltaic data (i.e., AC/DC power, current, voltage, and energy, panel temperature), hot water data (i.e., flow rate, in/out temperate, energy), and hydrogen fuel cell data (i.e., in/out power, current and voltage, energy).

Data from these systems is collected and uploaded to an online data acquisition system. The aggregated $GRID_C$ data, available on the project's website (www.$GRID_C$.net) is used by instructors to develop instructional units to be implemented in various undergraduate and graduate level courses. Furthermore, K-12 teachers are now using this data in their classrooms. Instructional units, using this data have been implemented in:

- Construction Technology (TED 221 - Department of Mathematics, Science and Technology Education, College of Education, NC State) in which students use drawings and models completed in a laboratory environment to simulate construction methods.
- Instructional Science Materials (EMS 373 - Department of Mathematics, Science and Technology Education, College of Education, NC State), with an emphasis on middle and secondary school science, the course provides an overview of experimental and laboratory approaches.
- Design of Solar Heating Systems (MAE 421 - Department of Mechanical and Aerospace Engineering, College of Engineering, NC State) provides an overview of solar insulation, flat plate collectors, thermal storage, heat exchanges, controls, performance calculations, suncharts, and photovoltaics.

- Current Trends in Technical Graphics Education (TED 532 - Department of Mathematics, Science and Technology Education, College of Education, NC State), is a graduate level course that discusses the current trends in technology, techniques and theories relating to technical graphics education.
- Selected Topics in Energy Efficient Building and Design (CST 293 - Construction and Industrial Technology Division, Pitt Community College (PCC)) familiarizes students with building principles that form the basis of energy efficient building and design. Students are exposed to passive solar design, thermal analysis, indoor air quality, and studying the house as system.

Therefore, the sample consists of 147 individuals from a variety of undergraduate and graduate courses at NC State and a course at PCC. Given the mix of community college students and university students enrolled in lower and upper level courses, subjects varied in age and class rank.

Integration of $GRID_C$ Data into Curriculum

In order to develop students' higher order thinking skills in the context of a data-rich learning environment, units were developed using the data acquired through the $GRID_C$ data acquisition system. In developing these units, the researchers and instructors considered that students must understand factual, conceptual and procedural knowledge, apply their knowledge to learn by doing, and then reflect on the process that led to the solution (Bransford, Brown & Cocking, 2000; Anderson, Krathwohl, Airasian, Cruikshank, Mayer, Raths & Wittrock, 2001).

Factual and conceptual knowledge includes an understanding of the systems, subsystems and components of the technology under study. In other words, what is the basic design, how does it function and what are the expected outputs? This knowledge, gained through lecture, readings or personal research, forms the basic understanding needed before proceeding with the design and problem solving process (Lumsdaine, Shelnutt & Lumsdaine, 1999).

Procedural knowledge includes an understanding of the engineering design and/or problem solving processes that lead to innovative solutions. The processes and strategies used to solve problems and make decisions must be understood (Schweiger, 2003; Woods, 2000). However, in order to develop higher order thinking skills, students must have the opportunity to apply their content and process knowledge and learn from errors (Bonanno, 2004; Moriyama, Satou, & King, 2002; DeLuca, 1992; Mathan & Koedinger, 2005). Performance data from the variety of renewable energy systems proposed for this project provide opportunities for students and teachers to analyze and evaluate system variables within the context of their disciplines.

Finally, Bransford, Brown, and Cocking (2000) discuss the importance of making students' thinking visible. The nature of the data collected and used in this study supports the development of thinking skills and allowing students to reflect on their thought process. Students have the opportunity to analyze, evaluate and predict, while applying concepts in a variety of situations. Reflection also includes looking back on the processes that led to decisions (Quintana, Zhang & Krajcik, 2005). Therefore, the researchers also asked students about the different metacognitive processes they used to reach solutions.

