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THE IMPACT OF DISAGGREGATING CONCEPT AND SPECIALIST LANGUAGE ON CONTENT LEARNING AND ACADEMIC IDENTITY FORMATION: AN INSTRUCTIONAL APPROACH FOR ENGLISH LANGUAGE LEARNER IN CONTENT-RICH SUBJECTS (THE QUANTITATIVE ANALYSIS)

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Abstract— **This study explored the impact on learning Scientific and Mathematical concepts among English language learners, when the concept and its Specialist language is disaggregated. It has been assumed that students who learn to understand concept in General discourse (everyday terms) prior to being explicitly taught Science/ Mathematics Specialist Language will develop better understanding of concepts and content in general. Lesson plans were developed using the disaggregated approach to teach both Science and Mathematics in southern Philippines. The school respondents were chosen according to their type as private or public; location as urban or rural; level as elementary or high school. An experimental group and control group was assigned for each pair. Using the pre-posttest design, result indicated that students taught with the disaggregated approach significantly improved content understanding and linguistic competence compared to students taught in traditional ways.**

Keywords: **Science and Mathematics learning, English Language Learners, content-rich instruction**

I. INTRODUCTION

In a rapidly changing technological world, Science and Mathematics have crucial and direct impact on both personal and societal levels (Orleans, 2007). Both fields are described as the key to all learning and knowledge production, which gears up economic activities (Australian Academy of Science, 2015). Consequently, scholars and educators alike to strongly argue that both areas should be accorded high importance by all citizens. This has led to a continuous effort across the world to make Science and Mathematics learning more inclusive and meaningful, with the ultimate goal of producing scientifically and mathematically literate individuals (Simmons et al., 2005; Torres-Velsquez & Lobo, 2005; Towers, Martin, & Heater, 2013; Wilkinson & Penney, 2014). The only acceptable way to literacy is to study the field itself (Zwiers, 2006) taking on all challenges embedded in the process such as understanding concepts and gaining proficiency in its specific discourse. Researchers have suggested that fundamental understanding of Science and Mathematical concepts and processes is an interactive precursor to children's development of the ability to think critically (Jarvis & Pell, 2002; Rannikmae, Teppo, & Holbrook, 2010). Conversely, when children begin to think critically, they will be able to apply scientific and mathematical concepts

and processes in everyday situations (Ismail, Mustafa, & Muda, 2011). This enhances their knowledge, skills and the habits of mind that are essential for successful and rewarding participation in society.

However, it is widely accepted that learning in Science and Mathematics is never a straightforward endeavor. These fields are complex enterprises which have tendencies to exclude those who lack identification with their inherent culture (O. Lee, 2005). For instance, Science and Mathematics discourses in English are specific registers; they have their own field, audience and style of communicating. These and other issues challenge children's literacy acquisition process. But conversely, some scholars argue that successful learning needs proficiency in the language that carries its concepts (Brown & Ryoo, 2008; Reveles, Cordova, & Kelly, 2004).

The development of Scientific and Mathematical concepts is intertwined with the development of the language through which they are presented and so their literacies are a significant aspect of inclusive teaching. Science education research from linguistic and semiotic views, pedagogical perspectives and sociocultural theories of meaning-making all suggest that language plays a role in the science teaching-learning processes and it is becoming more widely recognised that the use of Specialist language (unique linguistic register) in Science and Mathematics pose difficulty for both speakers of English as Second Language or English Language Learners (ELLs) and for monolingual English speakers (O'Toole & Laugesen, 2011; Lee, 2005). The interaction between the Specialist language and unfamiliar scientific concepts can cause confusion among learners, especially in a school context where the motivation of students to learn Science is limited.

Brown and Spang, (2008) cautioned that an approach to instruction that treats Science terms as though they are the only way to describe the phenomena has the potential to negatively impact students' ability to conceptualize the idea and signals cultural mismatch. The thematic patterns that exist within the specialized language of science are not automatically acquired by students unless their prior experience has been such that they have been taught the vocabulary and technical terms as well as how to properly use the scientific grammar properly and apply it within scientific contexts (Brown & Spang, 2008; Lee-Brown, 2005; Rosenthal, 1996). It could be argued that if scientific language is used as the only means of presenting students with new concepts, there is the risk of presenting new ideas through incomprehensible language. More effective science instruction may involve the presentation of new ideas expressed through familiar language then gradually shift to specialist language (Mushi, 2011). The few studies that have been conducted in line with this notion reported a positive effect on student achievement in science but they have been limited to monolingual English speakers (Reveles & Brown, 2008; Reveles et al., 2004).

