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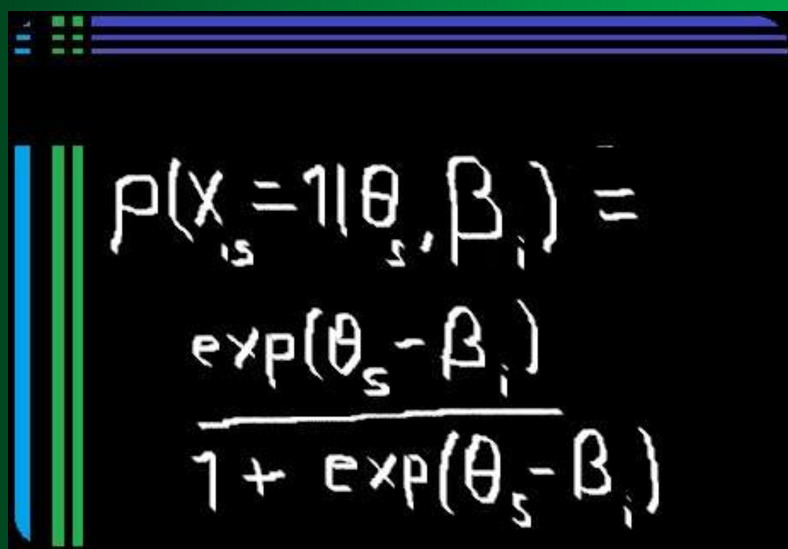

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Articles

Students' Attitudes and Problem Solving with Vee Diagrams

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This paper examines critical issues emerging from a study conducted, over two school terms with groups of Years 7 and 10 students from 3 Australian regional schools, to investigate the impact of using some innovative meta-cognitive strategies on students' problem solving skills and attitudes towards mathematics. Attitudinal data from questionnaires were analyzed using the Rash Model. Qualitative data collected from some Year 7 and Year 10 students enabled a tentative comparison of emerging trends across the two year groups based on their responses to selected questionnaire items, reflective prompts and vee diagrams of mathematical problems. Findings have implications for ways in which innovative ideas in mathematics may be presented to students to ensure a more positive and seamless incorporation into their regular learning in mathematics classrooms at primary and secondary levels.

Keywords: problem solving, mathematics attitudes, innovative strategies, meta-cognitive strategies

Learning mathematics more meaningfully and more flexibly, making connections between mathematical ideas and their applications in real life and in problem solving, and developing not only proficiency in solving problems but including as well the development of their critical ability to justify their solutions and strategies in terms of mathematical principles and concepts are some of the fundamental ideas that currently underpin many national curricular reforms in mathematics (AAMT, 2006; NCTM, 2000). Along with these desirable cognitive developments is also the need to develop students' positive attitudes towards mathematics. According to many researchers (Leder, 1987; Zan, Brown, Evans & Hannula, 2006), students who are successful in mathematics often have positive attitudes towards mathematics, and those that consistently fail mathematics have entrenched negative mathematics attitudes. Highly promoted also in innovative, quality and/or productive teaching frameworks (Queensland Department of Education and Training (DET), 2009; New South Wales Department of Education and Training (DET), 2003) is the need to encourage students to work and communicate mathematically through problem solving, making connections, investigation, thinking, reasoning, justifying, proving, and reflecting as part of regular mathematics classroom practices. It is also important that mathematical tasks are interesting and engaging to enable these productive, working and communicating mathematically processes. As Hollingworth, Lokan & McGrae (2003) noted in their video study of Year 8 teachers in a variety of countries, “Australian students would benefit from more exposure to less repetitive, higher-level problems, more discussion of alternative solutions, and more opportunity to explain their thinking” (p. xxi). They noted “an over-emphasis on ‘correct’ use of the ‘correct’ procedure to obtain ‘the’ correct answer. Opportunities for students to appreciate connections between mathematical ideas and to understand the mathematics behind the problems they are working on are rare” (p.xxii). For this paper, the main focus question is: *Why is it that, in the classroom, when students are provided with the opportunity to be innovative and creative in their own approaches, these are not often readily accepted or welcomed?* This paper reports relevant data from a literacy-numeracy project conducted to assist a group of Years 10 and 7 educationally disadvantaged (ED) students improve their literacy and numeracy learning outcomes as prescribed by the *K-10 Mathematics Syllabus* (NSWBOS, 2002)

Instead of continuing “a syndrome of shallow teaching, where students are asked to follow procedures without reasons, and (where) more than ‘shallow teaching’ is needed for students’ conceptual understanding and problem solving abilities to improve, the project reported here deliberately focused on ED students building on their cognitive structures and deepening of their understanding of the interconnections between mathematics principles and concepts on one hand, and (multiple) methods of solutions on the other, by requiring them to use two meta-cognitive strategies as part of their mathematics learning and problem solving experiences within a classroom setting. The usefulness of these two meta-cognitive tools: vee diagrams and reflective stories, were then examined and the impact these cognitive constructions and developing understanding on students’ attitudes towards mathematics and performance with workshops tasks and tests were also monitored. In contrast to their normal mathematics classroom practices, the students that participated in the project used the innovative strategies as means to support their thinking and reasoning and communication of their mathematical understanding and reflections during weekly workshops.

The selection of workshop tasks (i.e., content and problem type) were intended to provoke cognitive conflict while assisting the students to overcome the typical struggles and difficulties often experienced when faced with solving different and unfamiliar tasks. It was anticipated that addressing these difficulties through the appropriate use of guiding questions on vee diagrams and prompts for reflective stories would be a suitable pedagogical approach to provoke the necessary cognitive conflict (Piaget, 1972). The latter should evoke an active reorganization of a student’s existing pattern of meanings towards the grasping of meaning, felt-significance that meaning is grasped, and being motivated and choosing to learn mathematics more meaningfully. To encourage and facilitate these processes, students were encouraged and supported to actively engage with completing vee diagrams and composing reflective stories. During the project, it was further expected that students' attitudes towards mathematics would be influenced by their performance with workshop tasks and tests.

Theoretical Principles

Whilst the constructivist perspective promotes meaningful learning and the active engagement of students in constructing their own meanings based on their learning experiences (Piaget, 1972; Ausubel, 2000), Gowin's educating theory (1981) proposes that the ultimate goal of teaching is the *achievement of shared meaning*. By using *educative materials of the curriculum*, the teacher and student aim at congruence of meaning; the teacher acts intentionally to change the meaning of the student's experience, using curriculum materials. In a moment of choosing to pay attention to the teacher and the materials, the student acts intentionally to *grasp meaning*. *The aim is shared meaning*. Interactions and negotiations of meanings between the student and the teacher can be brief or can last a long time, but the aim is to *achieve shared meaning*. In this interaction, both teacher and student have definite responsibilities.

For the teacher, s/he is responsible for seeing to it that the meanings of the materials the student grasps are the meanings the teacher intended for the student to take away (see also Thompson & Salandha, 2003). The student, on the other hand, is responsible for seeing to it that the grasped meanings are the ones the teacher intended. When these *separate responsibilities are fulfilled* and shared meaning is achieved, an *episode of teaching has happened*.

After teaching has resulted in shared meaning, the student is ready to decide whether to learn or not. *Choosing to learn a grasped meaning is a responsibility of the learner and cannot be shared*. Each learner is responsible for his/her own learning.

A vee diagram, as introduced by Gowin, is an epistemological tool which explicates the principles of his educating theory and a means of guiding the *thinking* and *reflections* involved in *making connections* between the *conceptual structure* of a discipline on one hand, and its *methods of inquiry* on the other, as required for the investigation and analysis of a phenomenon or event to generate new knowledge claims as answers to some focus questions. A completed vee diagram would therefore provide a record of the conceptual and methodological analyses of a phenomenon/event to generate new knowledge. To guide the *thinking* and *reasoning* involved in *mathematical problem solving*, the original epistemological vee (see Gowin, 1981) was later modified by Afamasaga-Fuata'i (2005, 1998) as illustrated in Figure 1 (Appendix A).

The vee's left side, the "*Thinking*" side, depicts the philosophy or personal beliefs (i. e., *Why I like mathematics?*) and theoretical framework (i.e., principles: "*What general rules and definitions do I know already?*" and concepts: "*What are the important ideas?*") driving the investigation/analysis of a phenomenon/event (e.g., "*Problem*") to answer some focus questions (i.e., "*What are the questions I need to answer?*"). On the vee's right side, the "*Doing*" side, are the records (i.e., "*What is the information given?*"), methods of transforming the records (i.e., "*How do I … find my answers?*") to generate some answers or new knowledge claims (i.e., "*What are* *my answers to the [focus] questions?*") and value claims (i.e., through reflection: "*What are the most useful things I have learnt?*").

Uses of vee diagrams as assessment tools of students' conceptual understanding have been examined over time in the sciences (Novak & Cañas, 2006; Mintzes, Wandersee & Novak, 2000) and mathematics (Afamasaga-Fuata'i, 2008, 2005, 1998).

Mathematics Attitudes

Efforts in the classroom to redress the common societal perception that "mathematics is difficult" are often exacerbated no less due to the already entrenched attitudes and feelings that students have by the time they reach secondary level. Kloosterman & Gorman (1990) suggest that the formation of the belief that some students learn more readily than others and not everyone will be high achievers in school can lead to a notion that affects achievement in mathematics: the notion that it makes little sense to put forth effort when it does not produce results that are considered desirable. Also affecting learning and attitude are other factors such as motivation, the quality of instruction, time-on-task, and classroom conversations (Hammond & Vincent, 1998; Reynolds & Walberg, 1992) and as a result of social interactions with their peers (Reynolds & Walberg, 1992; Taylor, 1992)

Many studies have been conducted on mathematics attitudes and teaching (Leder, 1987; McLeod, 1992; Zan, Brown, Evans, & Hannula, 2006) but for the purposes of this project, McLeod's (1992) definition of attitudes is adopted: "*affective responses that involve positive or negative feelings of moderate intensity and reasonable stability*" (p. 581). McLeod contends that attitudes develop with time and experience and are reasonably stable, so that hardened changes in students' attitudes may have a long-lasting effect. Lefton (1997) also argues that attitude is a learned pre-disposition to respond in a consistently favourable or unfavourable manner towards a given object. Positive and negative experiences of school activities produce learned responses which may in turn impact on students' attitudes as they get older, when positive attitudes towards mathematics appear to weaken (Dossey, Mullis, Lindquist, & Chambers, 1988). Awareness of these complex interacting factors informed the research project in relation to the potential impact of the innovative meta-cognitive strategies on students' attitudes, motivation to complete mathematical tasks and subsequent mathematics performance.

Method

Using a single-group research design, the project monitored the impact the usage of vee diagrams and reflective stories had on students' mathematics attitudes and abilities to solve mathematics tasks. First, to determine changes in student's attitudes to mathematics, a pretest-posttest research strategy was used by administering questionnaires at the beginning and end of the project. Second, to track students' mathematics competence during the project, an interrupted time series design model was utilised by administering a diagnostic test three times (beginning, middle and end of project) to establish students' ability estimates at three different points. Third, weekly workshops were offered, which required students to apply vee diagrams to guide the analyses of tasks and to display both the solutions and conceptual bases of methods used. Fourth, students used their self-created concept lists from vee diagrams (vees) and/or given prompts, on a "*Tell Your Own Story*" (TYOS) sheet, to compose reflective responses of their mathematics experiences. Data from students' vee diagrams and reflective responses provided additional evidence to substantiate test results and document students' increasing proficiency or otherwise, using the innovative tools. The researcher also kept an anecdotal diary of the workshops.

A total of 32 Year 10 students took the pre-questionnaire (pre-Q) from 3 regional Australian schools (coded A, B and C) while 22 Year 10 students took the post-questionnaire (post-Q) from Schools A and B only. Approximately forty four (44) workshops throughout Terms 2 and 3, 2007 were offered, as extra assistance in mathematics. A workshop was held at least once a week over two school terms for each school (A, B and C). The researcher participated in all workshops assisted variously by student teachers (in Schools B and C) and in addition, a school teacher in School A.

Since the project deliberately set out to introduce vee diagrams and reflective compositions, educating the students to use this innovative approach, required that the teacher and students socially interacted and negotiated meaning to achieve a convergence of shared meaning about what needed to be done. The first workshop therefore focused more on familiarizing students with the vee diagram, its different vee sections and specific guiding questions and demonstrating the process of how a vee diagram may be completed using a simple mathematical task.

Incrementally introducing vee diagrams to students, they were provided with partially completed vee diagrams in which the sections: *Problem, What is the given information?, What are the questions I need to answer?* and *What are the main ideas?* were already completed. Their task was to complete the rest of the sections, namely: *What general rules or definitions do I know already?, How do I use the given information and what I know to find my answers?, What are my answers to the focus questions?, What did I learn as a result of solving the problem?* and *Why do I like mathematics?*.

As students became more familiar with the process of completing vee diagrams, increasingly more of the vee sections were left blank until only the problem and focus question sections were provided whilst students completed the rest. By encouraging students to think and reason from the problem statement (often a word problem), they were guided to identify the main ideas, articulate the relevant general rules and identify appropriate methods to generate solutions and answers for the problem's focus questions.

A similar incremental approach was also implemented with the TYOS prompts; students individually completed their sheets question by question after having a whole class discussion of the necessary process. Consequently, students, over subsequent workshops, progressively completed vee diagrams and TYOS prompts with the researchers and teachers facilitating and scaffolding students' efforts as students and teachers interacted and negotiated meaning towards a convergence of shared meaning. Whilst these joint endeavours did not always result in satisfactory completion of all questions/prompts by the end of a lesson, the social dynamics of classroom dialogue and conversations led to enlightenment about, and clarifications of, the purpose and role of the vee diagram and TYOS strategies in learning about mathematics and solving problems more meaningfully. By the sixth workshop, partially completed VEE DIAGRAMs provided only the *Problem*, *Focus Questions* and *Given Information* entries with the provision of only the *Problem* and *Focus Questions* entries by the ninth workshop until the end of the project, with the students left to complete the rest of the vee sections. This strategy ensured students were incrementally eased into learning about a different and new idea within the first few workshops.

Students were also allowed to discuss their ideas in pairs or groups of 3 but the final completion of VEE DIAGRAMs and TYOS sheets were done individually. Students were also invited to bring along problems to be solved from their normal classes and/or pose their own as challenge tasks for the application of the vee diagram and/or for the others to have a go at solving.

Weekly workshops involved the completion of vee diagrams of problems/activities followed by completion of the *Tell Your Own Story* sheet. The extent to which both of these two tasks were fully completed within one workshop differed between workshops as it was dependent on the time of day and prior classes students attended. It was not uncommon for students to take anywhere from 5 to 10 minutes of a 50 minute lesson to finally settle down to work particularly in the afternoon classes.

In general, the focus of each workshop was primarily for students to routinely develop and reinforce the processes of asking the guiding questions; reasoning with the given task description; identifying given information; reflecting upon their current knowledge in order to identify relevant concepts, principles and procedures; reflecting upon their solutions to formulate their value and philosophical claims; and then finally communicating their constructed meanings through entries in their vee diagrams and responses to TYOS prompts. Whilst the processes of thinking, reasoning and reflection were continually reinforced with each subsequent workshop session, students were also encouraged to consider how the same strategies could be applied in their normal classes.

Data Analysis

Response categories for the questionnaires items were scored 1 to 5 in increasingly levels of positive attitudes (variable) towards mathematics whereas responses to test items were scored 0 (incorrect) and correct (either 1 or 2) to indicate zero, partial and/or full credit in successfully completing an item (i.e., variable: mathematical competence). These responses were then added across items to give each person a total score to summarise a student’s responses to all items. A person with a higher total score than another is deemed to show more of the variable assessed. Summing the item scores to give a single score for a person implied that the items were intended to measure a single variable, often called a *unidimensional variable*.

Analyses of questionnaire and test data were conducted using the Rasch Unidimensional Measurement Model (RUMM) (Rasch, 1980) and the software Quest (Adams & Khoo, 1996). The Rasch model is the only item response theory (IRT) model in which the total score across the items characterizes a person totally. It is also the simplest of such models having the minimum of parameters for the person (just one) and just one parameter corresponding to each category of an item (generally referred to as a threshold). The case where the response categories are the same across items (e.g., SD, SD, N, SA, VSA) the Rasch model has been called the “rating scale model”; the case where the response categories are different across items has been called the “partial credit model” (e.g., 1 or 2 marks). However, the literature (Rasch Analysis, 2005; Bond & Fox, 2001) argue that the structure and response process for a person responding to an item is identical in the two specifications. Rather than emphasizing two models for the above different specifications, it is more efficient to refer to one RUMM with different numbers of categories and different parameterizations. For a dichotomous item, there is just one threshold whilst there is two in the case of three ordered categories (Rasch Analysis, 2005).