In accordance with these purposes, at the completion of each unit, students will have achieved certain learning objectives and an understanding of the different components of renewable energy systems and the engineering processes used to design and/or evaluate these systems. Students are now able to relate discipline specific knowledge to the renewable energy systems under study and apply knowledge to evaluate the appropriateness of renewable energy systems in given situations. And finally, they are able to identify strategic knowledge and processes used to make decisions based on data analysis.

The results of the analyses indicate significant gains in metacognitive performance, as well as gains for specific items under five of the categories. Cronbach's alpha was used to check for internal consistency for each category. Alpha coefficients for the categories of awareness, cognitive strategy, planning, self-checking and approach/avoidance indicate a good scale.

Method

Instruments

Each instructional unit was implemented by the instructor assigned to the course. With the introduction of each unit, students were instructed on the unit's learning objectives and required activities, and the class began with a pre-test consisting of general renewable energy knowledge items and a metacognitive inventory. During the unit, students kept a journal. Upon completion of each unit, the post-test knowledge questions and the metacognitive inventory were administered. Data collected with pre-/post-tests, journals, forums and activities requiring knowledge application were archived for statistical analysis and reporting.

Students' awareness of their cognitive processes as they approach and solve problems was evaluated using the metacognitive inventory (see Appendix). The Metacognitive Inventory (MI) was developed using six items from the Problem Solving Inventory (PSI) and 20 items from the State Metacognitive Inventory (SMI), with slight modifications. This inventory was designed such that it may be used in the varied situations in which the developed curricula are implemented. The items cover six categories: approach-avoidance and confidence from the PSI, and awareness, cognitive strategy, planning, and self-checking from the SMI. The PSI is a 35-item test, which uses the Likert scale response options to assess individuals' awareness of their style of solving life problems such as relationship conflicts and career choices (Heppner, 1994). Estimates of reliability indicated internally consistent constructs and construct validity measured validity (Heppner and Petersen, 1982). The SMI, a 20-item test, which also makes use of Likert scale response options, is used to assess the extent to which students are aware of thinking skills they use to complete tests. Alpha estimates and factor analysis were used to determine the reliability and unidimensionality of the subscales, while construct validity was used to measure validity (O'Neil and Abedi, 1996).

Participants

The sample consists of 147 individuals. Student data was collected from a variety of undergraduate and graduate courses at NC State and a course at PCC. Given the mix of community college students and university students enrolled in lower and upper level courses, subjects varied in age and class rank. The instructional modules developed were reviewed to ensure that they broaden opportunities and enable the equitable participation of women, non-traditional age groups, under-represented minorities, and persons with disabilities. Notably, the partnership in this proposal with PCC enhances the involvement of diverse populations in project activities.

North Carolina's Community College System has, throughout its history, served non-traditional age groups through its successful outreach to adults seeking education, training and retraining for the workforce, including basic skills and literacy education, occupational and pre-baccalaureate programs. The 58 North Carolina community colleges reported over 810,000 curriculum and continuing education student enrollments for the 2007-2008 academic year. Among the nearly 300,000 curriculum student enrollees, females outnumbered males approximately 2 to 1 (NCCCS, 2008a). Racial diversity is also noteworthy: 24.9 percent of the student population is black; 1.5 percent American Indian; 2.1 percent, Asian; and 3.6 percent Latino. At PCC, with over 9,000 curriculum students enrolled, approximately 31 percent are black, 0.5 percent American Indian, 1.1 percent Asian, and 2.1 percent Latino (NCCCS, 2008b).

Results

Metacognitive Inventory Outcomes

The first unit was implemented in the fall semester of 2008. Subsequently, units were implemented and data gathered from six other classes, providing the researchers with 147 observations. Several observations were deleted for certain analyses. In one course, the instructor distributed, but did not ask students to complete the MI at the beginning of the unit. Therefore, many students completed and submitted their pre-MIs and post-MIs simultaneously. This resulted in the loss of 50 observations, making N = 97, for the analysis of the MI and its individual items. Table 1 provides descriptive statistics for the MI pre- and post-tests.