Consequently, this study intends to investigate the impact on learning of language manipulation in teaching Science and Mathematical concepts in a more linguistically diverse context. The study was conducted in the southern Philippines where English is commonly the third or fourth language to be learnt by school students and is generally only spoken within the school campuses (Alvarez, 1991; Tsai, Wu, & Liang, 2011). This research context provides a rich context for investigation. It involves both English Language Learners and localised debates regarding language use. Religious and political tensions compound resistance to the use of various languages in schools serving different cultural communities in the Philippines. This study also investigates academic identity: the connection between self-association and the field of study during the learning process (Brown, 2006). Consideration of the formation of learner academic identities and its impact on school learning in such a context makes a potentially important contribution to knowledge in this field.

II. Literature Review

Over the last ten years, research in the area of disciplinary learning in Science has tended to be categorized into three broad perspectives (Prain, 2009). These are the focus on formal analysis of linguistic and semiotic practices (Brown & Ryoo, 2008; O'Toole & Schefter, 2008), effective pedagogical strategies drawing on cognitive theories of knowledge production (Gyllenpalm, Wickman & Holmgren, 2010; Howes, Lim & Campos, 2009; Khishfe & Abd-El-Khalick, 2002; Wallace & Louden, 2003) and sociocultural theories of meaning-making and practice among marginalized learners (Brown & Spang, 2008; Olitsky, 2007; Reveles & Brown, 2008; Reveles, Cordova, & Kelly, 2004). All of these researchers are interested in knowing how learners acquire the scientific literacy that is considered necessary for life in our increasingly technological world. All emphasize the important role of language, and particularly the unique discourse of the field, in the development of scientific literacy, although the authors may differ concerning what exactly is meant by this term.

A. Difficulties of 'Scientific' English and Mathematics Academic Language

Wellington & Osborne (2001) indicate that many pupils and older students misunderstand Science not only because of technicality but also because of the use of apparently 'normal' English in a science context. The most common complaints about Science textbooks are their lack of adequate explanations for important content (Brown & Ryoo, 2008, Wellington & Osborne, 2001, Rosenthal, 1996), or the presence of poorly developed explanations which cause confusion and can lead to incorrect ideas about important science concepts (Brown & Spang, 2008; Olitsky, 2007; Reveles, Cordova, & Kelly 2004; O'Reilley & McNamara, 2007; Reveles & Brown, 2008).

Further, Wellington & Osborne (2001) also point out that scientists use verbs in the passive voice rather than in active voice to indicate the importance of the process rather than the person and that the use of cohesive devices such as reference, substitution, conjunctions or repetition or even page layout can make science texts less accessible to learners. O'Toole and Shefter (2008) indicate the involvement of grammatical metaphor in both technicality and word stacks, which in turn problematize text cohesion. Cohesive devices and variations in voice contribute to the discursive features that characterize scientific English. Students from both multilingual and monolingual backgrounds have difficulty with similar language features but evidently multilingual students experience greater degrees of difficulty.

Scientists do not write to confuse readers but their style can have features that differ from language with which students are more familiar (O'Toole, 1998). Specific school subject areas like Science and Mathematics have their own distinctive grammatical features and language structures that students must move between and across in order to be successful learners (C. Lee, 2006; O. Lee, 2005), making it important that learners acquire specialist language proficiency through teaching, which may involve practice that strives to be more 'effective' rather than 'settled' (Wallace and Louden 2003).

