Reflective Idea-Image Connections: Effects of Pupil Metacognitive Awareness and Concept Understanding in Science

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Abstract

Reflective Idea-Image Connections (RIIC) is a knowledge representation strategy wherein thoughts are made visible and explicit by constructing a colorful network of ideas and symbolic representations. It is characterized by footnotes about their thinking processes throughout (before, during, and after) the construction and the association or linking of images.

This study was undertaken to:
(1) determine the effects of the RIIC on pupils' metacognitive awareness and concept understanding, and (2) find out if metacognitive awareness is related to concept understanding in Science.

The research participants were 66 fourth graders during the Fourth Quarter of the Academic Year 2008-2009. The researcher-developed lesson plans for the Fourth Quarter revolved around the theme, Energy and Interaction. The topics covered were:
(1) energy flow in the ecosystem, (2) forms of energy, and (3) forces.

The instruments used were the Concept Understanding Test (CUT) and the RIIC assessment rubric, both developed by the researcher and validated by three elementary science teachers; and the Metacognitive Awareness Inventory (MAI) of Schraw and Dennison (1994). The CUT and the RIIC assessment rubric were used to measure pupils' concept understanding while the MAI was used to determine pupils' metacognitive awareness.

The data gathered were primarily geared toward determining the effects of RIIC on pupil's metacognitive awareness and concept understanding as well as knowing if metacognitive awareness and concept understanding were correlated. Statistical tools such as t-test for independent and paired samples, and Pearson r were utilized.

Findings of the study revealed that: (1) The RIIC had no significant effect on metacognitive awareness, and (2) there was no significant correlation between MAI and CUT.

Some recommendations of the study are: (1) for teachers to utilize RIIC as a strategy to present a lesson, or assess pupils' learning. (2) for them to make use of RIIC in the development of the General science curriculum. (3) for researcher to conduct a similar study across grade levels.

Introduction

Children have a multitude of experiences in the environment they live in. In order to make sense of these experiences, children have the natural tendency to touch, seek, and inquire about things that are near them. Cognitive theorists believe that *mental processes* are involved whenever children try to learn and make sense of these experiences through interpreting and organizing every bit of information. Experts like Paivio (1991) and Vygotsky (1962) believe that children can learn from imagery, and in the process, construct meaningful links between them. Other theorists like Ritchie and Karge (1999) and Anderson (1990) support claims that mental images allow children to recall bits of information and be able to retain, and connect them to other existing information in the long-term memory. In the school setting, these theoretical perspectives necessitate teachers to provide learners with activities that will enable the latter to maximize learning and be given freedom to process information. However, as observed, instructional activities are sometimes insufficient for meaningful learning to occur. To address this issue, the mental processing of information should involve metacognition, or one's knowledge of cognition and the ability to process or monitor information based on the feedback that the learner receives via learning (Metcalfe & Shimamura, 2004). Metacognition involves *thinking skills,* which include children's ability to make inferences, formulate, and test hypotheses; analyze and apply models and concepts, and conduct a comparative analysis (Strong et al., 2004).

However, the interest about the ability of children to think about their own thinking in consonance with the learning goal of developing learners who are able to create meaningful and coherent representations of knowledge (Lambert & Mccombs, 1998), is not given utmost importance and attention. Unfortunately, there is evidence that teachers are still not focusing effectively on developing thinking skills and strategies, and that students are not acquiring, developing, and using the full range of their thinking abilities (*French et al*., 1992). It is because of this existing problem especially among science learners that the Reflective Idea-Image Connections (RIIC) as a metacognitive and Knowledge Representation Strategy (KRS) was developed. It is utilized to encourage learners to integrate multiple ways of thinking, making their thoughts visible and explicit. In this strategy, pupils are given the chance to construct a mental image based on specific science lessons presented through various instructional strategies. This enables learners to critique their own learning network as well as those of others. The formation of mental imagery and the opportunity to critique their own thinking improves their metacognitive awareness and concept understanding, thus, meaningful learning eventually takes place.