The Rasch Model, where the total score totally summarises a person’s standing on a variable, is based on a fundamental requirement: *that the comparison of two people is independent of which items may be used with the set of items assessing the same variable* (Rasch Analysis, 2005; Bond & Fox, 2001). Thus the Rasch model is taken as a criterion for the structure of the responses which they should be satisfied, rather than a mere statistical description. For example, comparison of the performance of two students’ work marked by different graders should be independent of the graders. In this case, it is considered that the researcher is deliberately developing items that are valid for the purpose and that meet the Rasch requirements (Rasch Analysis, 2005). The Rasch Model provides a range of details such as infit mean squares [ims] and standardized infit *t* [infit *t*] for the purpose of testing the fit of the data to the model (i.e., *test of fit*). For example, if item infit and outfit mean square values lie within a specified range (often 0.83 to 1.20) around 1.00, then items are accepted as fitting the model. If not, then a theoretical consideration against the purpose of the test/questionnaire is necessary to determine whether or not to delete the item from further analysis. If the data fit the model, the Rasch analysis linearises the score, bounded by 0 and the maximum score on the items, into measurements. This linearised value in logits determines the *location of the person* on the unidimensional continuum (Rasch Analysis, 2005; Bond & Fox, 2001).

The model is therefore paramount and misfit suggests the items or questions are not working together consistently to define an interpretable construct. Hence, evaluation of the fit of the data to a Rasch model provides information about the coherence of items to measure the underlying theoretical variable or construct. Separation reliability indices are also provided by the Rasch analysis to indicate how well the items and persons worked consistently to produce valid measures of the underlying variable.

For the project, thirty four (34) items in the attitude questionnaire used a 5-point Likert scale with response categories ranging from Very Strongly Agree (VSA), Strongly Agree (SA), Neutral (N), Strongly Disagree (SD) to Very Strongly Disagree (VSD) with marks for test items ranging from zero (incorrect) up to 2 marks to represent partial and/or full credit for different items. Subsequently, all questionnaire and test results were analysed using the RUMM.

The response data from the vee diagrams and reflective stories, on the other hand, were analysed qualitatively. Students' responses were collated and recorded in a spreadsheet in preparation for the identification of emerging main categories and subsequent development of a framework to organize its presentation in a more meaningful manner.

For this paper, the initial analysis of students' attitudes reported in Afamasaga-Fuata'i (2009) was extended further to examine the type and nature of items that shifted (positively and negatively) over time. In addition, a comparison of students' responses to the single open question in the questionnaire: Item 35 (*I intend to take mathematics next year*) was conducted to provide additional data to specifically answer this paper's focus questions. A copy of the questionnaire is in Figure 2 (Appendix A).

Results

Results from the extended analysis of questionnaire data is presented first followed by those from the open questionnaire item about students' intention to continue studying mathematics in the following year at Year 11.

Rasch analyses of students' responses to questionnaire items showed the overall fit for both items and persons, on average, was acceptable. An inspection of each item's fit however showed 6 items were outside the acceptable limit; consequently, the 6 misfit items were deleted from further analysis. Subsequent analysis confirmed all ims values were within the acceptable limit, thereby corroborating the fit of the data to the Rasch model. Findings (adequate fit of the data to the model, high person separation index and high Cronbach alpha) collectively indicated all items worked together to define and measure a single underlying construct and the persons who attempted the items performed in expected ways (see Afamasaga-Fuata'i, 2009). For example, those with positive attitudes were separated out along the continuum towards the top and those with negative attitudes towards the bottom.

Pre-questionnaire (pre-Q) and post-questionnaire (post-Q) comparisons (Table 1, Appendix A) indicated no statistically significant, difference in attitudes between administrations (p=0.18) and a small effect size (0.16). One way of interpreting the construct: "mathematics attitudes" as measured by the questionnaire items, is to analyse the items that were clustered at the top (positive attitudes) and bottom (negative attitudes) ends of the variable maps for the pre- and post-questionnaires (see Figure 3, Appendix A). The results of such an analysis indicated that "positive mathematics attitudes appeared variously described by strong feelings of liking, interest, enjoyment, intellectual challenge, not worrying and not being nervous when doing mathematics, the promotion of creative thinking and development of flexible methods of solution as calibrated for the pre-Q variable map. In contrast, by the end of the project, positive mathematics attitudes continued to be holistically described by these strong feelings and intellectual challenge and in addition, mathematics becoming a most favourite subject, perceiving teacher assistance (or scaffolding) as a positive requirement, being convinced that best strategies for flexibly solving problems and learning mathematics can result from a conceptual understanding of methods used and that these skills have cross-curricular value. Collectively, these positive descriptors (in terms of thinking, feeling, and acting in mathematics) lent support to their strong belief in their own abilities and potential to learn advanced mathematics. In contrast, poor mathematics attitudes at the beginning of the project appeared described by strong negative feelings (e.g., nervousness, blank minds, and strong dislike) and negative actions (e.g., resorting to memorization strategies in problem solving) and strong disagreement about the perceived usefulness of mathematics for a successful life. By the end of the project, some of these concerns became more positive except for the real-life relevance and mathematics' cross-curricular usefulness. In addition, negative attitudes were newly indicated by disagreements with the role of models/diagrams in problem solving, students' willingness to improve their mathematical understanding, continuing disenchantment with mathematics, and perceived irrelevance in understanding newspaper reports and finance graphs" (Afamasaga-Fuata'i, 2009, p.36).

For this paper, further analysis of the pre-Q and post-Q item estimates was conducted to identify the nature of the shifts of item estimates (or locations on the variable maps) between the two administrations, and any emerging categories. Consequently, provided in Table 2 is a comparison of item estimates (Columns 2 & 3), including standardized differences (δ_1 - δ_2) (Column 7) for the 14 items with complete data sets. An inspection of Column 9 revealed that only two items had differences that were statistically significant (e.g., Items 22: *Mathematics is not my strength, I avoid it whenever I can* [p=0.01] and Item 28*: To succeed in life you need to be able to do mathematics* [p=0.05]). For the former, the post-Q attitude estimate was relatively more negative while it was relatively more positive for the latter item. This might be interpreted to mean that students do realise the usefulness of mathematics in life but their efforts (or lack thereof) are unfortunately hampered by their current inability to do well in mathematics.

Further examination of the standardized differences (std'ised [δ_1 - δ_2]), Column 7, Table 2) indicated two categories, namely positive and negative values. Labelling these categories as those that "became more negative" (positive std'ised [δ_1 - δ_2]) and those that "became more positive" (negative std'ised [δ_1 - δ_2]) provided the results shown in Table 3. It appeared that Column 1 items (Table 3) indicate that project experiences may have influenced some ED students' attitudes to be more entrenched and/or gravitate towards the negative direction (i.e., item estimates became more negative). More particularly, project experiences for some ED students may have further reinforced that (i) mathematics is not their strength; (ii) they do not always enjoy studying mathematics; (iii) mathematics is not needed for understanding newspaper reports and graphs; (iv) they often need teacher support, (v) mathematics is not their favourite subject; (vi) they have blank minds and are unable to think when doing mathematics; (vii) they often avoid problems if they are unable to solve; and (viii) rules learnt in previous classes are forgotten.

Table 2
Year 10 Cohort Comparison of Item Estimates from the Two Questionnaires

ITEM NAME	Delta preq	Delta postq	Adjusted Delta preq d1	Adjusted Delta postq d2	Difference d1-d2	Difference d1-d2 std'ized	Chi-SQ	p
item 1	0.29	0.30	0.27	0.32	-0.05	-0.15	0.02	.88
	0.22	0.22						
item 2	-0.11	-0.16	-0.13	-0.14	0.01	0.05	0.00	.96
	0.19	0.19						
item 3	-0.01	0.09	-0.03	0.10	-0.14	-0.45	0.21	.65
	0.21	0.22						
item 5	0.14	-0.43	0.12	-0.42	0.53	1.90	3.60	.06
	0.18	0.22						
item 6	-0.10	-0.06	-0.13	-0.05	-0.07	-0.27	0.08	.78
	0.19	0.19						
item 12	0.12	0.22	0.10	0.23	-0.13	-0.42	0.18	.67
	0.18	0.26						
item 14	0.03	0.05	0.01	0.06	-0.05	-0.18	0.03	.86
	0.19	0.22						
item 15	-0.38	0.13	-0.41	0.14	-0.55	-1.77	3.13	.08
	0.21	0.22						
item 16	0.39	0.35	0.36	0.36	0.01	0.03	0.00	.98
	0.17	0.20						
item 19	0.59	0.54	0.57	0.55	0.02	0.08	0.01	.94
	0.18	0.20						
item 22	0.32	-0.36	0.30	-0.34	0.64	2.45	6.01	.01*
	0.17	0.20						
item 28	-0.53	-0.04	-0.55	-0.03	-0.52	-1.95	3.81	.05*
	0.19	0.19						
item 29	-0.29	-0.52	-0.31	-0.50	0.19	0.55	0.30	.59
	0.22	0.28						
item 33	-0.15	-0.28	-0.17	-0.27	0.10	0.35	0.12	.73
	0.19	0.22						
Means	0.02	-0.01	0.00	0.00	ChiSQ=17.49(df=13,p=0.18)			

*signficant

In contrast to Column 1 items, those in Column 2 (Table 3) suggest project experiences may have influenced students' attitudes to be more positive. For example, item estimates' shifts in the positive direction demonstrate that students' increased belief that (i) one needs to be able to do mathematics to succeed in life; (ii) mathematics is learnt by understanding the main ideas not memorise rules and procedures; (iii) they like solving mathematics problems; (iv) they do not feel nervous in mathematics classes and they feel they can do the mathematics; (v) understanding mathematics means more than simply memorizing steps and formulas; and that (vi) mathematics is interesting and mathematics classes are enjoyable.

Overall, the extended analysis revealed that the "became more negative" items tended to be the ones that reinforced negative attitudes whilst "became more positive" items plausibly reflected some influence of the innovative, meta-cognitive and problem solving strategies particularly in expanding students' perception of mathematics learning beyond a "doing and rote memorization" view to one that emphasizes the importance of understanding the main ideas that underpin methods, procedures and formulas.

Table 3
Standardised Differences (Pre-Q δ_1 estimate – Post-Q δ_2 estimate) δ_1 - δ_2

Became more negative		Became more positive	
Item 22: Mathematics is not my strength and I avoid it whenever I can.	2.45*	Item 28: To succeed in life you need to be able to do mathematics.	-1.95*
Item 5: I have always enjoyed studying mathematics in school.	1.90	Item 15: I learn mathematics by understanding the main ideas, not by memorizing the rules and steps in a procedure.	-1.77
Item 29: Mathematics is needed in understanding newspaper reports and finance graphs.	0.55	Item 3: I like solving mathematics problems.	-0.45
Item 12: Most of the time, I need help from the teacher before I can solve a problem	0.10	Item 6: I am nervous in mathematics classes because I feel I cannot do mathematics	-0.27
Item 19: My most favourite subject is mathematics.	0.08	Item 33: I do not have to understand mathematics, I simply memorise the steps to solve a problem.	-0.17
Item 2: When doing mathematics, my mind goes blank, and I am unable to think clearly.	0.05	Item 1: Mathematics is very interesting to me and I enjoy my mathematics classes.	-0.15
Item 16:If I cannot solve a mathematics problem, I just ignore it.	0.03		
Item 14: I have forgotten many of the mathematical rules I learnt in previous mathematics classes.	0.01		

*significant (see Table 2)

Year 10: To continue or not with mathematics in the following year

Pre-questionnaire responses to Item 35 (*I intend to take mathematics next year*) showed that 60.7% (n=33) of the students said they would compared to 50% (n=22) by the post-questionnaire. Students' explanations for their decisions appeared influenced by their perceptions about mathematics' utilitarian value, love, dislike of the subject and/or no reward for effort as briefly described below and illustrated by supporting quotes in Table 4.

Table 4
Main Categories of Student Explanations for Continuing with Mathematics

Main Category	Supporting Quotes
Utilitarian value	*Because maths will help later on in life with general things.* *Because it is useful.* *Because it's useful to learn & know about mathematics. It will help me in latter life with jobs and paying the bills.* *Because I really need a bit of help because I may need it in life e.g., bills.* *Well, I would like to be a builder. So if I don't get a job at the end of the year as a builder, I will (continue with mathematics).* *In case I want to do a job in the future that involves maths.* *Yes Because I will need it when I get a job in the future.* *I am continuing maths because I am going to need it in every day use when I am older.* *Yes I stay on because it will help maybe later on for careers.* *Only for year 11. I will probably drop it from yr 12 because I don't like it and I'm bad at it.* *It depends on the career path I want to take. I might need or not need it. But only because Mum says I have to. I don't like it very much unless I understand.* *I don't need maths for what I'm hoping to be later down the track.* *Maths is not a requirement I need for my job.*
Love of mathematics	*Yes because I believe I need to improve my understanding of this subject.* *To help me a bit more. Because I want to learn and understand maths more.* *To improve my learning skills and to improve at maths.* *Yes Because I want to get better at maths.* *I will take it next year to have the basic understanding of maths and I feel that it is important.* *I think mathematics is a very useful skill & can be fun.* *Because I would like to learn more about it and understand it better.* *I need to improve.* *Cos I enjoy maths.* *I intend to continue maths because it's fun sometimes.* *Because I like it.* *I really enjoy maths its one of my favourite subjects.* *I can learn by the teacher explaining what I have to do & to be with me along the way. I learn heaps also by talking to people about it.* *Because I really enjoy it all the time & my friends do too. Also that because it's the bestest subject that I do. But sometimes I feel that I'm not doing very good.*
Dislike of mathematics	*I hate maths and I can't do it.* *Because I don't really want to.* *Because I don't want to.* *No because I don't enjoy it.* *I don't really like maths, even if I was good at it.* *No I hate maths so I am not doing it next year.* *Probably won't take it because its on the same line as another subject I wanna do.*
No reward for effort	*Because I'm not a very good mathematician and I don't enjoy it that much.* *I really want to but I'm in the bottom maths & don't get very good marks & I feel that might do better in another subject, because I'm bad at Mathematics.* *Because I am failing and I don't wish to do maths in school next year because I think it will be a waste of time and I won't pass.* *I find maths more difficult than any other subject and would not do it over something I like doing.*

Utilitarian value – Students reasoned that they would continue to take mathematics because it is useful to learn and know for general things they do in life (e.g., paying bills, a future job as a builder, or careers in general) or because of their parents' expectations.

Love of mathematics - Students justified their continuation with mathematics intrinsically, based on their interest, enjoyment and liking for the subject thus they argued that it is important to continue learning, understanding and knowing more of it.

Dislike of mathematics – Students' decision not to continue with mathematics is emotively or experientially rationalized in terms of their negative feelings towards the subject, perceived inability to succeed in spite of efforts to perform better, apparent irrelevance to future career aspirations, or timetable clashes with another preferred, more likeable subject.

No reward for effort – Students recognize their own mathematical abilities based on previous and current experiences and concluded that there was no sense in taking a subject which they know they will not pass.

In addition to the listed categories, some students were ambivalent about their intentions to continue as reflected by responses such as "*Maybe I don't know yet*" and "*Don't know haven't thought about it.*" Other students opted to discontinue studying mathematics because they were leaving school at Year 10 (e.g., "*I'm not coming back next year so I'm not doing it.*"). Overall, it appeared that this group was split between continuing on with mathematics and discontinuing it after Year 10.

Discussion and Main Findings

Students' responses and subsequent analyses as presented in this paper was an attempt to answer the paper's focus question, namely, *Why is it that, in the classroom, when students are provided with the opportunity to be innovative and creative in their own approaches, these are not often readily accepted or welcomed?* The discussion below is organized around the main findings resulting from the extended analysis of questionnaire items and examination of student responses to the open question on continuation of further studies in mathematics. Overall, the literacy-numeracy project specifically examined the impact of two innovative meta-cognitive strategies on students' achievement of numeracy and literacy outcomes and attitudes towards mathematics; the latter being the focus of this paper. For this paper, the author was particularly interested in examining why students, instead of readily embracing the new innovation, initially struggled and tended not to sustain interest in it. Hence, to provide some answers, (1) the variations in item estimates between the pre- and post-Q administrations and (2) students' reasons for continuing/discontinuing further studies in mathematics were examined.

Item estimate variations – The shift in item estimates and the resulting two categories demonstrate that the innovative, meta-cognitive strategies introduced and implemented in the workshops influenced students' mathematics perceptions and attitudes two different ways.

First, a positive influence was demonstrated by items directly reflecting the fundamental ideas and processes promoted through the completion of vee diagrams and reflective stories, namely, identifying main ideas underpinning methods, procedures and formulas; developing a much broader (and more conceptual) perception of learning mathematics beyond simply doing the problem and rote memorizing formulas and procedures; enjoyment in solving problems; and perceiving a strong association between their mathematical ability and success in life.

Second, a negative influence was demonstrated with items describing avoidance actions; inability to think clearly; and acceptance of their abilities to do mathematics when problems are difficult. Item variations also confirmed their dependence on teacher support for guidance; lack of enjoyment studying school mathematics; their least-liked subject; and not needed for understanding newspaper reports and graphs.

Overall, the results demonstrated that, as a consequence of the innovative project, some students continued to develop more positive attitudes whilst others became more entrenched in their negative attitudes towards mathematics. Given the short-term duration of the innovative project, and as pointed out by McCleod (1997), attitudes develop with time and experience and are reasonably stable so that hardened changes may have long lasting effect. It is therefore reasonable, one hand, to expect that for students, who have had consistently poor experiences in mathematics, that they would take a much longer time (than the duration of the project) for their entrenched, negative attitudes towards mathematics to change. On the other, students who already feel positive about, and confident in, their mathematical abilities appeared to have even more positive attitudes as a result of the promotion of student autonomy in their own learning and development of their own mathematical ideas and ways of knowing and learning about mathematics as they completed vee diagrams and composed reflective responses in the project. In relation to the paper's focus question, the findings demonstrated that the nature of students' responses to the attitudinal questionnaire appeared to have been much influenced by their regular classroom practices with subsequent beliefs and attitudes (positive and negative) enculturated as a result of these experiences and that their participation in the short-term project appeared to push them further in the direction of their developed attitudes and perceptions.