Academic language for Mathematics also involves much more than learning vocabulary. Oftentimes, this Mathematical specialist language refers to words and phrases which are highly abstract and relate to critically important concepts that are not yet understood by students (Coggins, Kravin, Coates, & Caroll, 2007). This means that decoding mathematical texts requires a certain level of literacy (Lee, 2006). Abel and Exley (2008) and Lee (2006) state that Maths texts contain lexical ambiguities or are lexically dense: words possess multiple meanings, symbols and less familiar lexical terms are commonly used and operation cues involve complex semantic structures. Density of Mathematical sentences result from the presence of more content words, fewer grammatical words, complex and lengthy nouns and verb groups (Halliday, 2004). In addition, O' Halloran (in Abel & Exley, 2008) noted that the major verb process involve in Mathematics specialist language is the 'relational process', which is relatively unfamiliar to learners as it is less often encountered in teaching and learning subject English. Students need to be supported in developing a sense of the distinctive grammatical structures that are integral to Mathematics in order to achieve success at school in this subject area (Coggins, Kravin, Coates, & Caroll, 2007; Abel & Exley, 2008; Barton, 2006).

B. Assumptions regarding the Instructional Framework for Science and Math Teaching

Knowledge is transmitted in language, which means that the key to understanding a subject is control of its language. Lemke, in Wellington and Osborne (2001), suggests that learning science is essentially learning to talk in science; therefore, the subject should be learnt using the language of the field, scientific English. This is supported by recognition that science learning is an induction into a way of knowing and by the assertion that whatever is known is inseparable from the symbols in which the knowing is codified (Moje, Collazo, Carillo, & Marx, 2001; Reveles, Cordova, & Kelly 2004). This would imply that language is inseparable from the content of the subject matter and support the aggregation of specialist language and concept that is a feature of contemporary teaching practice in Mindanao. Hand, Yore, Jagger, and Prain (2010) conclude that researchers in the field of science pedagogy agree that the only way to learn science is to learn the language of the discipline.

The teaching and learning process in Science could focus on directed, explicit manipulations of language features of discourse within the field (Barba, 1995; Howes, Lim & Campos, 2009; Honig, 2012; Misiti, 2001; Reveles & Brown, 2008; Rosenthal, 1996; Sadler, 2004) rather than resting on the assumption that the integration of language and concept means that they cannot be separated (Lee 2005). It is the role of teachers to explicitly scaffold subject specific literacies, so students are equipped to differentiate between and work with these complex language structures (Echevarria, Vogt & Short, 2004). Coggins, Kravin, Coates and Caroll (2007) warn that being able to repeat the definition of a mathematics terms does not necessarily indicate understanding of the concept. If students do not possess the decoding skills to make meaning of maths texts they run the risk of failing when confronted with unfamiliar mathematical problems (Abel & Exley, 2008). Echevarria, Vogt and Short (2004) suggest three types of scaffolding to help students in mathematics: verbal scaffolding, which helps advance language skills; procedural scaffolding, which includes modelling and coaching; and instructional scaffolding, which include graphic organizers to enhance comprehension.

C. The Academic Identity Construct

According to Gee (2000), identity is the reflection of a "certain kind of person" in a given context. Academic identity describes how an individual would like to be understood as well as how they are in the process of constructing themselves in a learning instance. Learners construct academic identities as they communicate the ways in which they see themselves as students or as people who participate in the ordinary activities, routines, and norms of schooling. These include contributing to a class discussion, collaborating in an activity with peers, or getting good grades. They construct disciplinary identities as they see themselves as doers of various academic disciplines or school subjects (Reveles, Cordova, & Kelly, 2004; Olistsky, 2007) in this case subject positioning themselves in science or mathematics classes (Maeng & Kim, 2011).

Gee (2002), suggests four ways to view identity within classroom settings. Every individual has a 'nature identity', which is innate and channelled by nature; an 'institution identity', which describes positions in society; a 'discourse identity', which reflects individual accomplishment as recognized by others; and an 'affinity identity', which expresses experiences within a certain sort of affinity group. Each of the identities is inseparable from each other. They are all present and woven together as a given person acts within a given context. Thus, it is possible for learners to formulate their identities to the desired context (Gee, 2002; Johnson & Carlone, 2007), for instance enculturation in a science classroom. Johnson and Carlone (2007) proposed a model to describe science academic identity that entails performance; the social use of relevant scientific practices such as ways of talking and using tools; having recognition from within and outside as a science person; and so-called 'competence': having the knowledge and understanding of science content. Again, one strand cannot stand alone, they interrelate within learners as they continue to shape and reshape their academic identity to fit into the science class context (or not).