This study specifically sought to answer the following questions: (1) Do pupils exposed to RIIC have higher mean score in the MAI than pupils exposed to the conventional strategy? (2) Do pupils who utilize RIIC have higher mean posttest CUT score than pupils who

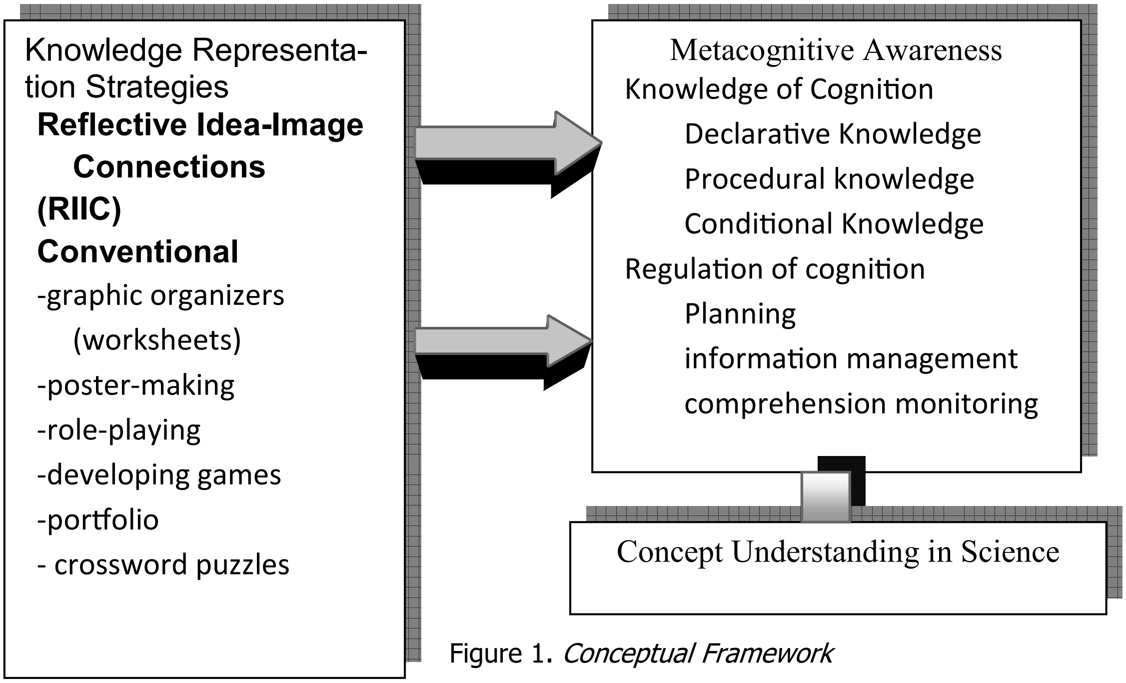


Figure 1. *Conceptual Framework*

utilize the conventional strategy? (3) Is the MAI score positively correlated to CUT score? Figure 1 illustrates the conceptual framework of the study.

The use of RIIC as a knowledge representation strategy affects the pupils' metacognitive awareness. It consists of two broader categories: 1) Knowledge of Cognition which refers to knowledge about one's skills, abilities, and intellectual resources (declarative knowledge); knowledge about how to implement learning procedures (procedural knowledge) based one one's knowledge of his/her own cognition; and knowledge of how and when to use those learning procedures (conditional knowledge), and 2) Regulation of Cognition which refers to setting goals and allocating resources prior to learning (planning) and using skills and strategy sequence in processing the information effectively (information management strategies). Likewise, regulation of cognition enables pupils to assess one's learning strategy (monitoring) to correct comprehension and performance errors (debugging). Moreover, after each learning episode, the performance and effectiveness of the strategy is analyzed (evaluation).