The null hypothesis is not rejected and the normality assumption is satisfied. Therefore, a paired t-test is used for the analysis. The results indicate significant gains in metacognitive performance, as measured by the MI ($t(78) = 2.63$, $p < 0.01$).

A Wilcoxon signed-rank test was performed on each of the 26 MI items. The MI made use of five point Likert scale response options. The items were grouped in the following six categories: awareness, cognitive strategy, planning, self-checking, problem-solving confidence, and approach/avoidance style.

Descriptive Statistics for the Metacognitive Inventory (MI) Pre- and Post-Tests

	Mean	Std. Deviation	Minimum	Maximum	Median
MI Pre-test	3.96	0.41	2.85	5	3.92
MI Post-test	4.07	0.44	2.92	5	4.04

Table 1

MI – Normality Assumption Checks (Results of Shapiro-Wilk Test)

	Statistic (W)	df	Sig.
Difference in General Knowledge Pre- and Post-Tests	0.990	79	0.785

Table 2

Awareness

Table 3 presents the descriptive statistics for 'Awareness' items

Descriptive Statistics for 'Awareness' Items

Item		Mean	Std. Deviation	Min	Max	Median
4 I am aware of the need to plan my course of action.	Pre	4.38	0.65	2	5	4
	Post	4.12	0.73	1	5	4
12 I am aware of my ongoing thinking process.	Pre	4.02	0.73	2	5	4
	Post	4.07	0.71	2	5	4
13 I am aware of my own thinking.	Pre	4.22	0.78	1	5	4
	Post	4.32	0.69	2	5	4
20 I am aware of my trying to understand assignments before I attempt to solve them.	Pre	3.90	0.77	2	5	4
	Post	3.98	0.79	2	5	4
21 I am aware of which thinking techniques and strategies to use and when to use them.	Pre	3.56	0.83	1	5	4
	Post	3.97	0.70	2	5	4

Table 3

Wilcoxon Signed-Rank Test Results for 'Awareness' Items

Item	Signed Rank
4 I am aware of the need to plan my course of action.	-155.0**
21 I am aware of which thinking techniques and strategies to use and when to use them.	333.0***

Where * indicates significance at p < 0.05, ** significance at p < 0.01 and *** significance at p < 0.001.

Table 4

Cognitive Strategy

Table 5 presents the descriptive statistics for 'Cognitive Strategy' items.

Descriptive Statistics for 'Cognitive Strategy' Items

Item		Mean	Std. Deviation	Min	Max	Median
8 I think through the meaning of assignments before I begin.	Pre	3.48	0.94	2	5	4
	Post	3.82	0.82	2	5	4
16 I use multiple thinking techniques to complete an assignment.	Pre	3.65	0.75	2	5	4
	Post	3.97	0.65	3	5	4
17 I attempt to discover the main ideas in assignments.	Pre	3.92	0.73	2	5	4
	Post	4.06	0.78	2	5	4
24 I select and organize relevant information to complete assignments.	Pre	4.02	0.68	2	5	4
	Post	3.98	0.68	2	5	4
25 I ask myself how the assignments are related to what I already know.	Pre	3.96	0.67	2	5	4
	Post	4.19	0.68	3	5	4

Table 5

Wilcoxon Signed-Rank Test Results for 'Cognitive Strategy' Items

Item	Signed Rank
8 I think through the meaning of assignments before I begin.	201.0**
16 I use multiple thinking techniques to complete an assignment.	177.5**
25 I ask myself how the assignments are related to what I already know.	109.5*

Where * indicates significance at p < 0.05, ** significance at p < 0.01 and *** significance at p < 0.001.