Discourse is considered to be central to the formulation of academic identities. Knowledge and understanding are socially constructed through talk, activity and interaction around meaningful problems, tasks, and tools (Norris & Philipps, 2003; Olitsky, 2007; Reveles & Brown, 2008). Language use reflects the prescribed classroom discursive practices which channel the acquisition of knowledge and guide in developing acceptable academic identity within a classroom culture.

Several studies have investigated the advantages of scaffolding student's academic identity and simultaneously learning the literacies of science. For instance, Brown and Ryoo (2008) showed that students taught with science concepts using everyday language prior to using scientific language significantly improved understanding compared to students taught in traditional linear ways. This study suggests the potential of disaggregating the language from the concepts in studying science content. However, the study did not compare groups in terms of language proficiency. Ethnographic studies, such as those of Brown and Spang (2008); Reveles, Cordova and Kelly (2004); Reveles and Brown (2008) and Olitsky (2007), have used discourse analysis to investigate how teachers manipulate the use of language to accommodate all learners in science classes. Data from these various studies showed that teacher scaffolding through appropriate opportunities for learners to be engaged in learning activities improved learner understanding of concepts, their command of specialist language and the likelihood of perceiving themselves as part of the discipline.

D. Addressing the Gap in Literature

Given that learning Science and Mathematics is both a cognitive and social process, this research builds on existing knowledge by modifying the Directed Discourse Approach to Science Instruction (DDASI: Brown & Reveles, 2008). An *Engaging Disaggregation of Word and Concept Instructional* strategy (EDWIN) was developed and applied to Science and Mathematics elementary and secondary classes in Mindanao, Philippines. The project compared group performances (redressing a shortcoming in Brown & Ryoo 2008) and applied a combination of the Gee (2000) and Johnson and Carlone (2007) constructs of 'academic identity', through analysis of discourse in technical contexts (building on work by Olitsky, 2007) to better understand patterns of success and failure (responding to a call in Lee, (2005) in this contested cultural context (extending or challenging Milligan, 2003).

III. Research Questions

This study explored the impact of disaggregating concepts from the specialist language that carries them when teaching in content-rich subjects. Its impact on learning among English Language Learners was investigated to find out whether a particular instructional approach improves instruction in Science and Mathematics. Identity factors that facilitate or impede the acquisition of science and math literacies among English language learners were also explored.

A. Specific Research Questions

1. How does disaggregating words and concepts affect students' learning when examined across factors of conceptual understanding and linguistic understanding?
2. What are other factors that may significantly affect achievement in Science and Mathematics among English language learners?

IV. Method

This study employed an *Embedded Mixed Methods Design* which combined the advantages of both quantitative and qualitative data gathering wherein the former is more effective at recording outcomes of the intervention while the latter is capturing how individuals experienced the process (Creswell, 2012). Given the theoretical framework that learning content rich courses is highly cognitive and social process, there is an emergent need to both quantify and qualify the investigation process.

A. Subject, Site and Sampling Technique

There were four elementary and four high schools involved in the study, two urban and two rural schools at each level and one private and one public school in each pair. Each school provided one control group and one treatment group for both Science and Math**.** The control group received instruction in the locally conventional methods and techniques implemented by the school. On the other hand, teaching for the treatment group involved the disaggregation of concept and specialist language through the Engaging Disaggregation of Word and Concept Instructional strategy (EDWIN).

This study was conducted at Cotabato City and Maguindanao Province, in Mindanao, the third largest island in the Philippine archipelago. The elementary student-respondents came from the 5th grade. And the junior high-school student-respondents were sampled from the 7th grade. Private schools have an average of 40 students per class. However, the public schools have more students with an average normal class size of 60. In total, the estimated average number of student-respondents was 400. The said participants were chosen using the *non-probability purposive convenience sampling technique* (Creswell, 2012*)*. The school classifications and academic year were purposely sampled to provide a basis for comparing across school types and students geographical location.

B. Data Collection Strategies

The usual approach to teaching Science and Math in the Philippines makes no provision for language shifting. Lessons start with either reviews or questions which contain academic language right from the outset. There is an extensive use of textbooks and other written materials to illustrate the concept. Students are asked to memorize the definitions of words. Brown & Ryoo (2008) described this use of dense scientific English or academic language in introducing concept type as 'aggregated' and, representing the local default position, it will provide the control condition for the *quasi-experimental component of this mixed method stud*y.