The research hypotheses were (1) Pupils exposed to RIIC strategy have significantly higher mean score in the MAI than pupils exposed to the conventional strategy,
(2) Pupils who utilized RIIC have higher mean score in the CUT than pupils who utilized the conventional strategy, and
(3) Pupils who obtain higher mean score in the MAI have higher mean posttest score in the CUT.

Methodology

The study followed a quasi-experimental two-group pretest-posttest design. The research participants had comparable average grades in Science during the first and second quarters of the same academic year. Participants, both in the experimental class and conventional class, were randomly grouped into fours or fives, in triads, then in pairs. Consequently, each participant from both classes performed the tasks (Knowledge Representation) individually.

Research Instruments

Three (3) instruments were used in the study: (1) Concept Understanding Test (CUT), (2) RIIC Assessment Rubric, and (3) Metacognitive Awareness Inventory (MAI).

The CUT, a 40-item researcher-developed multiple-choice test, with a reliability of 0.73, was used to evaluate the participants' conceptual understanding in Science for the fourth quarter. The topics covered in the said test were energy flow, forms of energy, and forces. The validity of the said test was established by three (3) elementary science teachers. The RIIC Assessment Rubric was used to assign scores according to concept-links (2 points each), cross-links (10 points each), hierarchies (5 points each), examples (1 point each), pictures (5 points each), and colors (5 points each). The cumulative total was then determined to score the constructed RIIC.

The MAI of Schraw and Denisson (1994) was the third instrument used. It had eight sub-processes subsumed under two broader categories: (a) knowledge of cognition and (b) regulation of cognition. The use of MAI allowed the determination of the metacognitive skills as well as the identification of the awareness level of students in relation to their self-regulation.

Data Collection Procedure

Sections on Energy and Interaction were taught by the researcher. The topics covered were: (1) Energy flow in the ecosystem (2) Forms of energy and (3) Forces. The RIIC and conventional groups were randomly assigned. The RIIC group was exposed to RIIC while the conventional group was exposed to conventional strategies such as answering worksheets, role-playing, making illustrations, and working on a portfolio. The CUT and the MAI were administered to both groups at the start of the quarter in order to identify the skills they were equipped with prior to the treatment. Several strategies such as laboratory activities, demonstration activities, reading articles, watching video clips, and lecture-discussion were employed in presenting the lessons to both RIIC and conventional groups during the fourth quarter. Participants in the RIIC group were tasked to construct RIIC based on the lessons. RIIC was also used as a form of assessment. After each lesson, the constructed RIIC was linked to previous RIICs and so on. These were later synthesized at the end of the unit. The RIICs were done in groups, then in pairs, and individually. The gradual shift from a group activity to an individual one allowed participants to prepare for the individual RIIC construction.

Meanwhile, after each lesson was presented, the conventional group was tasked to role play, answer crossword puzzles or graphic organizers, create a portfolio, role play, make posters, or develop games based on what they have learned.

Anecdotal reports, scratch sheets, and output of their tasks or activities were used to gather information on how participants were able to form their conceptual knowledge and develop their metacognitive awareness during verbal interaction within the group or with their seatmates while answering or doing the conventional strategies or during group/individual RIIC construction.

The CUT posttest was administered after all the lessons were presented. Conceptual understanding of the theme was also assessed using the students' RIIC (for the RIIC group) or illustrations, posters, and graphic organizers (for the conventional group) via an assessment rubric. Pupils of both groups also answered the MAI to determine their awareness level regarding their own learning/metacognition.

Data Analysis Procedure

To compare the groups in terms of their metacognitive awareness and concept understanding in science, paired samples t-test was used. The significance in the difference between the mean pretest scores of CUT and MAI as well as the significance is the difference of the mean posttest scores of MAI and of CUT were determined. Similarly, t-test for independent and paired samples were used to determine the effects of RIIC on metacognitive awareness and concept understanding in Science. Pearson r was also utilized to show the correlation between MAI and CUT. The values obtained were between MAI and CUT. The values obtained were interpreted using the r scale.