Continuation with the Study of Mathematics - In the light of the above discussion of students' entrenched and developed perceptions about, and attitudes towards, mathematics learning, the emerging categories of students' reasons for continuing or discontinuing mathematics studies demonstrated that for about half of the students, despite their expressed attitudes (especially if they were negative) they still preferred to continue studying mathematics in the following year for utilitarian reasons and/or their love of mathematics. Some students recognize that they need to improve their performance and learn more mathematics. The other half of the students explicitly preferred not to continue with mathematics because they do not like the subject and they saw no reason to continue studying a subject that leads to failure and provides little reward for a lot of effort. Some students also indicated they would leave school at the end of Year 10.

Implications

The main findings presented above from the two sets of analyses have implications for teaching and learning mathematics and the evidence-based need to put in place innovative programs to inspire students much earlier than Year 10. Furthermore, the usefulness of vee diagrams as an epistemological tool for thinking, reasoning, justification and reflection should be made more explicit to students much earlier than Year 10 to enculturate some positive perceptions of their own learning and love of mathematics. Allowing students to communicate the benefits of vee diagrams in problem solving could draw students' attention to the potential of vee diagrams to systematically guide their thinking, reasoning, justification, reflection and communication during and after problem solving. It was evident that students appreciate and enjoy solving mathematics problems that provide them with a positive learning experience and feeling of significance that they have understood the new meaning; therefore teachers should explicitly encourage students to think, reason, make connections to their existing knowledge, reflect on their learning and communicate their new meanings during and after problem solving experiences. Teacher-led discussions which draw out the educational value of thinking, reasoning, justification, and reflection would be useful in promoting a more comprehensive and conceptual view of doing mathematics and hence more positive attitudes towards mathematics. Teachers should be encouraged to support the use of vee diagrams and reflective prompts in the classroom to support students' thinking, reasoning, justification, reflection and communication of their mathematical learning as promoted through productive and quality teaching and learning frameworks.

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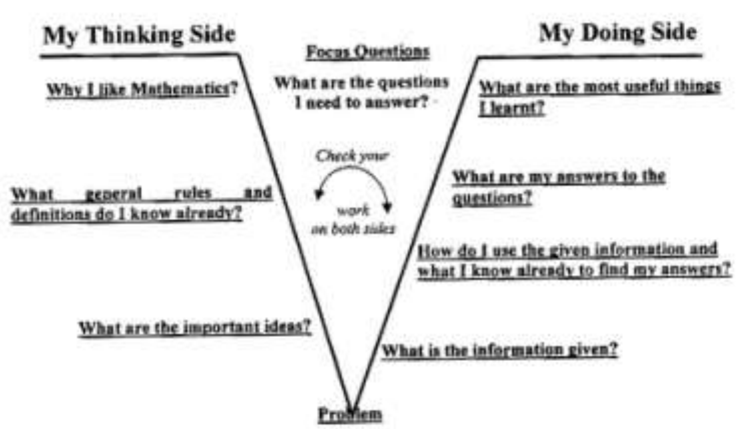
Appendix 1
Mathematics Problem Solving Vee Diagram



Appendix 2
Mathematics Attitude Questionnaire

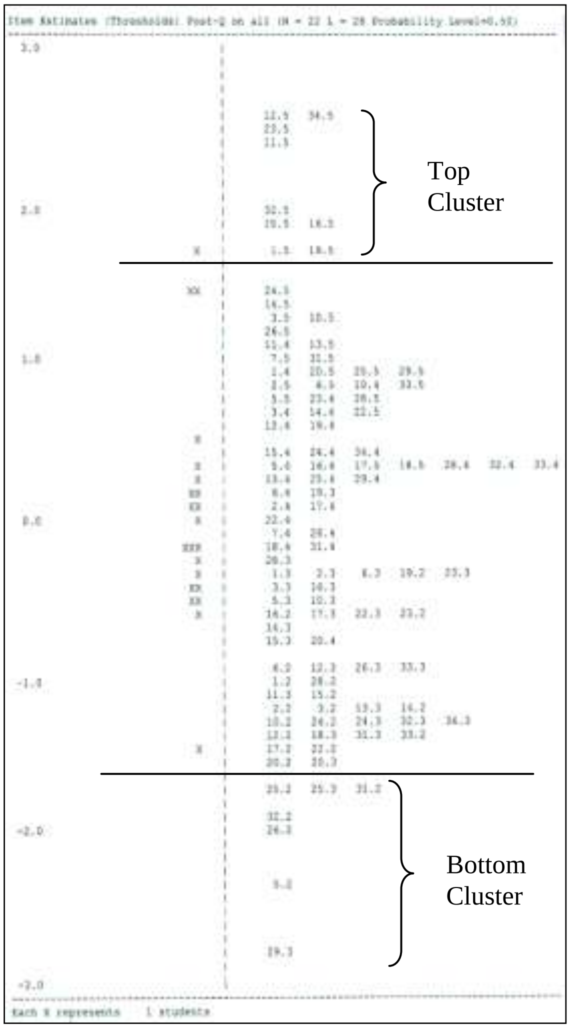
1. Mathematics is very interesting to me and I enjoy my mathematics classes.
2. When doing mathematics, my mind goes blank, and I am not able to think clearly.
3. I like solving mathematics problems.
4. Mathematics makes me feel uncomfortable and impatient.
5. I have always enjoyed studying mathematics in school.
6. I am nervous in mathematics classes because I feel I cannot do mathematics.
7. It makes me nervous to even think about having solving a mathematics problem.
8. I really like mathematics; it's enjoyable.
9. I can cope with a new problem because I am good in mathematics.
10. I get worried when solving a problem that is different from the ones done in class.
11. I can find many different ways of solving a particular mathematics problem.
12. Most of the time, I need help from the teacher before I can solve a problem.
13. I believe that if I use what I know already, I can solve any mathematics problem.
14. I have forgotten many of the mathematical concepts that I have learnt in previous mathematics classes.
15. I learn mathematics by understanding the main ideas, not by memorizing the rules and steps in a procedure.
16. If I cannot solve a mathematics problem, I just ignore it.
17. Successfully solving a problem on my own provides satisfaction similar to winning a game.
18. I feel nervous when doing mathematics.
19. My most favourite subject is mathematics.
20. Mathematics classes provide the opportunity to learn skills that are useful in daily living.
21. To succeed in school, you don't need to be good in mathematics.
22. Mathematics is not my strength and I avoid it whenever I can.
23. I don't think I could learn advanced mathematics, even if I really tried.
24. Doing mathematics encourages me to think creatively.
25. I learn to think more clearly in mathematics if I make a model or draw diagrams of the problem.
26. Mathematics is important for most jobs and careers.
27. Solving mathematics problems helps me learn to think and reason better.
28. To succeed in life you need to be able to do mathematics.
29. Mathematics is needed in understanding newspaper reports and finance graphs.
30. Communicating with other students helps me have a better attitude towards mathematics.
31. I am interested and willing to improve my understanding of mathematics.
32. The skills I learn in mathematics will help me in other subjects at school.
33. I do not have to understand mathematics, I simply memorise the steps to solve a problem.
34. I learn mathematics well if I understand the reasons behind the methods used.
35. I intend to continue taking mathematics next year.

Appendix 3
Rasch Results of the Year 10 Questionnaire Data

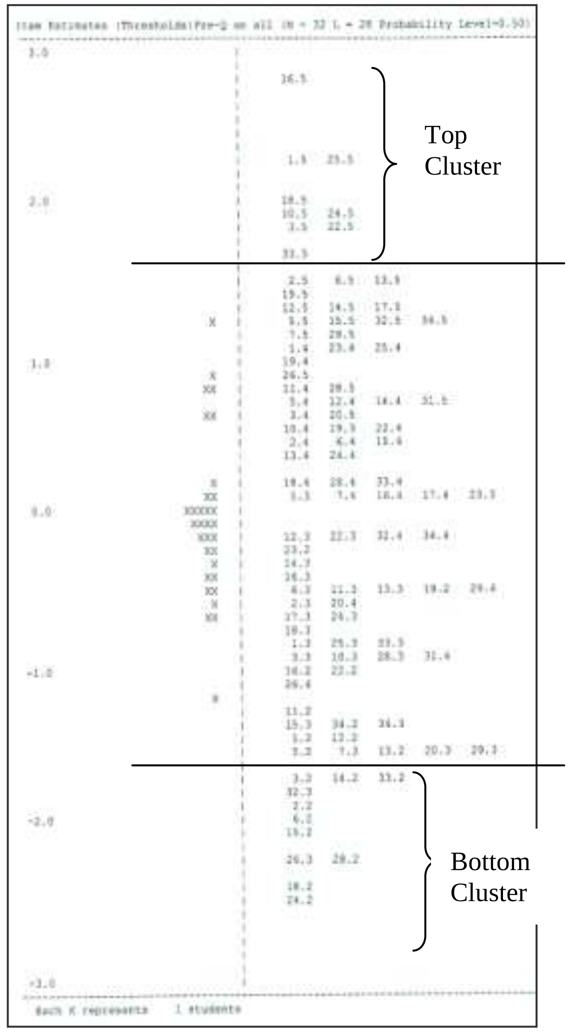
	Pre-Questionnaire	Post-Questionnaire
Items	n = 28	n = 28*
Mean Estimate	0.00	0.00
Standard deviation	0.36	0.37
Item Separation Reliability	0.00	0.00
Items with zero scores	0	0
Items with perfect scores	0	0
Cronbach's Alpha	0.82	0.90
Persons	n = 32	n = 22
Mean Attitude Estimates	- 0.03	0.05
Standard deviation	0.49	0.69
Effect size		0.16 (small)
Case Separation Reliability	0.83	0.92
Cases with zero scores	0	0
Cases with perfect scores	0	0
Mean Questionnaire score (s.d.)	49.63 (11.80)	55.64 (16.92)
Effect size		0.52 (medium)

*the other 6 items did not have complete data sets

Appendix 4
Item clusters for the pre- and post- questionnaire data



(a)



(b)

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Assessing Students' Meaningful Learning through a Paper and Pen Test

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Students' meaningful learning can be assessed in a paper and pen test by deliberately asking questions that require them to indicate deep understanding of complex ideas that are relevant or real life. These questions are of higher order thinking skills outlined in the revised Bloom's Taxonomy of Educational Objectives. This study aimed to describe the indicators for students' meaningful learning after they had gone through a series of group activities where they discuss and engage in meaning making of an authentic task involving modeling of linear equations and functions. A six-item paper and pen test with open ended questions and problems was administered to a class of freshmen taking Bachelor of Science in Education major in Mathematics. In depth analysis of four selected students' written solutions and explanations was used to describe their meaningful learning. Results indicated that three of the four students had positive learning outcomes than the errors they committed which were mostly due to careless miscalculations. Apart from doing menial tasks as graphing and doing computations, students were challenged to give reasons on the mathematical processes they needed to go through and apply what they learned in different contexts.

Keywords: Meaningful learning, deep understanding, linear equations, functions

Meaningful learning is achieving deep understanding of complex ideas that are relevant to students' lives (Jonassen, Peck and Wilson, 1999). Kierkegaard posits that "In order to help our students to learn effectively, we teachers must understand what he understands… and in the way he understands it" (cited in Kegan, 1994, p.278). This means, more than being able to see if a student gets the correct answer or not, teachers should know students' thinking and reasoning skills on a concept so that misconceptions could be corrected or student's correct novel approaches could also be encouraged.

The revised Bloom's Taxonomy of Educational Objectives (Anderson & Krathwohl, 2001) can be used to assess the meaningful learning of students (Clark, 2002). Meaningful learning occurs if students are able to apply higher order thinking skills in solving problems, in explaining or elaborating on Algebra concepts. These higher order thinking skills (as outlined in the revised Bloom's Taxonomy of Educational Objectives) are apply, analyze, evaluate, and create.

This study is both descriptive and qualitative. It describes what concepts in linear equations and functions students have learned after a series of activities they were engaged in social interaction with one another. The focus of the study involves only four cases, but in depth results of their written work are reported here. This study suggests a way to make meaning how students understand the concepts learned in the class activities. It aims to answer the question "to what extent has meaningful learning occurred after each activity?"

This is a case study of four students who were selected on the basis of their self-efficacy (confidence) levels in Algebra. The four cases selected included two students identified as having the lowest self-efficacy and two students having the highest self-efficacy. Students' profile as to their background in their high school mathematics was gathered at the start of the term: name, type of high school where they graduated from, and their age. Careful scrutiny and analysis for the reporting of the results in the study was anchored on these four cases.

The research question posed was systematically pursued using the basic interpretative qualitative research design. Qualitative data for the students' perceptions, insights, and knowledge claims as they engaged in collaborative metacognitive activities were collected from the solutions and answers in paper and pen tests which were carefully analyzed for their meaningful learning. The detailed description of meaningful learning necessitated the use of specific cases. Hence, a multiple case study research design was also employed.

Meaningful Learning

To measure students' meaningful learning, mean scores from the three pencil and paper tests were used. The researcher relied on the solutions and answers students indicated to illustrate whether they can apply, analyze, evaluate and create as defined in the revised Bloom's Taxonomy of Educational Objectives. Success in these test items indicated that students have demonstrated higher levels of cognitive functioning in contrast to rote learning.

Meaningful Learning from Students' Paper and Pen Tests

Table 1
Students' Paper and Pen Test Scores in Percentages

	Linear Equations and Functions
Patricia	96
Ria	80
Michael	90
Sara	62

Although, in as much as the teacher who rated these papers tried his best to be objective, judging from these averages, both Michael and Sara demonstrated satisfactory understanding of the necessary concepts in linear equations and functions. Looking at Ria's and Sara's quizzes, one may doubt if they really had meaningful learning because these scores were satisfactory. Clearly, Ria and Sara's low scores in their tests show that they were not able to exhibit higher levels of cognition. Therefore, these test scores were not sufficient to show that Ria and Sara had meaningful learning. To a limited extent, it can be deduced that they had somewhat meaningful learning.

Paper and pen test on linear equations and functions (first metacognitive activity).

Patricia was able to relate the words “uphill” and “downhill” to slope of lines. She creatively used directions (southwest to northeast and northwest to southeast) and drawings of a hiker to illustrate her point. Clearly she understood the concept of slope. She was able to explain vividly in her own way how the slope can be related to a different context such as climbing up and down a hill. Her answer was considered the best in this item in the class. Please see the next figure.

Patricia correctly answered all items except a mistake in the graph. Patricia sketched the graph correctly with the use of the x and y intercepts, and labeled them properly but failed to check if all values in the line are meaningful. She included even the negative values in the graph when the quantities in the problem represent only positive values.

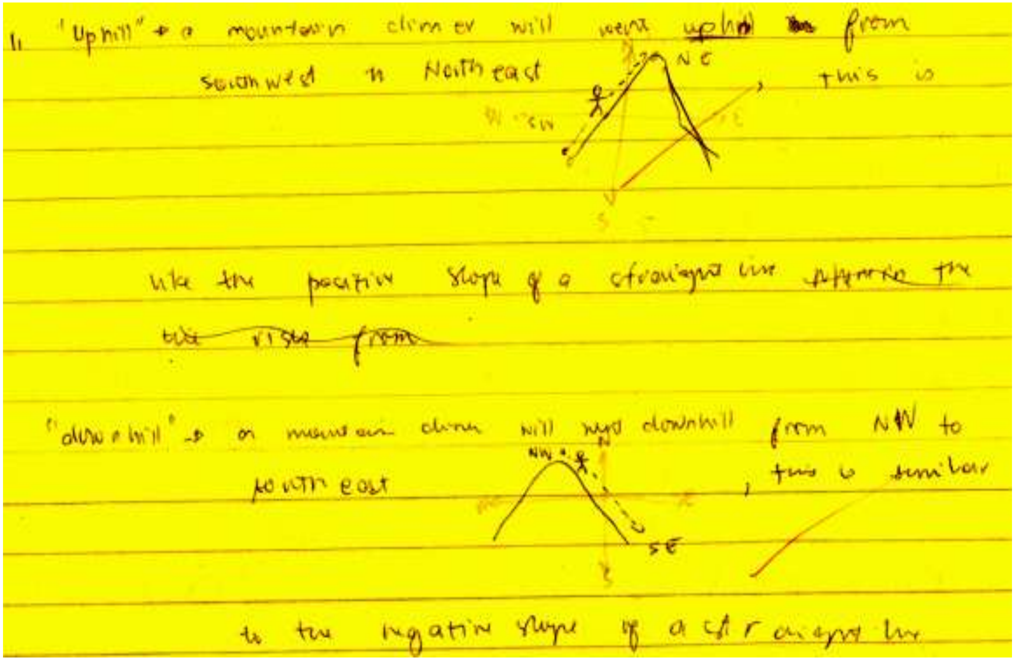


Figure 1. Patricia’s answer in quiz 1 item 1

Patricia was careful in her calculations in solving the problems. She wrote down given values and labeled them, gave representations of the variables she used in the equation, represented costs, income and profit with correct equations and correctly evaluated for the required quantities asked in the problem. She also understood that rates of change are slopes of a linear function.