Table 6

Table 4 presents the results of Wilcoxon signed-rank tests for significant items under awareness. Item 4, "I am aware of the need to plan my course of action," showed a decrease in perceived frequency of use. Item 21, "I am aware of which thinking techniques and strategies to use and when to use them," showed significant gains from pre- to post-tests.

Table 6 presents the results of Wilcoxon signed-rank tests for significant items under cognitive strategy. Item 8, "I think through the meaning of assignments before I begin," item 16, "I use multiple thinking techniques to complete an assignment," and item 25, "I ask myself how the assignments are related to what I already know" showed significant gains from pre- to post-tests.

Table 9 presents the results of Wilcoxon signed-rank tests for significant items under self-checking. Items 14, "I keep track of my progress, and if necessary, change my techniques or strategies," and 22, "I check my accuracy as I progress through assignments," showed significant gains from pre- to post-tests.

Table 11 presents the results of Wilcoxon signed-rank tests for significant items under problem-solving confidence. Item 7, "I am usually able to think up

Planning

Table 7 presents the descriptive statistics for 'Planning' items.

Descriptive Statistics for 'Planning' Items

Item		Mean	Std. Deviation	Min	Max	Median
2 I try to determine what assignments require.	Pre	4.45	0.57	3	5	4
	Post	4.34	0.58	3	5	4
10 I make sure I understand just what has to be done and how to do it.	Pre	3.91	0.74	1	5	4
	Post	3.91	0.75	2	5	4
18 I determine how to solve assignments.	Pre	4.13	0.58	3	5	4
	Post	4.13	0.60	3	5	4
19 I try to understand the goals of assignments before I attempt to answer or solve.	Pre	3.77	0.84	2	5	4
	Post	3.97	0.81	2	5	4
26 I try to understand assignments before I attempt to solve them.	Pre	4.07	0.76	2	5	4
	Post	4.22	0.73	2	5	4

Table 7

Self-Checking

Table 8 presents the descriptive statistics for 'self-checking' items.

Descriptive Statistics for 'Self-Checking' Items

Item		Mean	Std. Deviation	Min	Max	Median
6 I almost always know how much of an assignment I have left to complete.	Pre	3.93	0.73	2	5	4
	Post	4.05	0.82	1	5	4
14 I keep track of my progress, and if necessary, change my techniques or strategies.	Pre	3.76	0.69	2	5	4
	Post	3.93	0.72	2	5	4
15 I check my work while I am doing it.	Pre	3.59	0.92	1	5	4
	Post	3.81	0.87	2	5	4
22 I check my accuracy as I progress through assignments.	Pre	3.68	0.84	2	5	4
	Post	3.90	0.75	1	5	4
23 I correct my errors.	Pre	4.29	0.69	2	5	4
	Post	4.26	0.75	2	5	4

Table 8

Wilcoxon Signed-Rank Test Results for 'Self-Checking' Items

Item	Signed Rank
14 I keep track of my progress, and if necessary, change my techniques or strategies.	109.0*
22 I check my accuracy as I progress through assignments.	158.0**

Where * indicates significance at $p < 0.05$ and ** significance at $p < 0.01$.

Table 9

Problem-Solving Confidence

Table 10 presents the descriptive statistics for 'problem-solving confidence' items.

Descriptive Statistics for 'Problem-Solving Confidence' Items

Item		Mean	Std. Deviation	Min	Max	Median
5 I trust my ability to solve new and difficult problems.	Pre	4.10	0.73	2	5	4
	Post	4.07	0.67	2	5	4
7 I am usually able to think up creative or effective alternatives to solve a problem.	Pre	3.90	0.75	2	5	4
	Post	4.13	0.67	2	5	4
11 When I become aware of a problem, one of the first things I do is to try to find out exactly what the problem is.	Pre	4.26	0.62	3	5	4
	Post	4.20	0.57	3	5	4

Table 10

Wilcoxon Signed-Rank Test Results for 'Problem-Solving Confidence' Items

Item	Signed Rank
7 I am usually able to think up creative or effective alternatives to solve a problem.	125.5**

Where ** indicates significance at $p < 0.01$.