Results and Discussion

Pupils' Metacognitive Awareness

Prior to the intervention, the pretest mean scores in the MAI of the control and experimental groups were determined and compared using paired samples t-test. Table 1 shows the pretest mean scores of the two groups in the MAI and the result of the statistical analysis.

The conventional (control) group had higher MAI pretest scores (M = 38.17, SD = 6.56) than the RIIC (experimental) group (M = 34.50, SD = 7.33). This implies that prior to the intervention; the conventional group had higher metacognitive awareness than the RIIC group. However, after the RIIC intervention, the conventional group did not significantly differ from the RIIC group in terms of MAI post test scores.

This non-significant difference affirms Flavell's (1976) study in which he suggested that metacognition of young children are quite limited and that they do relatively little monitoring of their own memory, comprehension, and other cognitive enterprises. Meanwhile, Table 2 indicates the categories of the MAI that were improved using RIIC.

Table 1
t-test of the difference of the pretest mean scores in the MAI

Group	N	Mean	% of the MAI	SD	p-value
Conventional	33	38.17	73.40	6.56	0.039*
RIIC	33	34.50	66.35	7.33	

*significant at .05 level

Table 2
Pretest-Posttest Mean Scores of the MAI Knowledge of Cognition Category

Sub-processes	**Conventional**		**Sig**	**RIIC**		**Sig**
	Pretest	**Posttest**		**Pretest**	**Posttest**	
Declarative	21.12	22.62	0.32	16.75	19.12	0.09
Procedural	20.25	28.00	0.01*	18.00	15.25	0.48
Conditional	18.67	26.17	0.06	17.20	16.20	0.77

It is evident in Table 2 that only the declarative aspect of knowledge of cognition was improved. This means that students were knowledgeable of their abilities, skills, and intellectual resources as learners but did not significantly improve their procedural and conditional sub-processes. They were not knowledgeable of strategies on how to implement learning procedures as well as why and when to use those. This might be attributed to a non-explicit procedural training King (1991).

When participants were asked how they constructed their RIIC, one of them responded, "*…inaayos po naming yung ideas…*

Nilagay po naming yung main topic sa gitna tapos yung subtopics po dinugtong namin" (we organized the ideas … we put the main topic in the middle and attached the subtopics). This therefore indicates that information processing includes procedural and declarative sub-processes. This includes organizing, chunking, and mental visualizing of concepts learned. Participants were also observed to practice chunking wherein they broke a body of information into smaller units. Through this, information was easily sequenced to identify relationships among chunks of information. In relation to this Table 3 presents the outcome of the mean scores of the regulation of cognition category.

Table 3
Pretest-Posttest Mean Scores of the MAI Regulation of Cognition Category

Sub-processes	**Conventional**			**RIIC**		
	Pretest	**Posttest**	**Sig**	**Pretest**	**Posttest**	**Sig**
Planning	20.57	24.43	0.11	22.57	24.43	0.45
Information	17.80	26.00	0.00*	15.20	26.00	0.00*
Comprehension	21.57	22.71	0.46	19.71	22.71	0.33
Debugging	14.20	26.80	0.00*	26.60	26.80	0.90
Evaluation	18.50	23.50	0.04*	15.67	23.50	0.01*

Based on Table 3, the highest mean score obtained for the conventional group's pretest is on comprehension (M = 21.57) which is consistent with their pretest mean score in the CUT (refer to Table 3). Although it is not significantly different from the RIIC group (M = 19.71), it is still numerically greater. Meanwhile, the highest mean score obtained for the RIIC group is in the category debugging (M = 26.60) wherein participants of this group were able to correct comprehension and performance errors. When pupils recognize that what they are doing was not making sense during RIIC construction, they self-monitor and then self-correct. In doing so, they applied fix-up strategies, wherein, when given feedback on their constructed RIIC, they were able to redirect/revise their work with greater understanding. Table 2 also shows that although debugging has the highest mean score, the information sub-process has the largest difference with pretest mean score of 15.2 and posttest mean score of 26.0.