The quantitative investigation was carried through a Quasi-Experimental design utilizing a Pre-Post Test technique. The researcher drew on the learning competencies included in lesson planning to construct a test including both multiple-choice and open-ended items. The same instrument served as both pre- and post-test, incorporating questions using both general and specialist language, making specific use of the target discourse. The instruments underwent pilot testing and the processes of statistical evaluation (specifically calculation of Cronbach's Alpha Coefficient to ensure reliability and peer analysis to ensure validity). The researcher administered both the pre-test and post-test. The same test was administered to both control (default aggregated language/content) and experimental (EDWIN) groups.

C. The Test

The test was divided into two components, comprising Multiple Choice and the Open-Ended items. There were three dependent measures extracted from the test; a general discourse score, a specialist language score and the combined total score. The general discourse score indicates students' ability to engage with scientific and mathematical concepts in general discourse: common English vocabulary. The specialist language (aggregate) reflects students' ability to understand, explain and manipulate scientific and mathematical concepts using scientific language or mathematical vocabulary. The total score combines the scores of the students in two earlier measures.

There were forty (40) Multiple Choice test items in Science which were equally divided into twenty (20) items written in general discourse and twenty (20) items written using the specialist language (technical vocabulary). There was less test items for Mathematics because of its computational nature. Only twenty-five (25) Multiple Choice items were classified into two, twelve (12) items were expressed in general discourse and the other thirteen (13) items were written in densely mathematical syntax. Students were also given ten (10) Open-Ended questions written in specialist language for both Science and Mathematics. These test items required them to provide written explanations or procedural calculations.

D. Scoring system

Students have to select the best answer from the given options in Multiple Choice test, while in Open-Ended, their written answers ranged from detailed use of specialist language to use of general discourse/everyday language to explain phenomena or procedures. Scoring systems were employed to treat the answers of the students in both test types. Going back to Multiple Choice, one point was given for every correct answer and the total possible score was 40 points in Science and 30 in Mathematics. It was broken down to their ability to answer questions with different vocabulary usage. The total possible score was 20 points for Science test written in Specialist language and a separate 20 perfect score points for Science test in General discourse. The number of test items in Math explained the difference, a perfect score of 15 points for specialist language and 13 points also for general discourse with the total possible score of 25 points.

Two scoring rubrics were designed to measure the students' conceptual understanding in the Open-Ended test. The first scoring system assessed their ability to use general discourse to state their conceptual understanding. For example, with this question, "*Describe an example of physical adaptation*" when a student A answered "*Eagles use its keen eye sight, strong sharp claws, and pointed sharp beaks to get food*". His answer illustrated a conceptually correct answer in Science content, written in general discourse. This was an acceptable answer and one point was given for every correct concept which made a total possible score of 10 points in general discourse. If for instance, student B answered the same question with "*Eagles can capture its prey through its body parts such as eyes, claws and beaks. This characteristic is a way of coping with the environment for protection like offense and defence and survival".* This illustrated an answer with the correct Science concept written in specialist language. Thus, one point was also given for every correct concept with a perfect score of 10 points for specialist language. A score of zero was given for no response, an incorrect concept, wrong answers or procedures stated either in specialist language or in general discourse. To give emphasis, the total possible score of 10 points in Open – Ended test reflected their ability to think conceptually correct and their strength to express through language manipulation.

Statistical Treatment

Results of the multiple- choice and open-ended tests were analysed using the Statistical Software Program Package (SPSS) version 22. T-test was used to analyse the scores between variables. Regression analysis was also employed to further examine the relationship of variables. Cohen's D was applied to compute the effect size.

E. The Instructional Intervention Approach

The researcher has modified the Directed Discourse Approach to Science Instruction (Brown 2004: Brown et al. 2005). This pedagogical technique takes a disaggregate approach to teaching science by emphasizing the need to teach the fundamental components of the science idea without using detailed scientific language. Further, it proposes the use of inquiry and scaffolding activities to assist students in their transition from understanding the basic scientific ideas to using scientific language to describe the phenomena being studied. Many researchers argued that "the thematic patterns that exist within the specialized language of Science are not automatically acquired by students, unless their prior experience has been such that they have been taught the vocabulary and technical terms as well as how to properly use the scientific grammar and apply it within the scientific context" (Watts, 2003; Wilkins, 2004) On this note, that the conceptualization of EDWIN strategy has emerged to contextualized the instructional approach intervention. This strategy was tailored to address the research theoretical framework and fit to content rich courses such as Science and Math. EDWIN stands for E - ENGAGING, D – DISAGGREGATION of, W – WORD AND CONCEPT, IN – INSTRUCTION. The strategy had four stages when applied to lesson planning and implementation. Each of the stages is briefly described below.