Table 11

creative or effective alternatives to solve a problem," showed significant gains from pre- to post-tests.

Table 13 presents the results of Wilcoxon signed-rank tests for significant items under approach/avoidance style. Item 1, "After I solve a problem, I analyze what went right or what went wrong," showed significant gains from pre- to post-tests.

Alpha coefficients for the categories of awareness, cognitive strategy, planning, and self-checking indicate a good scale. Cronbach's alpha decreases as the number of items in the category decreases, which may explain the lower alpha values for the categories of problem-solving confidence and approach/avoidance style. However, given the smaller number of items in these categories, alpha for approach/avoidance still proves adequate.

Discussion

The present analyses show significant gains in metacognitive performance, as measured by the metacognitive inventory. The metcognitive inventory makes the thinking process visible, thereby allowing researchers to see the significant increase in students' reflections on their thought processes. This outcome is of particular importance as research on technological problem solving, critical thinking, novice/expert performance and metacognition has shown that students must understand factual, conceptual and procedural knowledge, apply their knowledge to learn by doing, and then reflect on the process that led to the solution (Bransford, Brown & Cocking, 2000; Anderson, et al., 2001).

Detailed analyses of the MI showed significant gains for certain items. The

Approach/Avoidance Style

Table 12 presents the descriptive statistics for 'approach/avoidance style' items.

Descriptive Statistics for 'Approach/Avoidance Style' Items

Item		Mean	Std. Deviation	Min	Max	Median
1 After I solve a problem, I analyze what went right or what went wrong.	Pre	3.97	0.78	1	5	4
	Post	4.18	0.66	2	5	4
3 When confronted with a problem, I stop and think about it before deciding on a next step.	Pre	4.17	0.73	2	5	4
	Post	4.20	0.82	1	5	4
9 In trying to solve a problem, one strategy I often use is to think of past problems that have been similar.	Pre	4.10	0.85	1	5	4
	Post	4.22	0.70	2	5	4

Table 12

Wilcoxon Signed-Rank Test Results for 'Approach/Avoidance Style' Items

Item	Signed Rank
1 After I solve a problem, I analyze what went right or what went wrong.	140.5**

Where ** indicates significance at $p < 0.01$.

Table 13

Estimates of Reliability

Cronbach's alpha was used to estimate the internal consistency for each of the six categories. Table 14 presents the results of the reliability estimates.

Reliability Estimates (Cronbach's Alpha)

Category	# of Items	Alpha (α)
Awareness	5	0.80
Cognitive Strategy	5	0.78
Planning	5	0.75
Self-Checking	5	0.77
Problem-Solving Confidence	3	0.57
Approach/Avoidance Style	3	0.63

Table 14

majority of gains were in the category of 'cognitive strategy.' Students reported thinking through the meaning of assignments before beginning each assignment, using multiple thinking techniques to complete assignments, and relating assignments to their existing knowledge. Such positive changes indicate a development of a 'cognitive strategy.' Furthermore, students showed significant gains in 'self-checking.' They were found to check the accuracy of their work as they progressed through assignments, keeping track of their progress and making necessary changes to their techniques and strategies. Students also analyzed what went wrong and what went right after solving a problem (approach/avoidance style).

Significant gains were found in other metacognitive inventory categories as well. Students reported a greater ability to think up creative or effective alternatives to solve a problem, which showed a significant increase in the area of 'confidence.' In the category of 'awareness,' students reported becoming more aware of which thinking techniques and strategies to use and when to use them. However, within the same category of 'awareness' students showed a decrease in awareness of their need to plan a course of action. Collection of more data will allow for a deeper evaluation of these statements. Surprisingly, no items under 'planning' showed significant changes. It is possible that instructors do not stress the importance of the elements of planning in problem-solving. An inclusion of such discussions in the classroom may lead to positive changes in the category of 'planning' and the overall metacognitive iventory score.