Furthermore, debugging sub-process (regulation of cognition) overlapped with procedural skills (knowledge of cognition). Image strategies, similar to mind-mapping technique, were used in the mental visualization of science concepts. When participants were instructed to pay attention to the mistakes they made, they specifically identify the relationship(s) between concepts. The representation of the perceived and organized information is being matched to the known faults or solution patterns. Procedural skills are then necessary in selecting and isolating the faults. This supports the Repair Theory (Brown & Vahnlen, 1980) which posits that an impasse occurs when a procedure cannot be performed, and that an individual applies various strategies to overcome the said impasse.

Figure 2 and Figure 3 describe and illustrate the two broad categories of MAI as shown in the constructed visual network and as written in the footnotes. Each figure displayed knowledge of cognition--declarative and procedural (Figure 2), and regulation of cognition (Figure 3).

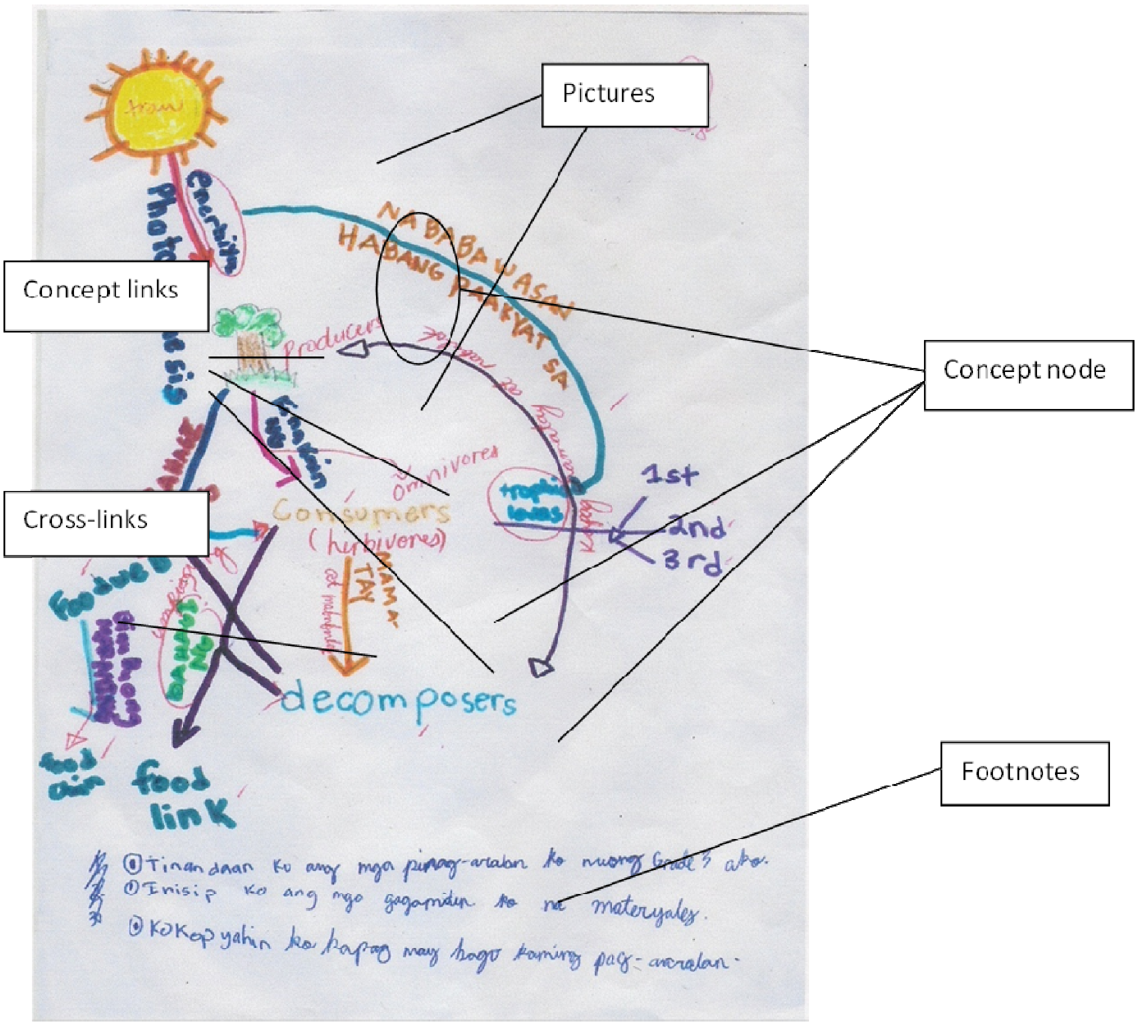
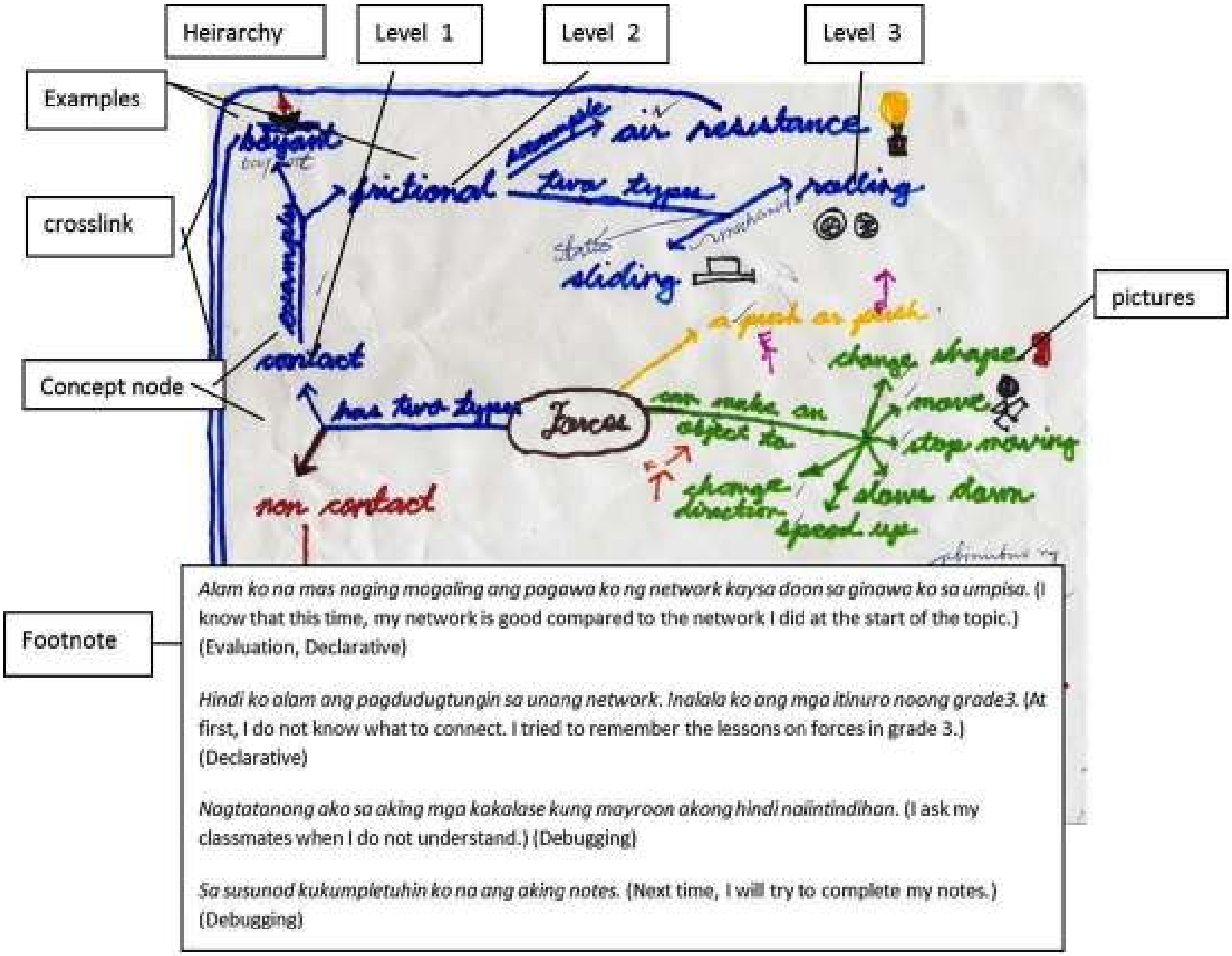