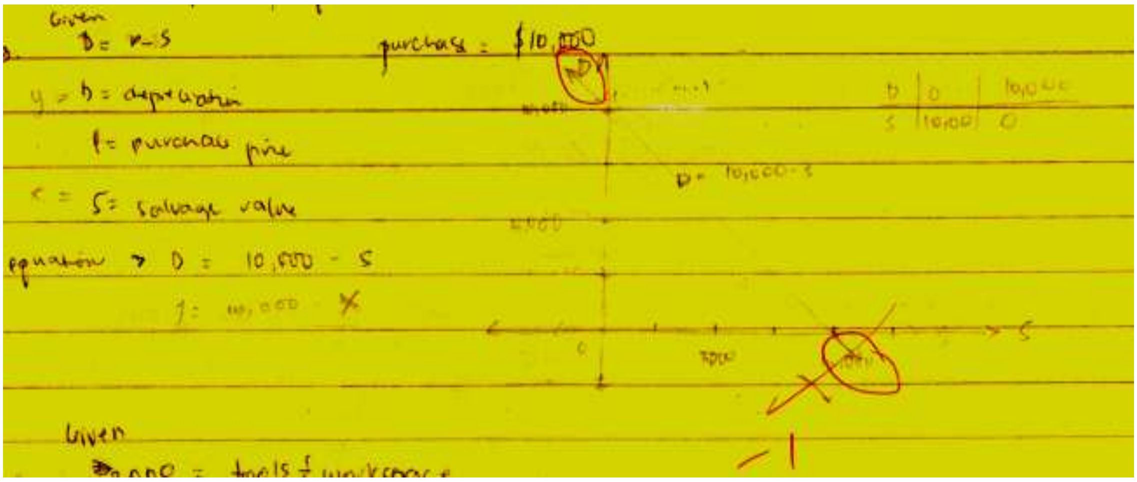


Figure 2. Patricia’s answer in quiz 1 item 2

Both Patricia and Ria were able to explain clearly why the *y*-intercept is indicated as the value of *b* in the equation. However, they did not mention the definition of the *y*-intercept instead they made use of the procedure of obtaining the *y*-intercept by setting the *x* value in the equation to zero. Nevertheless, both were able to articulate their reasoning.

Ria gave an example to illustrate her understanding of the slope as it relates to the words “uphill” and “downhill”. She made use of analogy of going up and down the hill as going up and down in a Cartesian plane.

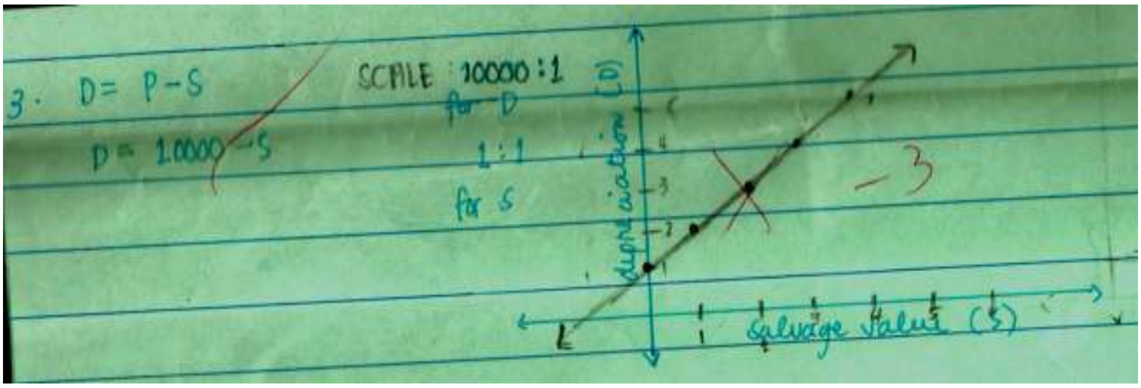


Figure 3. Ria’s answer in quiz 1 item 3

Just as Patricia, Ria also included the negative values in the graph which were meaningless values in the problem. On top of that she indicated a scale of 8:1 that only applies to the y-axis. She did not properly label the scale as applying it only on the y-axis. Her graph can be interpreted as applying the scale to values of both the x and y axes. In another item, Ria did not only include the negative values in the graph, she also had a graph that has positive slope when the equation clearly showed a negative slope. The Points in her graph gave values that were inconsistent with their true values in representing equations.

Ria had difficulty in problems involving cost and profit. She did not include the cost of materials needed to make an item unit in the cost function. Although she correctly represented the income function, her profit function was incorrect because it required the use of the cost function. Consequently, she gave wrong answers in subsequent sub items that made use of the profit function. In her interview, she explained that her lack of exposure and familiarity to this kind of problem had caused her points for her quiz. Please refer to the next figure.

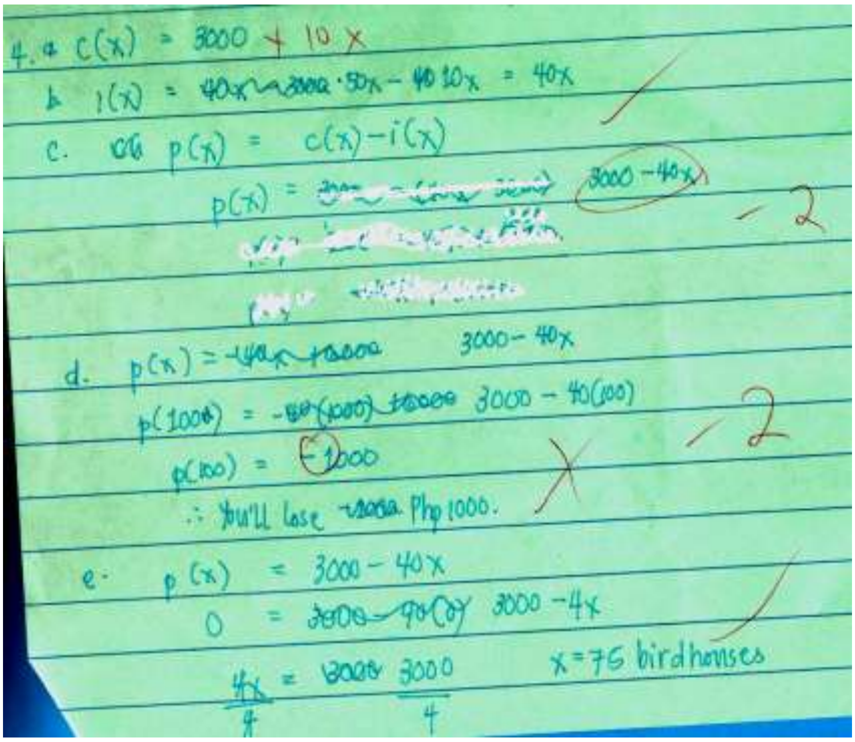


Figure 4. Ria's solution and answer in quiz 1 item 4

In another item, Ria listed the given values in a tabular form. She also made use of the two-point formula in writing the linear equation. However, along the way, she made a careless computation. Please refer to the figure shown below.

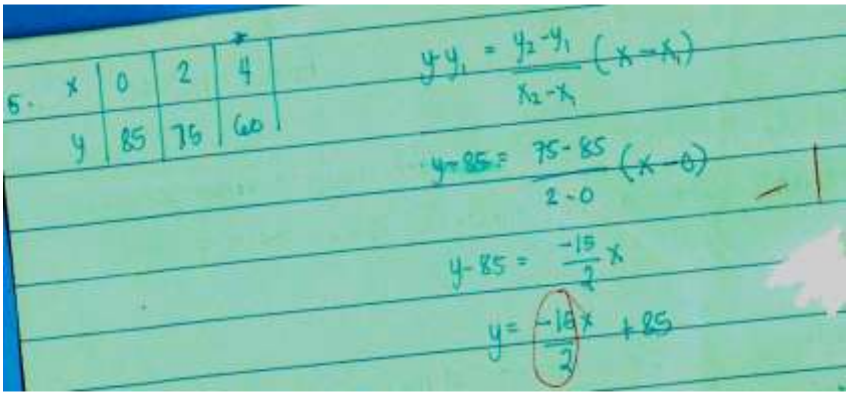
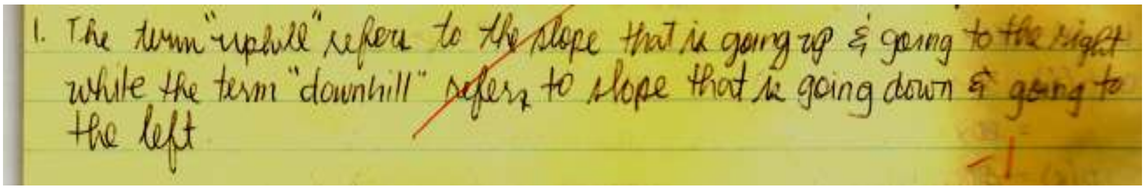


Figure 5. Ria's solution and answer in quiz 1 item 5

Michael related the terms "uphill" and "downhill" to the slope by illustrating directions (going up and right; going down and left) but he incorrectly mentioned downhill as going down and left (refer to Figure 25). Not only was he able to sketch the graph correctly with complete labels, he was also able to consider only realistic values in the graph. He correctly identified what properties of lines (slope, y-intercept, x-intercept, a solution) the given numbers in the problem represent. He correctly gave the functions and used these in finding the required unknown values in the problem. He showed complete solutions and gave answers that were properly labeled.


1. The term "uphill" refers to the slope that is going up & going to the right while the term "downhill" refers to slope that is going down & going to the left

-1

Figure 6. Michael's answer in quiz 1 item 1

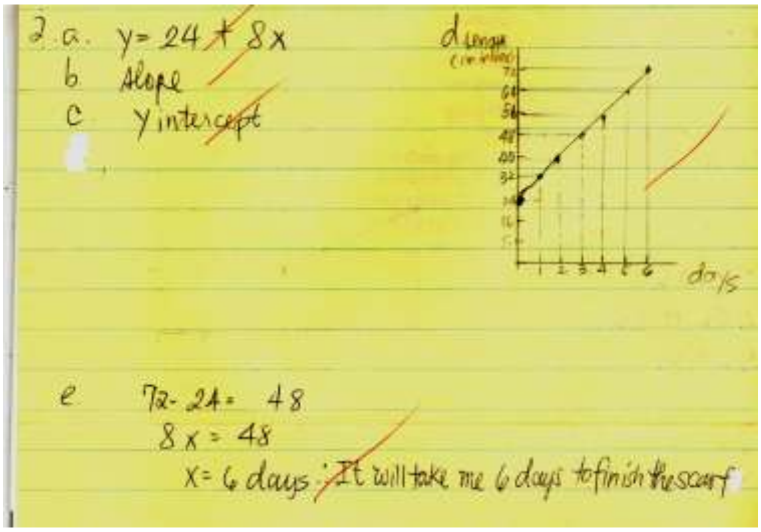

2 a. $y = 24 + 8x$
b. slope
c. y intercept
e $72 - 24 = 48$
$8x = 48$
$x = 6$ days ∴ It will take me 6 days to finish the scarf

Figure 7. Michael's answer in quiz 1 item 2

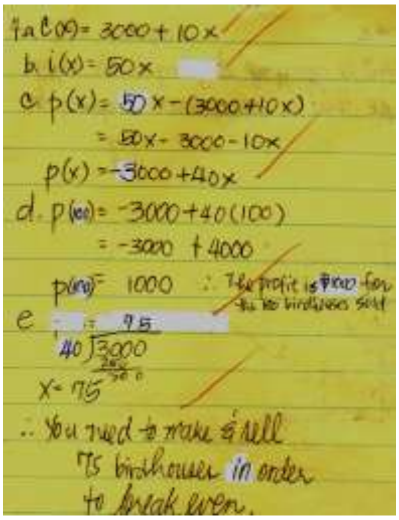

4 a. $C(x) = 3000 + 10x$
b. $i(x) = 50x$
c. $p(x) = 50x - (3000 + 10x)$
$= 50x - 3000 - 10x$
$p(x) = -3000 + 40x$
d. $p(100) = -3000 + 40(100)$
$= -3000 + 4000$
$p(100) = 1000$ ∴ The profit is ₱1000 for the 100 birdhouses sold
e. $= 75$
$40 \overline{)3000}$
$x = 75$
∴ You need to make & sell 75 birdhouses in order to break even.

Figure 8. Michael's solution and answer in quiz 1 item 4

When asked to explain why "The *b* in the equation $y = mx + b$ is the *y*-intercept", Michael just repeated what was said in the problem, he wrote "because the slope of the equation is always beside the value of *x*. The *y*-value would always depend on the slope and the *y*-intercept" He knew how to get the slope and the *y*-intercept from a linear equation but he cannot explain why such were the representations in the equation. He was not able to make a link between the concept and his procedural knowledge.

Sara was able to relate hills to linear functions in that she wrote "hills have slopes just like linear functions. The line is formed depending on its slope. When you are climbing a mountain going up so the same as" But she was not able to differentiate an uphill from a downhill which was demanded in the question as implied by the phrase "that these depend on where you are standing on a hill and which way you are looking"

As with Ria and Patricia, Sara's graph not only included negative values, the axes were not properly labeled leaving readers to guess what values were represented by the points. The line was also incorrect because it intersected the y-axis at a negative value when the given y-intercept should have been 24 inches.

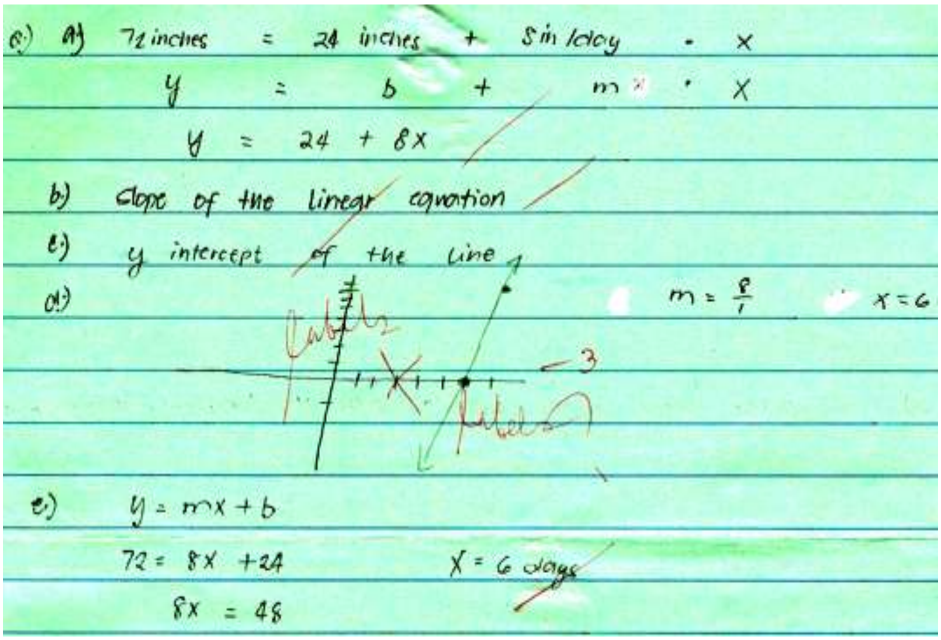


Figure 9. Sara's answer in quiz 1 item 2

Just like Ria, Sara's other graph was incorrect in that despite giving the correct equation, she gave a line segment that has positive slope which contradicted the indicated negative slope in the equation. Her solution shows that she got a correct y-intercept but somehow failed to translate this idea into the graph. The graph indicated a zero y-intercept.

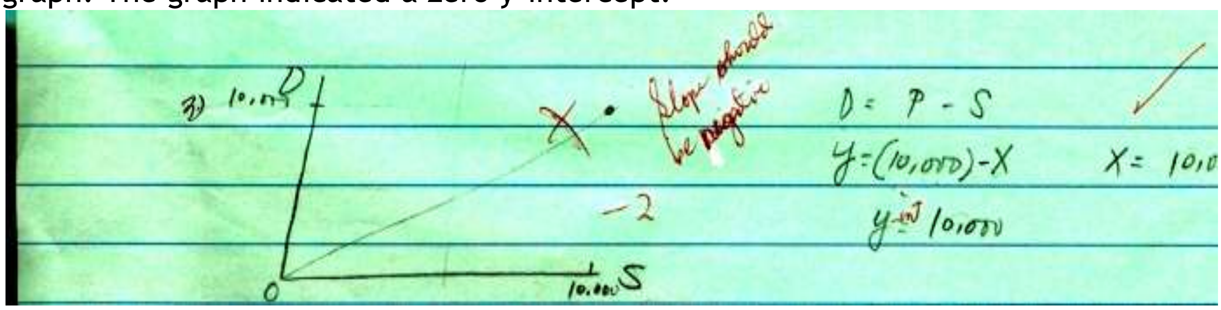


Figure 10. Sara's answer in quiz 1 item 3

Sara correctly gave the cost and income functions. However, she interchanged the minuend and subtrahend in her profit function. That is, she subtracted the income from the cost instead of the other way around. Thus, her subsequent answers were also incorrect as these made use of the profit function.