In order to estimate the internal consistency for each of the six categories Cronbach's alpha was used. Alpha coefficients for the categories of awareness (α=0.80), cognitive strategy (α=0.78), planning (α=0.75), and self-checking (α=0.77) indicate a good scale.

Cronbach's alpha decreases as the number of items in the category decreases, which may explain the lower alpha values for the categories of problem-solving confidence (α=0.57) and approach/avoidance style (α=0.63). However, given the smaller number of items in these categories, alpha for approach/avoidance still proves adequate. Alpha in these categories may be improved by increasing the number of items within the categories. The researchers are currently evaluating possible items to be included in future surveys.

In an effort to gain a deeper understanding of the metacognitive inventory outcomes and to further test its reliability, $GRID_c$ researchers are actively recruiting instructors from various NC State departments, local colleges and universities, and K-12 teachers, to help develop and implement $GRID_c$ curricula. Also, in an effort to obtain quality data with a maximum number of usable observations, steps have been taken to ensure that instructors are aware of the importance and value of proper data collection.

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Nasim Lari has served as a researcher on the GRIDC project since 2008. Her research interests include employing quantitative methods to address various topics in education. She has taught various courses in economics and statistics at North Carolina State University and the University of North Carolina at Chapel Hill.

Appendix

Please rate how strongly you agree or disagree with each of the following statements by circling the single appropriate number.

#	Item	Strongly Agree 5	Agree 4	Neither Agree Nor Disagree 3	Disagree 2	Strongly Disagree 1
1	After I solve a problem, I analyze what went right or what went wrong.	5	4	3	2	1
2	I try to determine what assignments require.	5	4	3	2	1
3	When confronted with a problem, I stop and think about it before deciding on a next step.	5	4	3	2	1
4	I am aware of the need to plan my course of action.	5	4	3	2	1
5	I trust my ability to solve new and difficult problems.	5	4	3	2	1
6	I almost always know how much of an assignment I have left to complete.	5	4	3	2	1
7	I am usually able to think up creative or effective alternatives to solve a problem.	5	4	3	2	1
8	I think through the meaning of assignments before I begin.	5	4	3	2	1
9	In trying to solve a problem, one strategy I often use is to think of past problems that have been similar.	5	4	3	2	1
10	I make sure I understand just what has to be done and how to do it.	5	4	3	2	1
11	When I become aware of a problem, one of the first things I do is to try to find out exactly what the problem is.	5	4	3	2	1

#	Item	Strongly Agree 5	Agree 4	Neither Agree Nor Disagree 3	Disagree 2	Strongly Disagree 1
12	I am aware of my ongoing thinking processes.	5	4	3	2	1
13	I am aware of my own thinking.	5	4	3	2	1
14	I keep track of my progress and, if necessary, change my techniques or strategies.	5	4	3	2	1
15	I check my work while I am doing it.	5	4	3	2	1
16	I use multiple thinking techniques or strategies to complete an assignment.	5	4	3	2	1
17	I attempt to discover the main ideas in assignments.	5	4	3	2	1
18	I determine how to solve assignments.	5	4	3	2	1
19	I try to understand the goals of assignments before I attempt to answer or solve.	5	4	3	2	1
20	I am aware of my trying to understand assignments before I attempt to solve them.	5	4	3	2	1
21	I am aware of which thinking techniques and strategies to use and when to use them.	5	4	3	2	1
22	I check my accuracy as I progress through assignments.	5	4	3	2	1
23	I correct my errors.	5	4	3	2	1
24	I select and organize relevant information to complete assignments.	5	4	3	2	1
25	I ask myself how the assignments are related to what I already know.	5	4	3	2	1
26	I try to understand assignments before I attempt to solve them.	5	4	3	2	1