Figure 2. *Energy flow in the ecosystem.*

In Figure 2, the metacognitive awareness sub-process exhibited were mainly on the regulation of cognition (evaluation, debugging). It should be noted that the pupil was able to synthesize several topics (Introduction to Forces, Contact Forces, Non-contact Forces, and Magnetism) of the unit, Forces. Each topic was presented with a color specific to the topic. Also, the pupil was able to identify two cross-links that connected contact and non-contact forces. Evidently, the pupil was able to give examples toward the end of the chain of concept nodes. The number of pictures and the form were not remarkable, but the pupil was able to show some of them. When asked why only few pictures were seen in his constructed RIIC, the pupil discreetly smiled but replied in a serious tone, *"Eh, nahihirapan po ako magdrowing…Hindi [po] ako magaling magdrowing"* (I had a hard time drawing … I don't know how to draw).



Alam ko na mas naging magaling ang pagawa ko ng network kaysa doon sa ginawa ko sa umpisa. (I know that this time, my network is good compared to the network I did at the start of the topic.) (Evaluation, Declarative)

Hindi ko alam ang pagdudugtungin sa unang network. Inalala ko ang mga itinuro noong grade3. (At first, I do not know what to connect. I tried to remember the lessons on forces in grade 3.) (Declarative)

Nagtatanong ako sa aking mga kakalase kung mayroon akong hindi naiintindihan. (I ask my classmates when I do not understand.) (Debugging)

Sa susunod kukumpletuhin ko na ang aking notes. (Next time, I will try to complete my notes.) (Debugging)

Figure 3. *Forces and interaction (pupil E31) after instruction.*

Pupils' Concept Understanding

Prior to the intervention, the groups' concept understanding in Science was compared. The pretest mean and posttest mean scores were obtained and the significance of the difference was determined using the independent samples t-test as seen in Table 4.

Table 4
t-test of the difference between pretest mean scores in CUT

Group	N	Mean	SD	p-value
Conventional	33	15.93	5.03	0.751
RIIC	33	15.50	4.88	

The conventional group (M = 15.93, SD = 5.03) and the RIIC group (M = 15.50, SD = 4.88) did not differ significantly in terms of pretest CUT scores. This implies that before the intervention, the groups were comparable in terms of concept understanding in Science. This may be attributed to their being in the same-age group. Likewise, the pupils were heterogeneously grouped in relation to the average grade of each section.

Table 5 presents the CUT posttest mean score of the RIIC group (31.94) which is numerically higher than the conventional group's mean score (26.12).

Table 5

t -test of the difference between the posttest mean scores of both groups in the CUT

Group	N	Mean	SD	p-value
Conventional	33	26.12	6.86	.002*
RIIC	33	31.94	6.40	

The RIIC group had higher CUT posttest scores (M = 31.94, SD = 6.40) than the conventional group (M = 26.12, SD = 6.86).

To determine in which of the science topics RIIC is most effective, the posttest-pretest mean difference for each topic was obtained. Table 6 shows that RIIC is most effective on energy flow in the ecosystem.