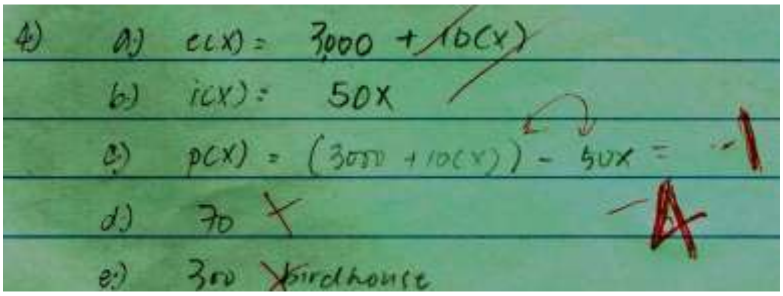


Figure 11. Sara's answers in quiz 1 item 4

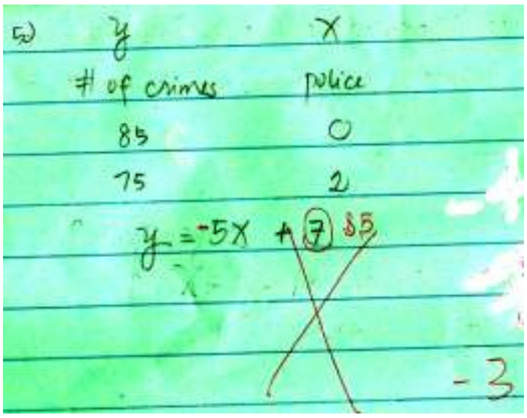


Figure 12. Sara's answer in quiz 1 item 5.

At another item, Sara wrote the variables and their representations. She wrote the given values in tabular form but failed to show any solution on how she was able to write the equation. Her equation indicated an incorrect slope 5 (supposed to be -5) and an incorrect y-intercept 7 (instead of 85). This means she did not know how to use the concept of slope and y-intercept, nor a formula in writing a linear equation as there were no solutions to support this.

When asked to explain why the value b in $y = mx + b$ is the y-intercept, Sara wrote "It always depends on the x and how the slope moves." She seems to be confused on what the question was asking her to do. Her answer was way too far from the correct answer. Clearly she did not understand what the y-intercept is and why it is designated as b in the equation $y = mx + b$.

Patricia had deep understanding of the concepts learned in the lesson. She correctly explained what the variables represent and why such variables behave as they do in the equation. She got all items correctly answered except that she failed to consider realistic values in her graphs. This is indicative that meaningful learning had occurred.

Ria's low score can be attributed to her misuse of a scale in her graphs. She was so confident to use a scale factor that unknowingly she incorrectly graphed the linear functions. Furthermore, she gave an incorrect cost function that had affected her subsequent answers. She justified such errors to her lack of exposure to problems of this kind. Nonetheless, she should have taken time to further analyze what the given Php10 variable cost could have meant. She also had a careless computation. If she only took time to evaluate her answers, she might have noticed her errors and had a higher score instead. During the interview, Ria claimed to have learned the lesson from the metacognitive activity. This could be a case where over self confidence can also adversely affect one's performance in that she did not take time to go over her answers once again.

Michael was able to answer all items except the last one where he was asked to explain why in the equation $y = mx + b$, b is the y-intercept of the line. Nonetheless, his correct answers in other items indicated that he was able to apply all the lessons learned in a problem solving situation. This is indicative that meaningful learning had occurred.

Sara's paper and pen test indicated that she did not understand how slopes could indicate the trend of the linear function. She had an incomplete answer in the first question that asked for an explanation on how slopes of linear functions can be compared to a hill. She explained during the interview that she lacked the time in answering the test. On the other hand, Sarah correctly translated two out of three real life problems to a mathematical model using symbols and operations. However, she did not indicate the labels in her graph. There were also computational errors in her solutions. There were items where she was confused which quantities should be substituted to which variables. When asked why in the equation $y = mx + b$, b is the y-intercept, she gave a vague answer, "it depends on x and how the slope moves." Sara had yet to learn a lot of things in this topic. Although, she claimed that the metacognitive activities she did with the group had improved her self-efficacy in linear equations and functions, it looks like because she had low to moderate metacognitive behaviors in this activity that she just had this much understanding of linear equations and functions.

Table 2 summarizes the meaningful learning of the four cases on linear equations and functions.

Meaningful learning was ascertained from their paper and pen tests. Students' paper and pen tests indicated meaningful learning. They had positive learning outcomes than the errors they committed. Their errors were mostly due to careless miscalculations. Students sometimes performed well in their test and at times barely passed. Their performances in their tests made one doubt whether meaningful learning had occurred. Factors such as the inadequate time allotment in the test administration and the difficulty of test were some of the possible reasons. Clearly, meaningful learning required that they expend more efforts in engaging activities for meaning making as much as did Patricia and Michael. They have to take more active part and share of the group work. Since meaningful learning requires exhibiting higher order thinking skills, they should not be contented with the menial tasks as graphing, bringing reference materials, and doing computations. They should challenge themselves to give reasons on the mathematical processes they need to go through, ask more inquiry questions and be involved in seeking for answers to these questions. Going beyond the acquisition of facts require that students can apply what they learned from these lessons in different contexts.

Table 2
Patricia's' Meaningful Learning

Cases	Meaningful Learning
Patricia	(+) Correctly described, applied and used slopes and intercepts in solving problems; (+) Formulated correct linear equations and functions as models of a real-life problem; (+) Correctly identified what the given and unknown quantities represent in the linear equations and graphs; (+) Graphs were sketched correctly except that it inappropriately included negative values for the given problem; (+) Carried out all computations correctly; (+) Explained clearly the reason why the y-intercept can be found as the constant term in the slope-intercept form of the equation;
Ria	(+) Correctly described, applied concepts of slopes and the intercepts in solving a problem; (+) Formulated (all except 1) correct linear equations and functions as models of the given problems; (+) Correctly identified what the given and unknown quantities represent in the linear equations and graphs; (-) Scales used in the graph were inconsistent with the values in the problem; (-) Graphs inappropriately included negative values; (+) Failed to check the graph with the slope in the equation it represents; (-) Had one miscalculation due to carelessness; (+) Correctly wrote a linear equation given two sets of values; (+) Explained clearly the reason why the y-intercept can be found as the constant term in the slope-intercept form of the equation;
Michael	(+) Used directions to describe slopes but incorrectly mentioned downhill as going down towards left; (+) Formulated correct linear equations and functions as models of the given problems; (+) Correctly identified what the given and unknown quantities represent in the linear equations and graphs; (+) Correctly applied slope and intercepts in solving problems; (+) Sketched the graph correctly by considering only realistic values and indicating all necessary labels; (+) Carried out all computations correctly; (+) Knew how to identify but (-) Can't explain why the y-intercept is the constant term of the slope-intercept form of a linear equation.
Sara	(-) Can't differentiate an uphill from the downhill as illustrations for slope; (-) Tried to formulate linear equations and functions as models of the given problems but got 2 wrong equations from the attempts; (-) Graph was incorrect and had no labels; (+) Was able to identify what the given and unknown values represent; (-) Did not understand what the y-intercept is and why it can be found as the constant term in the equation $y = mx + b$.

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Appendix
Paper and Pen Test on Linear Equations and Functions

1. The words "uphill" and "downhill" are relative words in the English language. They depend on where you are standing on a hill AND which way you are looking. How could we use these words to describe some of the lines we graphed and communicate it to everyone in the class?

2. You and a friend are knitting a scarf that will be 72 inches long. Your friend knits the first 24 inches and then gives you the scarf to finish. You expect to knit at a rate of 8 in/day.
   (a) Use the verbal model to write an equation giving the length y of the scarf (in inches) after you have been knitting for x days.

Length of scarf	=	Length knitted by your friend	+	Knitting rate	•	Knitting time

   (b) The knitting rate is none other than the ________________ of the linear equation.
   (c) The length knitted by your friend refers to the _______________ of the line.
   (d) Graph the equation.
   (e) After how many days will you finish the scarf?

3. "Straight line" depreciation is given by D = P – S, where D is the depreciation, P is the purchase price, and S is the salvage value. If a corporation purchases a machine $10,000, graph the equation using D as the vertical axis and S as the horizontal axis.

4. You make and sell birdhouses. Your fixed costs for your tools and workspace are Php3,000. The cost of wood and other materials needed to make a birdhouse is Php10. You sell each birdhouse for Php50. Let x represent the number of birdhouses you make and sell.
   (a) Write a function for your total costs, c(x).
   (b) Write a function for your income, i(x).
   (c) Your profit is the difference of your income and total costs. Write a function for your profit, p(x).
   (d) What is your profit when you make and sell 100 birdhouses?

(e) You are said to "break even" when your profit is Php0. That is, you neither earn nor lose. How many birdhouses do you need to make and sell in order to break even?

5. A police department finds that the number of crimes (y) committed in one week in a small city depends on the number of police officers (x) on special patrol. If there are 85 crimes committed when no police are on special patrol and the number drops to 75 when two police are on special patrol, write the equation for the relationship.

6. We have been told that any equation in the form $y = mx + b$ is called the slope-intercept form of a straight line where "*m*" is the slope and "*b*" is the y-value where the line crosses the y-axis. Why is "*b*" always the y-intercept?

Academic Tracking: Dominance of Triarchic Skills

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The purpose of this paper is to determine the triarchic skills level (creativity, practical and analytical) and differences among different curriculum tracking. The study aims to determine the multiple correlates of triarchic skills among 4th year high school students. A descriptive correlational study was conducted in a national high school in Region III (Philippines) involving 195 respondents across different year level Stratified Proportional sampling was used to ensure that appropriate numbers of elements are drawn from homogenous subsets. Sternberg Triarchic Abilities Test version 1993) was administered. General Weighted Average and individual grades for each subject were also collected and documented. The National Career Assessment Examination (NCAE) results were also used and gathered. There was a significant difference Analytical among Special Science Curriculum with Basic Education Curriculum (p =.036) and Special Performing Arts (p=.000) but did not differ with Information and Communication Technology Curriculum. The SCC differed with ICT (p=.010) in terms of creative skills but not with two groups: BEC and SPA (p=.620 and p=.474). There was no significant difference among curriculum tracking in terms of practical skills. The different curriculum tracking differed only in terms of analytical and creative skills but not with practical skills.

Keywords: Triarchic theory, Academic tracking

It has been considered that intelligence is a cumulative effects of different factors as presented by several empirical studies. The nature of Intelligence is not itself a vacuum. The role of genetics, nutrition, and exposure to family, home and environment are some of its underlying reasons for the individual's level of intelligence (Neisser, Boodoo, Bouchard, Boykin, Brody, Ceci, Halpern, Loehlin, Perloff, Sternberg, & Urbina 1996). Sternberg (1997, 1999) posited several assumptions on theory of successful intelligence. The way success is defined is bounded by socio-cultural context. There is indeed no single perspective on the personal meaning of success. Each has its own way of defining it. Enriching one's potential or strength is what the theory stood for. Furthermore, the weaknesses are intended to be changed and improved as well. The fusion and balance of the triarchic skills an important main assumption in his theory presented. Triarchic skills are composed of Analytical, Creative and Practical skills. Creative skills are directed toward putting together ideas; Analytical skills are geared on choosing the best of ideas and practical skills are helpful in carrying out the ideas (Sternberg 2006). In the study of Neisser et al (1996) concluded that there are many ways of defining intelligence and multitude of means to become intelligent.

It is noteworthy to consider the so called curriculum tracking in educational system. Curriculum tracking is defined as segregation of students according to curriculum standards, educational and career aspiration and ability levels. An empirical study noted that students who are tracked in less academically inclined curriculum tend to have limited occupational choices (Akos, Lambie, and Milsom & Gilbert 2007). Terwell (2005) concluded that high achieving students gain from high track while low achieving ones limit their potential. However in the contemporary views of intelligence, doing such will benefit students for curriculum tracking. Such preparation will match one's ability. This perhaps imply that the academic preparation may likely influence future career choice. Thus this espouses the assertion of successful Sternberg's Successful Intelligence that when one taught parallel to their ability and thinking they will perform better (Sternberg 2008). The theory implies working on the strength on one's individual instead of the weakness part. However the question whether the intended outcomes of curriculum tracking indeed reflective of the several variables. Does each curriculum tracking able to develop the triarchic skills? Does curriculum tracking able to maximize one' strength and maximum potential as it aimed for? Sternberg (2006) referred that intelligence is perceived as culturally and socially divergent. Individuals may not have all the skills but may have one or two that complements his or her weaknesses.

Curriculum tracking are as follows implemented in the said institution: Special Science Class otherwise known Engineering and Science Education Project was implemented with DECS Order No. 54 (1996) to provide a curriculum concentrated on pure sciences. Thus it primarily serves the high ability group which being referred to "intellectually gifted and science inclined students. Basic Education Curriculum (2002) is the restructured curriculum from 1983 Elementary Education and the 1989 Secondary Education Curriculum. This is comprised of five learning areas: Filipino, English, Science and Technology, Mathematics and lastly the "Makabayan ". The latter integrates different subject areas and coined "Laboratory of Life ". This curriculum introduced Integrated Science, Biology, Chemistry for the first until third year and two tracking (either Advanced Chemistry or Physics for fourth year. The Special Program in the Arts is intended for multi-artistically inclined students. This has the following specializations: Music, Visual Arts, Theater Arts, Creative Writing, Media Arts and Dance. Lastly, the Information and Communication Technology Curriculum aimed to keep paced with the computer technology. The four different curricula cater to diverse students' ability with emphasis on individual's strength. The common places for this diversified curriculum are the distinct outcomes, such as Special Science Curriculum (SCC) focused on pure sciences and prepared for Science based courses in the college. It is expected that the honing of strength will be relative to the outcomes. Thus the inquiry is aimed to determine on which among the triarchic abilities is significantly dominant in each curriculum tracking. Is it relative to its distinct outcomes outcomes in terms of triarchic skills namely: Analytical, Creative and Practical Skills?

This study is aimed to investigate the difference among curriculum tracking in terms of triarchic skills. This has the following objectives:

1. To determine the triarchic skills level (creativity, practical and analytical) among different curriculum tracking
   a. Special Science Curriculum
   b. Basic Education Curriculum
   c. Special Performing Arts
   d. Information and Communication Technology

2. To determine the difference in the triarchic skills (creativity, practical and analytical) among different curriculum tracking.
3. To determine the multiple correlates of triarchic skills among 4th year high school.

Methodology

There were 206 4th year high school students from a national high school in Region III. They were randomly selected from different curriculum : Special Science Class (*N*=65), Basic Education Curriculum (*N*=79), Information and Communication Technology (*N*= 35) and Special Performing Arts (*N*= 25). The data were collected within March 22 – 24, 2010. Only 195 of them were included for the data analysis. The exclusion of 11 cases was related to incomplete data (i.e. copy of grades). This may be related to ongoing computation and submission of grades at the time of data collection.

Stratified Proportionate Random Sampling was utilized for this survey to ensure that appropriate numbers of elements are drawn from homogenous subsets of that population instead of selecting a sample from a large total population. (Babbie, 2001). The total population per year level was known first before sampling took place. This ensured that the proportion of sample is based on the total population.

Measures

a. STAT (Sternberg Triarchic Abilities Test 1993 version) – this comprised of 36 items examination which has 9 subtests and collectively yield three basic scores.
   1. Analytic (subtest 1-3 multiple choice) - this consisted of analytical- verbal; analytical quantitative and analytical figural.
      a. Analytical- verbal (4 items) – students are supposed to substitute the artificial word of the appropriate word depending on the theme of the sentence.
      b. Analytical –quantitative (items) - student should supply the number in the number series pattern.
      c. Analytical Figural
   2. Creative (subtest 7-9 multiple choice) - this consisted of creative –verbal; creative quantitative and creative figural.
   3. Practical (subtest 4- 6 multiple choice)- this consisted of practical –verbal; practical quantitative and practical figural

Separate scores may be obtained

1. Verbal (subtest 1. 4 & 7)
2. Quantitative (subtest 2, 5 & 8)
3. Figural (subtest 3, 6 & 9)

b. General weighted Average (1st to 4th year high school) and Individual report of subjects (1st to 4th year) - this was obtained through computing of individual report of subjects as reflected in secondary student's permanent record. This is referred as B.P.S. Form 137-A wherein it contains the periodic ratings across year level (from 1st year to 4th year high school). This record contains personal information from the students like place of birth, parent or guardian, address and occupation. Extra Curricular activities and honors received were also asked and documented.

c. National Career Assessment Examination - This has the following subsets namely: clerical ability, manipulative skill, technical – vocational aptitude, non verbal ability, entrepreneurial skill, scientific ability, reading comprehension, verbal ability, mathematical ability and general scholastic aptitude. This aimed to improve the quality of secondary education graduates entering college and to lead the flow of students to courses in post secondary institutions of learning matching their aptitude. This aimed to diagnose and direct secondary education graduates to post secondary that match their aptitude. This is still in the recommendary status at current. However the implementation will be on its third year and with appropriate law.