Stage 1 – Engagement

This stage involves employing a query-oriented approach to introducing the concept/s to be learned. It further aims of making connections between past and present learning experiences to anticipate and focus students' thinking on the learning outcomes of current activities. This stage of the lesson will allow students to identify their understanding of the phenomenon being discussed and most importantly, teachers will understand students' prior learning, preconceptions of the concept maybe and may begin addressing misconceptions that the learners bring to the classroom.

Stage 2 - Enabling Discourse

In this stage, the teacher introduces the accurate concepts being spring-boarded in Stage 1, using general discourse while avoiding overly technical descriptions associated with the particular subject. The teacher can begin to ensure that the big "idea" is understood through language manipulations, illustrations, discussions, and the use of language strategies to learn scientific and mathematical literacies. This part of the lesson helps provide students with common-base of experiences. They identify and develop concepts, processes, skills or behaviors in an environment with less academic expectations, less fear and intimidation.

Stage 3 – Explicit Discourse

The teacher introduces the students to the specific specialist language of the concept and content being discussed. He further scaffolds students' use of the specialist language and require them to build the terms into their vocabulary repertoire by providing them with opportunities to use the language to clarify misconceptions and deepen their understanding or investigation. The use of specialist language should be clear and explicit at this point of instruction.

Stage 4 - Elaboration Opportunities

Teacher provides students with several opportunities to articulate their understanding of the phenomenon being explored in the presentation of the lesson. This final stage uses assessment activities to allow the students to write about and explain the concepts being discussed using technical language of the discipline (Science/Math) free of teacher's assistance. These parts of the lesson will allow students to build and manifests their conceptual and discursive understanding.

The EDWIN strategy was used to construct 5 lesson plans for five content lessons in both Science and Math subjects. Each of the lesson plans administered to the experimental groups were written according to its framework. The subject matter was purposely selected from the minimum competency for the 2nd grading period in the Philippine school system. This ensured rich content and the smooth conduct of the intervention without disrupting the on-going classes and planned instruction of teachers and schools involved, as most of the teachers, students, and classes are settled and would provide ample time for classroom teaching in participating schools.

Each lesson followed the usual one hour delivery and the five lessons were taught for 1 week of classroom instruction which was brief enough to limit research impact on normal school practice but long enough to reveal practical impact (cf., Brown & Ryoo 2008). The study utilized one lesson plan with one major topic and was taught for 4-5 days, which was sufficient time for students to demonstrate an improved conceptual and linguistic understanding of science.

V. Result Discussion

Students' prior knowledge and their ability to use both General Discourse and Specialist Language was established by the pretest results. The comparison of pre test scores showed that both control and experimental group were broadly similar. The following tables illustrate group performances and relative gains after the intervention.

In Mathematics 5 (elementary), the pretest result showed that control group performed better in questions written in General Discourse whether in Multiple Choice or Open-Ended test type. It shows understanding of words. But the experimental group got higher scores in Total Open test. This could be attributed to the geographical locations of some schools. Interestingly, in the post test both groups register no statistical difference in their performance in General Discourse and Total Multiple Choice. Although both groups showed significant increase on their post test scores, the experimental group showed greater learning gains in all other measures. For instance, in Specialist Language Multiple Choice, experimental; group mean learning gain is 31% significantly higher than control group's 14% learning gain. The intervention was effective: the experimental group outperformed the control group with learning gains of 36% compared to 22% of control groups in the Open-Ended questions, with an effect size of 0.7.