Table 6

Pretest-Posttest mean difference of RIIC on selected topics

Topic	**Mean**		**Significance**
	Pretest	**Posttest**	
Energy flow in an ecosystem	5.20	9.60	0.060
Forms of Energy	5.24	9.64	0.073
Forces	5.50	9.60	0.174

The numerically higher mean difference (4.40) could be accounted for mainly by the pupils' focus on learning the last topic for the quarter. It was during the discussion of several lessons for the topic on forces that the attention of some pupils was called because they were doing some scribbling or discreetly doing their projects in other subject areas. A group of pupils in the same class was overheard saying, *Ang daming gagawin* [*sigh*] (There are many things to be done).

Paired samples t-test was used to determine the significant difference of the utilization of RIIC and conventional strategies in the RIIC and conventional groups, respectively.

Table 7

Paired samples t-test of both groups in the CUT

Group	Test	Mean	SD	Significance
Conventional	Pretest	15.93	5.03	0.000*
	Posttest	26.12	6.86	
RIIC	Pretest	15.50	4.88	0.000*
	Posttest	31.94	6.40	

The posttest mean scores of the conventional and RIIC groups are significantly higher than their pretest mean scores in the Concept Understanding Test in Science. The scores in become higher regardless of the kind of strategy or type of lesson presented to the students. However, the posttest mean score of the RIIC Group is higher than that of the conventional group. The RIIC provided pupils with structure that allowed them to reflect concretely over time on the process of concept learning.

Relationship between MAI and CUT

Pearson r was used to determine the relationship between MAI and CUT. The values obtained were interpreted using the r scales:

Scale for r	Interpretation
0.75 - 1.00	Strong to perfect correlation
0.50 - 0.74	Moderately strong correlation
0.26 - 0.49	Moderately weak correlation
0.0 - 0.25	No to weak linear relationship

Based on the determined values of correlation shown on Table 8, it can be concluded that there is very little or almost no correlation between the metacognition and concept understanding of the experimental and control groups.

Table 8

Correlation of MAI and CUT posttest scores

Group	Pearson r	Significance
RIIC	-.012	0.47

Table 8 shows a nonsignificant correlation of -.012 (p > .05) between MAI and CUT posttest scores. Participants who obtained higher mean scores in MAI do not necessarily have higher scores in CUT. Results reveal that metacognition and concept understanding are two (2) independent variables. Several studies on intellectual ability (Swanson, 1990), academic a chievement (Pressley and Ghatalla, 1990), domain knowledge (Glenberg and Epstein, 1997), and comprehension (Leonsario and

and Nelson, 1990) indicate that metacognition and cognitive constraints on learning are separable. It should be noted that metacognition is a strategy wherein pupils evaluate and monitor their own cognitive processes (Shimmamura, 2000), while concept understanding is the pupils' ability to represent and make connections and links of learned knowledge.

Conclusion

Based on the gathered data, it was found out that: (1) The introduction of RIIC improved the performance of the experimental group in the Concept Understanding Test (pretest mean score of 15.50; posttest mean score of 31.94); (2) Pupils exposed to RIIC have a higher posttest mean score (40.21) in the MAI from a pretest mean score of 34.50; (3) Pupils in the RIIC group who obtained higher posttest scores in the MAI do not necessarily have higher posttest scores in the CUT. On careful examination of the findings, it can be concluded that (1) The RIIC strategy is as good as the conventional strategy in promoting metacognitive awareness; (2) The utilization of RIIC significantly improves pupil concept understanding in Science; and (3) Metacognition has very little or almost no correlation to concept understanding. Several recommendations of the study were (1) Teachers are encouraged to utilize RIIC as a strategy to present a lesson, or assess pupils' learning; (2) Curriculum planners may incorporate the utilization of RIIC to the General Science curriculum to improve concept understanding; and (3) Researchers may replicate this study across different grade levels to check for variations across different age groups.

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