Data Collection Method

A letter of permission was sent and approved by the school principal. The data collection was conducted last March 24 and 25, 2010 in Olongapo City National High School. The following participants took the examination (STAT) (SCC= 65, BEC=79, ICT=37 and SPA =25). Two teachers facilitated the distribution and administration of STAT (Sternberg's Triarchic Ability Test) guided by the test instructions. This took them two consecutive days to accomplish the target number of participants due to availability of participants. The test papers were later checked and encoded for further analysis. Reliability was also analyzed yielding a cronbach alpha of .7012.

National Career Assessment Examination (NCAE) results were requested and approved from the office Testing and Evaluation Office of Olongapo City National High School. This was released and distributed only on the first week of March prior to STAT administration.

The master's list was provided and forwarded thus necessitated to look for individual names among the 195 participants. Data on the following were retrieved and documented: Scientific Ability (SA), Reading Comprehension (RC), Verbal Ability (VA), Math Ability (MA), General Scholastic Aptitude (GSA), Clerical Ability (CA), Manipulative Skills (MS), Technical Vocational Aptitude (TVA), Non Verbal Ability (NVA) and Entrepreneurial Skill (ES).

General Weighted Average and Records of Academic subjects of those who took the STAT were requested and approved by the principal. The records of those who took the STAT were retrieved from the level coordinator .Only those whose permanent records were available by the time of data retrieval were included (N=195). Pertinent data were encoded specifically: Name, curriculum tracking, guardians' occupation, and all subjects' grades from first year to fourth year. General weighted average was computed.

Statistical Treatment

SPSS for Windows (version 11.5, SPSS Inc, Chicago, Illinois) was the statistical software used in this study.

Means and Standard Deviations. These were used to answer research objective no. 1 (To determine the triarchic skills level among different curriculum tracking).

Analysis of Variance (ANOVA). This was used to answer research objective no. 2 (To determine the difference in the triarchic skills across different curriculum). This statistical treatment is appropriate to answer whether the group means differ from each other (Munro, 2001). The independent variable (often called factor) has two or more levels. Curriculum tracking is a variable with four levels (SCC, BEC, SPA and ICT). The dependent variable (STAT scores) is a continuous variable. It satisfied the assumptions of ANOVA namely that STAT is continuous and normally distributed (Analytical skills -.084, Creative Skills - .612 and Practical -.005). Multiple group comparison was used specifically Scheffe for post hoc test. This was used to determine of which among groups are different. *F* test alone cannot determine which groups differ from each other (Munro, 2001). Scheffe is commonly used and reported in empirical studies. This was used to answer Research Objective no. 4 (To determine the difference in the NCAE across different curriculum).

Multiple Regression. This was used to answer Research Objective no. 3 (To determine the multiple correlates of triarchic skills among fourth year high school students). This was used to predict outcomes and explain the interrelationships among variables (Munro, 2001). Curriculum tracking was dummy recoded into the following : SCC= 1, BEC and SPA = 0; BEC = 1, SCC and SPA ; SPA =1 , BEC, and SPA = 0.

Results

The following are presented and arranged according to the objectives presented.

Research Objective 1: To determine the triarchic skills (creativity, practical and analytical) among different curriculum tracking.

The table 1 shows the means, *SD*s of the STAT (Analytical Skills) across different curriculum tracking. According to these data, the SCC scored higher in this area (*M*=10.38) has the highest mean among the four groups. Variability was consistent across curriculum tracking (*SD* ranges from 1.095 to 2.478).This would imply that the sample for each group are homogenous. Furthermore, the skewness and kurtosis measures were small, .084 indicating the normal distribution. This has been revealed in the visual inspection of the graph.

Table 1
Standard Deviations and n for Analytical Skills

Curriculum Tracking	*n*	*M*	*SD*
Special Science C	64	10.38	2.478
BEC	78	9.09	3.059
SPA	20	7.35	1.531
ICT	33	10.55	1.095

The table 2 shows the means, *SD*s of the STAT (Creative) across different curriculum tracking. According to these data, the SCC scored higher in this area (M=3.72) has the highest mean among the four groups. Variability was constant across curriculum tracking (*SD* ranges from 1.146 to 2.066). The scores assumed a normal distribution with skewness of .612.

Table 2
Descriptive Statistics for Creative Skills

Curriculum Tracking	*n*	*M*	*SD*
Special Science C	64	3.72	2.066
BEC	78	3.32	1.702
SPA	20	3.00	1.835
ICT	33	2.42	1.146

The table 3 shows the means, *SD*s of the STAT (practical skills) across different curriculum tracking. According to these data, the SCC scored higher in this area (M=4.22) has the highest mean among the four groups. Variability was constant across curriculum tracking (*SD* ranges from 1.496 to 1.600). This assumed a normal distribution with skewness of -.005.

Table 3
Standard Deviations and n for Practical Skills

Curriculum Tracking	*n*	*M*	*SD*
Special Science C	64	4.22	1.496
BEC	78	3.92	1.421
SPA	20	3.94	1.119
ICT	33	4.02	1.600

Research Objective no. 2: To determine the difference in the triarchic skills (creativity, practical and analytical) among different curriculum tracking.

The table shows that there was a significant difference between analytic skills and curriculum tracking, F (3, 191) =9.510, p= .000.The table 4 shows the number of subjects, the mean, and the standard deviation of analytic skills for each cell. A multiple comparison (Scheffe) test indicated that the group difference accounting for the significant F value was for the SCC with BEC (p=.036) and SPA (p=.000) but did not differ significantly with ICT (p= .992). The SCC tracking scored higher (M=10.38) than BEC group (M=9.09) and SPA (M=7.35). Special Science Curriculum otherwise known globally as Science Enriched Curriculum .Science courses are aimed to critically and logically choose ideas through scientific means. Thus, having the discipline likely will improve ones analytical skills.

Brody (2001) stated that analytical ability is relative to the academic achievement. It can be concluded based on the report grade from the SCC and ICT students that they have higher General Weighted Average and NCAE scores. Thus this findings support the hypothesis.

Table 4
Analysis of Variance for Analytic Skills

Variable and Source	*df*	*F*	*p*
Between Groups	3	9.510	.000
Within Groups	191		

The table shows that there was a significant difference between creative skills and curriculum tracking, *F* (3, 191)=4.062, *p*=.000.The table 5 shows the number of subjects, the mean, and the standard deviation of analytic skills for each cell. A multiple comparison (Scheffe) test indicated that the group difference accounting for the significant *F* value was for the SCC with ICT (*p*=.010) but not with the two groups: BEC and SPA (*p*=.620 and *p*=.474). The SCC tracking scored higher (*M*=3.72) than BEC group (*M*=3.32) and SPA (*M*=3.0). Creativity is considered as a desolated area in information systems field (Higgins & McIntyre, 1993). There was a predominance of use of analytical techniques. This would support the group difference between SCC and ICT tracking. Special Science Curriculum, Basic Education Curriculum and Special Performing Arts may have been similar to creative aspects. The so called "laboratory of life "introduced in the subject Makabayan in Basic Education Curriculum where it integrates different subjects like Physics and Chemistry to each year level.

Table 5
Analysis of Variance for Creative Skills

Source	*Df*	*F*	*p*
Between Groups	3	4.062	.000
Within Groups	191		

The table shows that there was no significant difference between practical skills and curriculum tracking, *F* (3, 191) =5.96, *p*=.96.The table 6 shows the number of subjects, the mean, and the standard deviation of analytic skills for each cell. This can be attributed to the homogeneity of the sample. It is said to be that problem solving skills are likely to improve at the later adulthood. Early adulthood is more focused on traditional cognitive abilities (Sternberg, Wagner, Williams, & Horvath, 1995). Tacit knowledge is composed of three defining characteristics namely: procedural, attainment of goals personal value and independence. Results from a landmark study supported that depth and breadth of experience may influence problem solving skills (Warren & Sternberg, 1985). With this empirical data, it can be concluded those 15 to 17 years old of age as the age ranges of the participants in this study that it is likely to expect homogenous level of practical skills.

Brody (2001) accounted the contribution of practical intelligence to academic achievement to be quite small. This strengthened and espoused the insignificant result of this hypothesis. One of the empirical assertions of Practical Intelligence is independence. It is not related with academic intelligence (Gottfredson, 2002). This may be one of the reasons that despite of the different tracking practical skills remained insignificant.

Table 6
Analysis of Variance for Practical Skills

Source	*df*	*F*	*P*
Between Groups	3	5.432	.001
Within Groups	191		

Research Problem 3: To determine the multiple correlates of triarchic skills (Analytical, Creative and Practical) among fourth year highs school students.

Multiple regressions were conducted to determine the best linear combination for predicting analytical skills. This combination of variables significantly predicted analytic skills, F (6, 185) = 19.04, p < .05, with six variables significantly contributing to analytic skills. The beta weights, presented in table 7 suggest that high general weighted average (4th year), nonverbal, verbal ability and being in Special Science Curriculum (SSC) and Information Computer Technology (ICT) tracking also contribute to the prediction. This indicates that 36 % of the variance in analytic skills was explained by the model.

Table 7
Simultaneous Multiple Regression Analysis Summary for Predicting Analytical Skills

Variable	*B*	*SEB*	*ß*
Basic Education Curriculum	-.815	.398	-.148
Special Performing Arts	-2.407	.613	-.273
Verbal Ability	.038	.010	.271
Non Verbal Ability	.020	.008	.178
GWA 3rd year	-.412	.217	-.427
GWA 4th year	.624	.220	.641
Constant	-12.434	5.258	5.258

Note. R^2= .382; $F(6,185)=19.04$, $p<.05$

Multiple regressions were conducted to determine the best linear combination for predicting creative skills. This combination of variables significantly predicted creative skills, *F* (6, 185) = 19.04, *p* < .05, with six variables significantly contributing to analytic skills. The beta weights, presented in table 8 suggest that high in mathematical ability, clerical ability, 3rd year general weighted average and being in Basic Education Curriculum (BEC) and Special Performing Arts (SPA) tracking also contribute to the prediction. This indicates that 15 % of the variance in creative skills was explained by the model.

Table 8

Simultaneous Multiple Regression Analysis Summary for Predicting Creativity Skills

Variable	*B*	*SEB*	*ß*
Special Science Curriculum	.716	.380	.187
Basic Education Curriculum	.812	.356	.220
Special Performing Arts	1.330	.496	.225
Mathematical Ability	.021	.007	.256
Clerical Ability	.011	.006	.130
GWA 3rd year	.080	.124	.124
Constant	-6.506	4.057	

Note. $R^2 = .174$; $F(6,185) = 6.493$ $p < .05$

Multiple regressions were conducted to determine the best linear combination for predicting practical skills. This combination of variables significantly predicted practical skills, *F* (6, 185) = 19.04, *p* < .05, with six variables significantly contributing to practical skills. The beta weights, presented in table 9 suggest that high mathematical ability and manipulative skills also contribute to the prediction. This indicates that 15 % of the variance in practical skills was explained by the model. The finding is similar to Sternberg (2006) where it yielded a significant relationship between SAT- Math and practical abilities.

Table 8
Simultaneous Multiple Regression Analysis Summary for Predicting Practical Skills

Variable	*B*	*SEB*	*ß*
Mathematical Ability	.012	.005	.195
Manipulative Skills	.019	.008	.308
Techno Vocational Skills	-.07	.009	-.248
Constant	3.159	.387	

Note. R^2= .246; $F(3, 190)$=4.081 p<.05

Discussion

This study espouses some assumptions of curriculum tracking utilizing the framework of Sternberg's Successful Intelligence. The triarchic skills comprised of analytical, creative and practical skills. The three seemingly are independent to each other in terms of curriculum tracking. . Special Science and Information Computer Technology curriculum are both high in analytical and divergent from Basic Education and Special Performing Arts. The results are relative to the goals and objectives of their tracking. Science inclined tracking are provided with more complexed problem solving, thus this trained them to be more critical and analytical. Likewise with Information Computer Technology, they were also regarded high ability students as reflected in their entrance examination. This would just support the triarchic ability of analytical skills of Sternberg,

The creative skills of Special Performing Arts, Basic Education Curriculum and Special Science Curriculum are parallel to each other. It is noteworthy to consider that the three are indeed different from Information and Computer Technology. The result may imply that computer tracking may be lacking in creativity given the nature.

However the practical skills are homogenous among curriculum tracking. The age of the participants are almost similar and close to each other. Practical skills can be more pronounced to older adults.

Conclusion

Triarchic skills specifically analytical and creative differ across curriculum tracking. Practical skills remained not significant across curriculum tracking. General weighted Average for (fourth year), nonverbal, verbal ability, being in Special Science Curriculum and in Information Computer Technnology contributed in the prediction of analytical skills. Furthermore high in mathematical ability, clerical ability and general weighted average (3rd year, being in Basic Education Curriculum and Special Performing Arts predicted creative skills. Practical skills have the following predictors such being high in mathematical ability and manipulative skills.

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The Development of Vocational Interest Using Holland's Typology: Realistic Occupational Choice Inventory for Engineering Technology

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This study focused on the Realistic Occupational Choice based on John L. Holland typology of Vocational Personalities (RIASEC). The Realistic occupations include skilled, trades, technical, and some service occupations. In response to the research findings of Holland Theory of Vocational Choice that a simple occupational knowledge test can be devised to explore the relationships hypothesized in the theory and to examine and classify typical occupations. The Realistic Occupational Choice Inventory was constructed for the purpose of assessing the students' occupational interest in career choices in service, technical, and engineering occupations. There is a need to construct a standardized scale that can assess the interest of the Filipino students in realistic occupations since there is no specific scale that measures Filipino skilled, service, technical, and engineering occupational interests. The results of the occupational interest inventory will assist the students to come up with better career decision so that they can perform better academically and choose a career that will prepare them before they enter the world of work. A Principal Component Analysis with varimax rotation was used to identify the subscales of the realistic factor. The scale indicates a very high internal consistency among the items with a Cronbach's alpha value of .96.

Keywords: RIASEC, Realistic, Skilled and service occupations

With the increasing demand for knowledgeable and skilled workers in this dynamic society, industries have developed linkages with academic institutions for their pool of workers. In developing countries like the Philippines, the role of technician as workers and engineers in the economy is significantly important as the country becomes more industrialized using modern production techniques. For this reason, it is the duty of the technician and engineering education system acting on behalf of its students and graduates to anticipate employers' preference for the services of technicians and engineers in terms of numbers, varieties, and quality to provide the economy with the right type of workforce (Tadeo, 1988).

According to Kochhar (2007), reality work is said to be the central and essential part of man's life. It cultivates him and makes his life meaningful and purposeful. Work has a profound role in establishing a person's life space, emotional tone, family situation, object relations, and where and how he will live. The kind of work that individual prefers to be involved can be perceived with his vocational choice and preferred occupational environment.

The Holland's Theory of Vocational Choice helps individuals to make better career decisions based on their preferred occupational environment. The core idea of this theory stated that most people resemble a combination of six personality types: RAISEC R – Realistic, I – Investigative, A – Artistic, S – Social, E – Enterprising, C – Conventional. Each type is characterized by a constellation of interests, preferred activities, beliefs, values, and characteristics. The RIASEC structure is the most widely used model of organizing career interest assessment instruments (Nauta, 2010).

Holland in 1959, presented a paper which attempted to delineate a theory of vocational choice which was comprehensive enough to integrate existing knowledge and at the same time sufficiently close observables to stimulate further research. Holland assumed in his theory that at the time of vocational choice, the person is the product of the interaction of his/her particular heredity with a variety of cultural and personal forces including peers, parents, and significant adults, his social class, and the physical environments. Out of this experience, Holland mentioned that the person develops a hierarchy of habitual or preferred methods for dealing with environmental tasks. Holland's RIASEC was first labelled and classified in the different occupational environments that are useful in organizing the person's vocational choice. Holland mentioned that at the time of vocational choice the person has a set of adjustive orientations. The adjustive orientations, corresponding to the six occupational environments, which are designated as motoric, intellectual, supportive, conforming, persuasive, and esthetic methods or orientations. Holland conceptualized each type as having distinctive lifestyle, preferred methods of dealing with problems, interpersonal skills, and other personal factors, and Holland clearly stated that interest inventories are personality inventories (Nauta, 2010). The first major revision of the theory more clearly specified the role of the environment, the revision also provided more explicit definitions of the main concepts and it included more comprehensive descriptions of the types. According to Nauta (2010) the most notable revision version of the theory was the 1973, the RIASEC labels were used for the types when there was an explicit incorporation of the hexagon for assessing the degrees of congruence and determining consistency among personality and environment types.

One of the previous occupational environment of designated in Holland first theory was the environments. The motoric environment which include occupations as labourers, machine operators, aviators, farmers, truck, drivers, and carpenters. Holland stated that persons with this orientation enjoy activities requiring physical strength, aggressive action, motor coordination, and skill. These people prefer to deal with concrete, well-defined problems as opposed to abstract, intangible ones; they prefer to act out rather than to think through problems. They avoid situations which require verbal and interpersonal skills, because they lack that skills and are often threatened by close relationship with others. They conceive of themselves as aggressive, strong, masculine persons with conventional political and economic

(Holland, 1959). This motoric environment was similar to the descriptions set in the RIASEC, as Realistic (R) environment also involves skilled, trades, technical and some service occupations. Both have the same core activities such as labourers, machine operators, aviators, farmers, truck, drivers, and carpenters. Holland stated that persons with this orientation enjoy activities requiring physical strength, aggressive action, motor coordination, and technical skill.