There was no significant difference in the performance of both groups in the pretest of Mathematics 7 subject in all the question types except in General Discourse Open-Ended where the experimental group registered a higher mean score. In posttest however, an observable impact of the teaching approach was reflected in the performance of experimental outperforming the control group in all questions types. To compare the performance of both groups, experimental group mean learning gains in Total Multiple Choice was 28% higher than control group's 4% learning gains. The intervention showed a nearly large effect size to experimental group while there a null effect to control group. This highlights that students' understanding of concepts was solidified during the teaching-learning process. Regardless of the language being used in the questions, they were able to get higher scores compared to their counterparts. Their ability to express themselves using the English General discourse and Specialist language has also improved. Their scores in Total Open-Ended showed that again experimental group showed more learning than the control group while nearly medium effect size to the former and small effect size to the latter.

Meanwhile, the result of Science 5 registered a different pattern of significant effects of the intervention. On the onset, as indicated by the pre-test scores, the experimental group significantly outperformed the control group in questions written in General Discourse both in Multiple Choice and Open-Ended types. They scored higher in Specialist language Open-Ended test. There are many factors contributed to this result, the post test result revealed an interesting insight, although the experimental was already better than control, the learning gains implied that they learned more after the intervention. To examine their performance, for instance, the overall performance in test types, Total Multiple Choice, both groups improved their scores but the experimental with 26% learning gains higher than 16% of control group. The effect size was also nearly large for the experimental group. Their ability to use language to write the correct concept as answers showed a similar trend, the experimental group showed higher learning gains (179%) than the control (18%). The result in the Open- Ended questions revealed a very large effect size to the experimental group, after the inter

There was a statistical difference in the performance of experimental and control groups in the pretest result of all test types except in General Discourse Multiple Choice. This implied that both groups are not on the same ability level in terms of schema and use of General Discourse. However, experimental groups outperformed their counterparts in the rest of the test types and in their over-all performance in Multiple Choice and Open-Ended pretests. Though, this is not indicative yet of relative effect of the teaching intervention. The post test result indicates that there is a statistical difference between the mean scores of both groups, and that experimental group performed better than the control. Further on, there was an improvement of scores for both groups, although mean learning gains vary between groups. Specifically, in the Multiple Choice test, a combination of scores showed that the experimental group had improved their scores as expected but this improvement is significantly different from the improvement of their counterpart: at 27% it was higher than the mean gain of 9% for the control groups. The same pattern transpired in the Open- Ended over-all performance, experimental mean percent gain 187% higher than 179% of control's mean gain. It signifies that the former have better usage of both General Discourse and Specialist language to express Scientific concepts. The intervention has a very large effect size on the experimental group, though, they are performing better prior to instruction, their achievement was largely improved further by the approach.

VI. Result Discussion

Students' prior knowledge and their ability to use both General Discourse and Specialist Language was established by the pretest results. The comparison of pre test scores showed that both control and experimental group were broadly similar. The following tables illustrate group performances and relative gains after the intervention.

A. Analysis 1

In Mathematics 5 (elementary), (see table 1)the pretest result showed that control group performed better in questions written in General Discourse whether in Multiple Choice or Open-Ended test type. It shows understanding of words. But the experimental group got higher scores in Total Open test. This could be attributed to the geographical locations of some schools. Interestingly, in the post test both groups register no statistical difference in their performance in General Discourse and Total Multiple Choice. Although both groups showed significant increase on their post test scores, the experimental group showed greater learning gains in all other measures. For instance, in Specialist Language Multiple Choice, experimental; group mean learning gain is 31% significantly higher than control group's 14% learning gain. The intervention was effective: the experimental group outperformed the control group with learning gains of 36% compared to 22% of control groups in the Open-Ended questions, with an effect size of 0.7.

There was no significant difference in the performance of both groups in the pretest of Mathematics 7 subject in all the question types except in General Discourse Open-Ended where the experimental group registered a higher mean score (see table 2). In posttest however, an observable impact of the teaching approach was reflected in the performance of experimental outperforming the control group in all questions types. To compare the performance of both groups, experimental group mean learning gains in Total Multiple Choice was 28% higher than control group's 4% learning gains. The intervention showed a nearly large effect size to experimental group while there a null effect to control group. This highlights that students' understanding of concepts was solidified during the teaching-learning process. Regardless of the language being used in the questions, they were able to get higher scores compared to their counterparts. Their ability to express themselves using the English General discourse and Specialist language has also improved. Their scores in Total Open-Ended showed that again experimental group showed more learning than the control group while nearly medium effect size to the former and small effect size to the latter.