The study by Felman et al. (1999) wanted to test the further the assumption of Holland's theory of personality types and environments that achievement of people is a function of the congruence or "fit" between their personality type and their environment. Holland's theory further assumes that each personality type is most likely to flourish in a corresponding environment (that is, the environment having the same label). Because this environment provides activities, tasks, and roles congruent with the competencies, interest, and self-perceptions of its parallel personality type (Felman et al., 1999).

The study of Anderson et al. (1997) examined the invariance of Holland's vocational interest model across gender to resolve the question concerning whether the theory was applicable for men and women. Results of the study indicated that males and females have similar RIASEC structures on the Strong Interest Inventory. Results and analyses comparing the fit of both the circular order form and circumplex form of Holland's model to the male and female samples were all non-significant, indicating that these models are a no more or less accurate representation of the observed data for men than for women (Anderson et. al, 1997). The researchers aimed to identify gender differences in misfit of Holland's model also yielded no evidence of differential fit.

Holland (1997) suggests that students will be more satisfied and perform better academically if they choose a major environment that is congruent with their interest. Individual search for and enter work environments that permit skills and abilities, express their attitudes and values, and take on agreeable problems and roles. The vocational identity among persons has been shown to be associated with occupational commitment, life satisfaction, well-being, adjustment, career decision making, self-efficacy, and career-choice readiness (Grotevant & Thorbecke, 1982).

Holland hypothesized that the persons with more information about occupational environment make more adequate choices than do persons with less information. The validity of this hypothesis was suggested by Stone's study, 1948 in vocational counselling on the effects of occupational courses. The research findings suggest that a simple occupational knowledge tests might be devised to explore the relationships hypothesized in the theory concerning the amount of selective perception of occupational information. The proposed occupational environment classification might be examined and classified rationally by reviewing the evidence for a sample of typical occupations for each orientation at each level.

In response to the research findings of Holland's Theory of Vocational Choice, a simple occupational knowledge test can be devised to explore the relationships hypothesized in the theory and to examine and classify typical occupations. The Realistic Occupational Choice Inventory was constructed for the purpose of assessing the students' occupational interest and career choices in skilled, service, technical, and engineering occupations. There is a need to construct a standardized scale that will assess the interest of the Filipino students in realistic occupations specifically in technology and engineering service occupations since there is no specific scale that measures this domain. The results of the occupational interest inventory will assist the students to come up with better career decision so that they can perform better academically and choose a career that will prepare them before they enter the world of work.

The result of this scale will help career counselors to help individual in assessing the person capabilities in pursuing a realistic vocational choice specifically in technology and engineering courses that will fit their occupational interest.

Method

Participants

A total of one hundred thirty five (135) second year technology engineering students from the different courses: Automotive, electrical, electronics, mechanical and refrigeration and airconditioning service works were selected as respondents. The participants age ranges from 17-20 years are in their major field of specialization and presently involved in acquiring the expected competencies in their field. The purpose of the Realistic Occupational Choice Inventory-Questionnaire (ROCI-Q) was explained to the students before the test was administered.

Instruments

The original Realistic Occupational Choice Inventory Questionnaire (ROCI-Q) was created using Holland's RIASEC typology. This inventory focused on the Realistic (R) factor which includes the skilled, trades, technical, engineering, some service occupations such as manipulation of tools and machines. The occupations required technical competencies in order to do the activities involved in repair, maintenance and follow some preventive measures in electronic, electrical, mechanical works.

The Realistic factor has five subscales of skilled and service occupations: (1) Automotive (2) Electrical (3) Mechanical (4) Refrigeration and Airconditioning works and (5) Electronics. Each subscales has 20 items reflecting the core activity of the skilled and service occupations, based on the O*NET Data of categories of occupational information and technical skills. It is also consistent with the expected competency required by the Technical and Education and Skills Development Authority (TESDA).

The automotive occupation provides the essential service in the field of quality control, performance testing, engine assembly and operations; technical background on diagnostic process, precision measurements and cost estimate for repair works in automobile. The electrical occupation provides training in power generation, transmission, and distribution; control and power utilization with emphasis on integration of principles and application of method analysis to electrical processes and equipment. The trainees are trained to maintain service and repair electro-mechanical devices, supervise building wiring; do cost estimating; perform simple design work; maintain and service electrical appliances and do other related electrical tasks. The electronics service occupation provide competency in the application of electronic devices, analysis of resistive and reactive circuits and understanding their use on solid devices as well as integrated circuits. The workers are expected to perform or function productively in the area of research and development, quality control, repair, calibration and maintenance, service and installation and sales of electronic equipment and system. In mechanical service occupation, the activities involved in the manufacture and production of metals into finished product by prescribing the operations involved utilizing available resources, techniques and control in the most economical way without sacrificing quality and the specifications. It includes the application of precision, measuring instruments, knowledge of materials and processes, reading and preparing working drawings, use and operation of machine tools, design and fabrication of jigs, and fixtures for economical production. The refrigeration and airconditioning service occupation activities involved the study of the principles and practical application of domestic, commercial and industrial refrigeration systems. The trainees can assist the engineers in simple design work, interpret and analyze working data, maintain and calibrate control systems. They can also perform specific tasks such as preventive maintenance, installing, repairing and overhauling refrigeration and airconditioning equipment. For each item the student has to response on a 5 point Lickert scale, "1"- that they strongly agree to do the tasks, "2" they agree to do the tasks, "3"- neutral 4- they disagree to do the tasks and " 5"- that they strongly agree to do the tasks.

Results

A Principal Component Analysis with varimax rotation was used to identify the subscales of realistic vocation interest. An examination of the scree plot showed that five subscales can be produced. The five subscales of the realistic factor accounts 62.68% of the total variance in realistic occupations. The five factors were labelled as automotive, electrical mechanical, refrigeration and airconditioning and electronics service occupations. Setting the eigenvalue at 1.0, the items with factor loadings below .40 were removed and 97 items were retained. The 97 items were classified under each subscales: Automotive service occupation (20 items), electronics service occupation (20 items), electrical service occupation (20 items), refrigeration and airconditioning (17 items), and mechanical service occupation (20 items). The test also indicates a very high internal consistency among the items with a Cronbach's alpha value of .96. The mean obtained is 276.88 and standard deviation is 56.54.

Discussions

The study developed a Realistic Occupational Choice Inventory using skilled, service, technical service occupations as the subscales of the Realistic (R) factor of Holland's RIASEC typology. Results showed that the original items of 100, 5 subscale attained high internal consistency, 3 items were eliminated because each item was already overload with the other subscale. An examination of the scree plot showed that the five subscale of the realistic factor can be retained. The decision on each subscale was based on the Map-of the-World (Counselor Version) developed by Prediger et. al (1993) as cited by Brown (2007) stated that the Map-of the-World shows the location of families jobs and based on their relationships to four primary work tasks: Working with data, people, things, and ideas. These job families are in congruent with the Holland typology in terms of administration and sales (enterprising), business operations (conventional), technical (realistic), science and technology (investigative), arts (artistic), and social service (social) (Louis, 2010). The decision to use the Map-of-the-World as an added guide to determining the subscales was to ensure that there was already an established framework using these subscales which were related to the Holland typology (Louis, 2010). The Map-of-the World became the additional reference in constructing the subscales for Realistic (R) based on Holland's typology as it was categorized as technical service occupations. The consequences of taking a vocational choice not congruent to individual occupational interest are mostly shifting of courses and poor academic performance. With this problems encountered by the students, the guidance program should be strengthened with the cooperation and endeavour of all mentors in conducting supplementary training, seminars, orientations and similar activities to develop students' potentials and interest that will lead to the enhancement of their self-esteem. The Realistic Occupational Choice Inventory is a response to the research findings and recommendation of Holland Theory of Vocational Choice. It is simple occupational scale devised to explore the relationships hypothesized in the theory and to examined and classified typical occupations. The kind of work that individual prefers to be involved can be perceived with his vocational and occupational choice test results.

The educational institutions should help their students in assessing the person capabilities in pursuing a vocational choice that will fit their occupational interest. It is the duty of every technical instructor to equip their students with the necessary knowledge and skills to be immediately productive in their job. Each worker must be confident in his/her skills and, he/she must possess the proper values needed to perform well in the industry. The role of educational higher learning is to assess the competencies of their students in order to develop their potentials to the fullest, prepare them for work and equip them for occupations. The institutions should analyze the productivity, motivational factors and manpower composition in various industries and their units that will help build up reliable national estimates of workforce, skill, productivity and other related matters in different sectors of the economy.

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A Closer Look at other Taxonomies of Learning: A Guide for Assessing Student Learning

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This report presented different taxonomies of learning that can be used by educators as their guide when planning for educational objectives, framing skills and competencies for students, and a guide in creating assessment tools. It covers descriptions and explanations of taxonomies with their features under their different levels. The conventional taxonomies were presented first such as the 1956 Bloom's taxonomy and the Revised Blooms Taxonomy. The alternative taxonomies also presented such as Gagne's taxonomy, Stiggins and Conklin's Taxonomy, Marzano's Dimension of Learning, and De Bono's Six Thinking Hats. Implications for instructional planning and assessing are further discussed.

Keywords: Learning taxonomy, domains of learning, Assessing student learning

In planning for instruction and developing a curriculum, the educator puts a prime importance in focusing the specific learner outcomes such as skills and competencies that needs to be developed. These statements usually come in the form of educational outcomes, goals, objectives, educational aims or learning intents. In order to provide evidence that these educational outcomes are met, different forms of assessment are conducted whether it is the traditional paper and pencil tests (binary type, multiple choice, short answer, etc.) or the alternative forms of assessment (performance-based, authentic assessment, portfolio assessment). Different learning taxonomies are generally used to frame specific skills that need to be measured by teachers. The most common taxonomic tool used by teachers in planning their lesson and writing items is Benjamin Bloom's (1956 taxonomy) cognitive skills which were later developed into the revised Bloom's taxonomy with the addition of a knowledge domain (see Anderson & Krathwohl, 2001).

The purpose of this report is to present the conventional taxonomies and some alternative ones used by teachers as a guide in creating assessment tools.

Bloom's Taxonomy

Bloom's taxonomy is composed of three domains: Cognitive, affective and psychomotor. Every time a teacher states objectives these four domains are present. Some behavioral terms for each domain are provided in order to guide teachers on what particular indicators can be used when planning for assessment. The most commonly used domain in creating paper and pencil tests are the cognitive domains (knowledge, comprehension, application, analysis, synthesis, evaluation). For more complex skills that cannot be captured through paper and pencil, a rubric can be used.

Table 1
Behavioral Terms for the Cognitive Domain

Cognitive level	Behavioral Terms
Knowledge	define, describe, identify, label, enumerate, match, outline, select, state, name, reproduce
Comprehension	Summarize, paraphrase, rephrase, convert, estimate, explain, generalize, paraphrase, infer, rewrite, compute
Application	Use, employ, give examples, changes, demonstrate, modify, predict, show, problem solving
Analysis	Relate, distinguish, differentiate, illustrate, separates, subdivides
Synthesis	Formulate, compose, produce, categorize, combine, create, devise, design, generate, organize, rearrange, reconstruct, reorganize, revise
Evaluation	Appraise, decide, justify, conclude, criticize, describe, defend

Table 2
Behavioral Terms for the Affective Domain

Affective Domain	Behavioral Terms
Receiving	Asks, chooses, describes, follows, gives, holds, locates, points to, relies, uses
Responding	Answers, assists, complies, conforms, greets, performs, practices, presents, recites, reports
Valuing	Completes, explains, initiates, invites, joins, justifies, proposes, shares, studies
Organization	Adheres, alters, arranges, defends, generalizes, integrates, orders, prepares, relates
Characterization	Acts, discriminates, displays, influences, modifies, proposes, qualifies, questions, revises, serves, solves, verifies

Table 3
Behavioral Terms for the Psychomotor Domain

Psychomotor Domain	
Imitation	Observes a skill and attempts to repeat it
Manipulation	Performs skill according to instruction rather than observation
Precision	Reproduces a skill with accuracy, proportion and exactness
Articulation	Combines more than one skill in sequence with harmony and consistency
Naturalization	Completes one or more skills with ease and becomes automatic with limited physical or mental exertion

Teachers are guided in stating learning intents and assessment based on six dimensions of cognitive process. Knowledge, with the lowest degree of complexity includes simple cognitive activity such as recall or recognition of information. The cognitive activity in comprehension includes understanding of the information and concepts, translating them into other forms of communication without altering the original sense, interpreting, and drawing conclusions from them. For application, emphasis is on students' ability to use previously acquired information and understanding, and other prior knowledge in new settings and applied contexts that are different from those in which it was learned. For learning intents stated at the Analysis level, tasks require identification and connection of logic, and differentiation of concepts based on logical sequence and contradictions. Learning intents written at this level indicate behaviors that indicate ability to differentiate among information, opinions, and inferences. Learning intents at the synthesis level are stated in ways that indicate students' ability to produce a meaningful and original whole out of the available information, understanding, contexts, and logical connections. Evaluation includes students' ability to make judgments and sound decisions based on defensible criteria. Judgments include the worth, relevance, and value of some information, ideas, concepts, theories, rules, methods, opinions, or products.

Comprehension requires knowledge as information is required in understanding it. A good understanding of information can facilitate its application. Analysis requires the first three cognitive activities. Both synthesis and evaluation require knowledge, comprehension, application, and analysis. Evaluation does not require synthesis, and synthesis does not require evaluation either.

Table 4
Alignment of Competence, Skill, and Behavioral Terms

Competence	Skill Demonstrated	Behavioral Term
Knowledge	• Observation and recall of information • Declarative knowledge • Mastery of subject matter	List, define, tell, describe, identify, show, label, collect, examine, tabulate, quote, name
Comprehension	• Understanding of information • Grasp meaning • Translate knowledge into new context • Interpret facts, compare, contrast • Order, group, infer causes • Predict consequences	Summarize, describe, interpret, contrast, predict, associate, distinguish, estimate, differentiate, discuss, extend
Application	• Use information • Use methods, concepts, theories in new situations • Solve problems using required skills or knowledge	Apply, demonstrate, calculate, complete, illustrate, show, solve, examine, modify, relate, change, classify, experiment, discover
Analysis	• Seeing patterns • Organization of parts • Recognition of hidden meanings • Identification of components	Analyze, separate, order, explain, connect, classify, arrange, divide, compare, select, explain, infer
Synthesis	• Use old ideas to create new ones • Generalize from given facts • Relate knowledge from several ideas • Predict, draw conclusions	Combine, integrate, modify, rearrange, substitute, plan, create, design, invent, what if?, compose, formulate, prepare, generalize, rewrite
Evaluation	• Compare and discriminate between ideas • Assess value of theories, presentations • Make choices based on reasoned argument • Verify value of evidence • Recognize subjectivity	Assess, decide, rank, grade, test, measure, recommend, convince, select, judge, explain, discriminate, support, conclude, compare, summarize

The Revised Bloom's Taxonomy

After 45 years since the birth of Bloom's original taxonomy, a revised version has come into the teaching practice, which was developed by Anderson and Krathwohl (2001). Statements that describe intended learning outcomes as a result of instruction are framed in terms of some subject matter content and the action required with the content. To eliminate the anomaly of unidimensionality of the statement of learning intents in their use of noun phrases and verbs altogether. There are two separate dimensions of learning: The knowledge dimension and the cognitive process dimension.

Knowledge Dimension has four categories, three of which include the subcategories of knowledge in the original taxonomy. The fourth, however, is a new one, something that was not yet gaining massive popularity at the time when the original taxonomy was conceived. It is new and, at the same time, important in that it includes strategic knowledge, knowledge about cognitive tasks, and self-knowledge.

Factual Knowledge

This includes knowledge of specific information, its details and other elements therein. Students make use of this knowledge to familiarize the subject matter or propose solutions to problems within the discipline. Factual knowledge is the basic elements that students must know to get acquainted with a discipline or solve problems within it. It can come in the form of a terminology like definitions, details, and elements like asking for examples of natural resources.

Conceptual Knowledge

This includes knowledge about the connection of information and other elements to a larger structure of thought so that a holistic view of the subject matter or discipline is formed. Students classify, categorize, or generalize ideas into meaningful structures and models. Conceptual knowledge deals with interrelationships among the basic elements within a larger structure that enable them to function together. The subtypes are classifications and categories (e. g., kinds of animals), principles and generalizations (e. g., law of supply and demand), and theorems and models (e. g., theory of evolution).

Procedural Knowledge

This category of knowledge dimension includes the knowledge in doing some procedural tasks that require specific skills and methods. Students also know the criteria for using the procedures in levels of appropriateness. Procedural knowledge involves knowledge on how to do something, and techniques and methods of specific skills. The subtypes are subject-specific skills and algorithms (e. g., computing for whole number division), subject-specific techniques and methods (e. g. steps in interviewing), criteria in determining when to use certain procedures (e. g., Polya's steps in problem solving).

Metacognitive Knowledge

This involves cognition in general as well as the awareness and knowledge of one's own cognition. Students know how they are thinking and become aware of the contexts and conditions within which they are learning. Metacogntion involves knowledge of cognition and awareness. The subtypes are strategic knowledge (e. g. use of heuristics), knowledge of cognitive tasks (e. g., knowledge cognitive demands of different tasks), and self-knowledge (awareness of one's own knowledge level).

The cognitive process dimension is where specific behaviors are pegged that is stated in active verbs. However, so that there is consistency in the description of specific learning behaviors, the categories in the original taxonomies which were labeled in noun forms are now replaced with their verb counterparts. Synthesis changed places with evaluation, both are now stated in verb forms.

Remembering. This includes recalling and recognizing relevant knowledge from long-term memory.

Understanding. This is the determination of the meanings of messages from oral, written or graphic sources.

Applying. This involves carrying out procedural tasks, executing or implementing them in particular realistic contexts.

Analyzing. This includes deducing concepts into clusters or chunks of ideas and meaningfully relating them together with other dimensions.

Evaluating. This is making judgments relative to clear standards or defensible criteria to critically check for depth, consistency, relevance, acceptability, and other areas.

Creating. This includes putting together some ideas, concepts, information, and other elements to produce complex and original, but meaningful whole as an outcome.

The use of the revised taxonomy in different programs has benefited both teachers and students in many ways (Ferguson, 2002; Byrd, 2002). The benefits generally come from the fact that the revised taxonomy provides clear dimensions of knowledge and cognitive processes in which to focus in the instructional plan. It also allows teachers to set targets for metacognition concurrently with other knowledge dimensions, which is difficult to do with the old taxonomy.

Table 1
Sample Objectives Using the Revised Taxonomy

The knowledge Domain		The Cogntive Domain						
		Remember	Understand	Apply	Analyze	Evaluate	Create	Remember
	Factual	#1						
	Conceptual		#2			#3		
	Procedural							
	Metacognitive	#4						

1: Remember the characters of the story, “Family Adventure.”
2: Compare the roles of at least three characters of the story.
3: Evaluate the story according to specific criteria.
4: Recall personal strategies used in understanding the story.

Both the Bloom’s taxonomy and the revised taxonomy are not the only existing taxonomic tools for setting our instructional targets. There are other equally useful taxonomies.

Gagne’s Taxonomy

One of these is developed by Robert M. Gagne. In his theory of instruction, Gagne desires to help teachers make sound educational decisions so that the probability that the desired results in achieving learning is high. These decisions necessitate the setting of intentional goals that assure learning.

In stating learning intents using Gagne’s taxonomy, we can focus on three domains. The cognitive domain includes Declarative (verbal information), Procedural (intellectual skills), and Conditional (cognitive strategies) knowledge. The psychological domain includes affective knowledge (attitudes). The psychomotor domain involves the use of physical movement (motor skills).

Verbal information includes a vast body of organized knowledge that students acquire through formal instructional processes, and other media, such as television, and others. Students understand the meaning of concepts rather than just memorizing them. This condition of learning lumps together the first two cognitive categories of Bloom’s taxonomy. Learning intents must focus on differentiation of contents in texts and other modes of communication; chunking the information according to meaningful subsets; remembering and organizing information.

Intellectual skills include procedural knowledge that ranges from Discrimination, to Concrete Concepts, to Defined Concepts, to Rules, and to Higher Order Rules.

Discrimination involves the ability to distinguish objects, features, or symbols. Detection of difference does not require naming or explanation.

Concrete Concepts involve the identification of classes of objects, features, or events, such as differentiating objects according to concrete features, such as shape.

Defined Concepts include classifying new and contextual examples of ideas, concepts, or events by their definitions. Here, students make use labels of terms denoting defined concepts for certain events or conditions.

Rules apply a single relationship to solve a group of problems. The problem to be solved is simple, requiring conformance to only one simple rule.
Higher order rules include the application of a combination of rules to solve a complex problem. The problem to be solved requires the use of complex formula or rules so that meaningful answers are arrived at.

Learning intents stated at this level of cognitive domain must be given attention to abilities to spot distinctive features, use information from memory to respond to intellectual tasks in various contexts, make connections between concepts and relate them to appropriate situations.

Cognitive strategies consist of a number of ways to make students develop skills in guiding and directing their own thinking, actions, feelings, and their learning process as a whole. Students create and hone their metacognitive strategies. These processes help then regulate and oversee their own learning, and consist of planning and monitoring their cognitive activities, as well as checking the outcomes of those activities. Learning intents should emphasize abilities to describe and demonstrate original and creative strategies that students have tried out in various conditions

Attitudes are internal states of being that are acquired through earlier experience of task engagement. These states influence the choice of personal response to things, events, persons, opinions, concepts, and theories. Statements of learning intents must establish a degree of success associated with desired attitude, call for demonstration of personal choice for actions and resources, and allow observation of real-world and human contexts.

Motor Skills are well defined, precise, smooth and accurately timed execution of performances involving the use of the body parts. Some cognitive skills are required for the proper execution of motor activities. Learning intents drawn at this domain should focus on the execution of fine and well-coordinated movements and actions relative to the use of known information, with acceptable degree of mastery and accuracy of performance.

Stiggins and Conklin's Taxonomy

Another taxonomic tool is one developed by Stiggins & Conklin (1992), which involves categories of learning as bases in stating learning intents.

Knowledge. This includes simple understanding and mastery of a great deal of subject matter, processes, and procedures. Very fundamental to the succeeding stages of learning is the knowledge and simple understanding of the subject matter. This learning may take the form of remembering facts, figures, events, and other pertinent information, or describe, explain, and summarize concepts, and cite examples. Learning intents must endeavor to develop mastery of facts and information as well as simple understanding and comprehension of them.

Reasoning. This indicates ability to use deep knowledge of subject matter and procedures to make defensible reason and solve problems with efficiency. Tasks under this category include critical and creative thinking, problem solving, making judgments and decisions, and other higher order thinking skills. Learning intents must, therefore, focus on the use of knowledge and simple understanding of information and concepts to reason and solve problems in contexts.

Skills. This highlights the ability to demonstrate skills to perform tasks with acceptable degree of mastery and adeptness. Skills involve overt behaviors that show knowledge and deep understanding. For this category, learning intents have to take particular interest in the demonstration of overt behaviors or skills in actual performance that requires procedural knowledge and reasoning.

Product. In this area, the ability to create and produce outputs for submission or oral presentations is given importance. Because outputs generally represent mastery of knowledge, deep understanding, and skills, they must be considered as products that demonstrate the ability to use those knowledge and deep understanding, and employ skills in strategic manner so that tangible products are created. For the statement of learning intents, teachers must state expected outcomes, either process- or product-oriented.

Affect. Focus is on the development of values, interests, motivation, attitudes, self-regulation, and other affective states. In stating learning intents on this category, it is important that clear indicators of affective behavior can easily be drawn from the expected learning tasks. Although many teachers find it difficult to determine indicators of affective learning, it is inspiring to realize that it is not impossible to assess it.

These categories of learning by Stiggins and Conklin are helpful especially if your intents focus on complex intellectual skills and the use of these skills in producing outcomes to increase self-efficacy among students. In attempting to formulate statements of learning outcome at any category, you can be clear about what performance you want to see at the end of the instruction. In terms of assessment, you would know exactly what to do and what tools to use in assessing learning behaviors based on the expected performance. Although stating learning outcomes at the affective category is not as easy to do as in the knowledge and skill categories, but trying it can help you approximate the degree of engagement and motivation required to perform what is expected. Or if you would like to also give prominence to this category without stating another learning intent that particularly focus on the affective states, you might just look for some indicators in the cognitive intents. This is possible because knowledge, skills, and attitudes are embedded in every single statement of learning intent.

Marzano's Dimension of Learning

Another alternative guide for setting the learning targets is one that had been introduced to us by Robert J. Marzano in his Dimensions of Learning (DOL). As a taxonomic tool, the DOL provides a framework for assessing various types of knowledge as well as different aspects of processing which comprises six levels of learning in a taxonomic model called the new taxonomy (Marzano & Kendall, 2007). These levels of learning are categorized into different systems.

The Cognitive System. The cognitive system includes those cognitive processes that effectively use or manipulate information, mental procedures and psychomotor procedures in order to successfully complete a task. It indicates the first four levels of learning, such as:

Level 1: Retrieval. In this level of the cognitive system students engage some mental operations for recognition and retrieval of information, mental procedure, or psychomotor procedure. Students engage in recognizing, where they identify the characteristics, attributes, qualities, aspects, or elements of information, mental procedure, or psychomotor procedure; recalling, where they remember relevant features of information, mental procedure, or psychomotor procedure; or executing, where they carry out a specific mental or psychomotor procedure. Neither the understanding of the structure and value of information nor the how's and why's of the mental or psychomotor procedure is necessary.

Level 2: Comprehension. As the second level of the cognitive system, comprehension includes students' ability to represent and organize information, mental procedure or psychomotor procedure. It involves symbolizing where students create symbolic representation of the information, concept, or procedures with a clear differentiation of its critical and noncritical aspects; or integrating, where they put together pieces of information into a meaningful structure of knowledge or procedure, and identify its critical and noncritical aspects.

Level 3: Analysis. This level of the cognitive system includes more manipulation of information, mental procedure, or psychomotor procedure. Here students engage in analyzing errors, where they spot errors in the information, mental procedure, or psychomotor procedure, and in its use; classifying the information or procedures into general categories and their subcategories; generalizing by formulating new principles or generalizations based on the information, concept, mental procedure, or psychomotor procedure; matching components of knowledge by identifying important similarities and differences between the components; and specifying applications or logical consequences of the knowledge in terms of what predictions can be made and proven about the information, mental procedure, or psychomotor procedure.

Level 4: Knowledge Utilization. The optimal level of cognitive system involves appropriate use of knowledge. At this level, students put the information, mental procedure, or psychomotor procedure to appropriate use in various contexts. It allows for investigating a phenomenon using certain information or procedures, or investigating the information or procedure itself; using information or procedures in experimenting knowledge in order to test hypotheses, or generating hypotheses from the information or procedures; problem solving, where students use the knowledge to solve a problem, or solving a problem about the knowledge itself; and decision making, where the use of information or procedures help arrive at a decision, or decision is made about the knowledge itself.

The Metacognitive System. The metacognitive system involves students' personal agency of setting appropriate goals of their learning and monitoring how they go through the learning process. Being the 5th level of the new taxonomy, the metacognitive system includes those learning targets as specifying goals, where students set goals in learning the information or procedures, and make a plan of action for achieving those goals; process monitoring, where students monitor how they go about the action they decided to take, and find out if the action taken effectively serves their plan for learning the information or procedures; clarity monitoring, where students determine how much clarity has been achieved about the knowledge in focus; and accuracy monitoring, where students see how accurately they have learned about the information or procedures.

The Self System. Placed at the highest level in the new taxonomy, the Self System is the level of learning that sustains students' engagement by activating some motivational resources, such as their self-beliefs in terms of personal competence and the value of the task, emotions, and achievement-related goals. At this level, students reason about their motivational experiences. They reason about the value of knowledge by examining importance of the information or procedures in their personal lives; about their perceived competence by examining efficacy in learning the information or procedures; about their affective experience in learning by examining emotional response to the knowledge under study; about their overall engagement by examining motivation in learning the information or procedures.

In each system, three dimensions of knowledge are involved, such as information, mental procedures, and psychomotor procedures.

Information

The domain of informational knowledge involves various types of declarative knowledge that are ordered according to levels of complexity. From its most basic to more complex levels, it includes vocabulary knowledge in which meaning of words are understood; factual knowledge, in which information constituting the characteristics of specific facts are understood; knowledge of time sequences, where understanding of important events between certain time points is obtained; knowledge of generalizations of information, where pieces of information are understood in terms of their warranted abstractions; and knowledge of principles, in which causal or correlational relationships of information are understood. The first three types of informational knowledge focus on knowledge of informational details, while the next two types focus on informational organization.

Mental Procedures

The domain of mental procedures involves those types of procedural knowledge that make use of the cognitive processes in a special way. In its hierarchic structure, mental procedures could be as simple as the use of single rule in which production is guided by a small set of rules that requires a single action. If single rules are combined into general rules and are used in order to carry out an action, the mental procedures are already of tactical type, or an algorithm, especially if specific steps are set for specific outcomes. The macroprocedures is on top of the hierarchy of mental procedures, which involves execution of multiple interrelated processes and procedures.

Psychomotor Procedures

The domain of psychomotor procedures involves those physical procedures for completing a task. In the new taxonomy, psychomotor procedures are considered a dimension of knowledge because, very similar to mental procedures, they are regulated by the memory system and develop in a sequence from information to practice, then to automaticity (Marzano & Kendall, 2007).

In summary, the new taxonomy of Marzano and Kendal (2007) provides us with a multidimensional taxonomy where each system of thinking comprises three dimensions of knowledge that will guide us in setting learning targets for our classrooms. Table 5 shows the matrix of the thinking systems and dimensions of knowledge.

Table 5
Thinking Systems and Dimensions of Knowledge

Systems of Thinking	Dimensions of Knowledge		
	Information	Mental Procedure	Psychomotor Procedure
Level 6 (Self System)			
Level 5 (Metacognitive System)			
Level 4: Knowledge Utilization (Cognitive System)			
Level 3: Analysis (Cognitive System)			
Level 2: Comprehension (Cognitive System)			
Level 1: Retrieval (Cognitive System)			

De Bono's Six Thinking Hats

Now, if you wish to explore on other alternative tools for setting your learning objectives, here's another help for us to make our learning intents target on the more complex learning outcomes, this one from Edward de Bono (1985). There are six thinking hats, each of which is named for a color that represents a specific perspective. When these hats are "worn" by the student, information, issues, concepts, theories, and principles are viewed in ways that are descriptive of mnemonically associated perspectives of the different hats. Let's say that your learning intent necessitates students to mentally put on a white hat whose descriptive mental processes include gathering of information and thinking how it can be obtained, and the emotional state is neutral, then learning behaviors may be classifying facts and opinions, among others. It is essential to be conscious that each hat that represents a particular perspective involves a frame of mind as well as an emotional state. Therefore, the perspective held by the students when a hat is mentally worn, would be a composite of mental and emotional states. Below is an attempt to summarize these six thinking hats.

Table 6
Summative map of the Six Thinking Hats

	THE HATS					
	WHITE	**RED**	**BLACK**	**YELLOW**	**GREEN**	**BLUE**
Perspective	Observer	Self & others	Self & others	Self & others	Self & others	Observer
Representation	White paper, neutral	Fire, warmth	Stern judge wearing black rode	Sunshine, optimism	Vegetation	Sky, cool
Descriptive Behavior	Looking for needed objective facts and information, including how these can be obtained	Presenting views, feelings, emotions, and intuition without explanation or justification	Judging with a logical negative view, looking for wrongs & playing the devil's advocate	Looking for benefits and productivity with logical positive view, seeing what is good in anything	Exploring possibilities & making hypotheses, composing new ideas with creative thinking	Establishing control of the process of thinking and engagement, using metacognition

These six thinking hats are beneficial not only in our teaching episodes but also in the learning intents that we set for our students. If qualities of thinking, creative thinking communication, decision-making, and metacognition are some of those that you want to develop in your students, these six thinking hats could help you formulate statements of learning intents that clearly set the direction of learning. Added benefits would be that when your intents are stated in the planes these hats, the learning episodes can be defined easily. Consequently, assessment is made more meaningful.

Discussion

In writing statements of learning intents for the subjects and courses, the aim is to state behavior outcomes to which teaching efforts are devoted, so that, from these statements, teachers can design specific tasks in the learning episodes for our students to engage into. However, it is needed to make sure that these statements will have to be set with proper level of generality so that they don't oversimplify or complicate the outcome.

A statement of intent could have a rather long range of generality so that many sub-outcomes may be indicated. Learning intents that are stated in general terms will need to be defined further by a sample of the specific types of student performance that characterize the intent. In doing this, assessment will be easy when the performance is clearly defined. Unlike the general statements of intent that may permit the use of not-so-active verbs such as know, comprehend, understand, and so on, the specific ones use active verbs in order to define specific behaviors that will soon be assessed. The selection of these verbs is very vital in the preparation of a good statement of learning intent. Three points to remember might help select active verbs (1) See that the verb clearly represents the desired learning intent, (2) Note that the verb precisely specifies acceptable performance of the student, (3) Make sure that the verb clearly describes relevant assessment to be made within or at the end of the instruction.

Although general intents give us an idea of the general direction of expected outcomes, it might be confused as to what specific behaviors of knowing will be assessed. Therefore, it is necessary to draw some representative sample of specific learning intent so that we will let students:

- write a definition of particular scientific term
- identify the synonym of the word
- give the term that fits a given description
- present an example of the term
- represent the term with a picture
- describe the derivation of the term
- identify symbols that represent the term
- match the term with concepts
- use the term in a sentence
- describe the relationship of terms
- differentiate between terms
- use the term in

If these behaviors are stated completely as specific statements of learning intent, teachers can have a number of specific outcomes. To make specifically defined outcomes, the use of active verbs is helpful. If more specificity is desired, statements of condition and criterion level can be added to the learning intents.

The lesson plan may allow the use of moderately specific statements of learning intents, with condition and criterion level briefly stated. In doing assessment, however, these intents will have to be broken down to their substantial details, such that the condition and criterion level are specifically indicated. Note that it is not necessarily about choosing which one statement is better than the other. We can use them in planning for our teaching.

If the instructional activities or learning episodes and assessment are well anchored on the intents guided by a clear taxonomy, direction of teaching and learning is better facilitated.

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