Meanwhile, the result of Science 5 registered a different pattern of significant effects of the intervention. On the onset, as indicated by the pre-test scores, the experimental group significantly outperformed the control group in questions written in General Discourse both in Multiple Choice and Open-Ended types (see table 3). They scored higher in Specialist language Open-Ended test. There are many factors contributed to this result, the post test result revealed an interesting insight, although the experimental was already better than control, the learning gains implied that they learned more after the intervention. To examine their performance, for instance, the overall performance in test types, Total Multiple Choice, both groups improved their scores but the experimental with 26% learning gains higher than 16% of control group. The effect size was also nearly large for the experimental group. Their ability to use language to write the correct concept as answers showed a similar trend, the experimental group showed higher learning gains (179%) than the control (18%). The result in the Open- Ended questions revealed a very large effect size to the experimental group, after the intervention. There was a statistical difference in the performance of experimental and control groups in the pretest result of all test types except in General Discourse Multiple Choice (see table 4). This implied that both groups are not on the same ability level in terms of schema and use of General Discourse. However, experimental groups outperformed their counterparts in the rest of the test types and in their over-all performance in Multiple Choice and Open-Ended pretests. Though, this is not indicative yet of relative effect of the teaching intervention. The post test result indicates that there is a statistical difference between the mean scores of both groups, and that experimental group performed better than the control. Further on, there was an improvement of scores for both groups, although mean learning gains vary between groups. Specifically, in the Multiple Choice test, a combination of scores showed that the experimental group had improved their scores as expected but this improvement is significantly different from the improvement of their counterpart: at 27% it was higher than the mean gain of 9% for the control groups. The same pattern transpired in the Open- Ended over-all performance, experimental mean percent gain 187% higher than 179% of control's mean gain. It signifies that the former have better usage of both General Discourse and Specialist language to express Scientific concepts. The intervention has a very large effect size on the experimental group, though, they are performing better prior to instruction, their achievement was largely improved further by the approach.

B. Analysis 2

The second analysis showed factors that might have significant effect to each of the question type and eventually to the over-all performance in the tests. Regression analysis identified the predictors through their coefficients value and direction.

As shown in Figures 1and 2, Mathematics analysis both in elementary (Mathematics 5) and high school (Mathematics7), study group, school type and school location have statistical significance effect to the questions and over-all performance in Multiple Choice test.

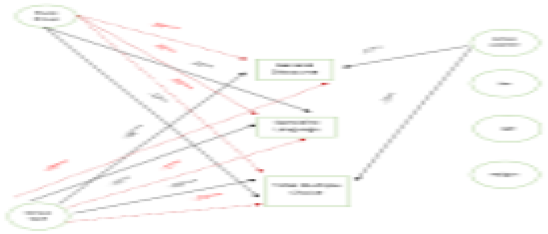

Fig 1: Predictors of Post test Scores in Mathematic-Multiple Choice test

Specifically, study group and school type have direct effect on the General Discourse, Specialist language and the over-all scores in Multiple Choice. The coefficient values further indicate that students from private schools within the experimental group got higher scores compared to students studying in public schools from the control group. School location has significant effect on General Discourse questions and also in the Total Multiple Choice test. This is interesting because students from rural schools performed better than those from urban schools. With the Open Ended test, study group, school type, school location and sex had statistically significant effects. This means that when students are taught using the disaggregation approach, they would get higher scores compared to students being taught with other approaches. When the students are studying in private schools and coming from urban places and being male they would likely perform better in Mathematics open ended test which would ask them to write their solution and tackle highly conceptual questions.

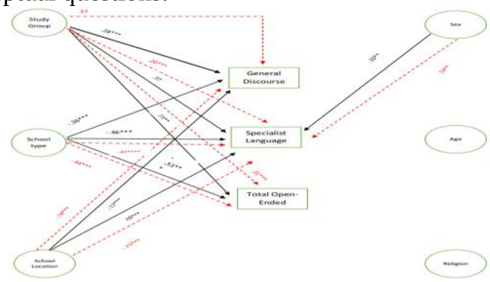

Fig 2: Predictors of Post test Scores in Open Ended test

Further regression analysis in Science subject showed interesting results. Predictors such as study group, school type, school location, sex and religion have statistically significant effects on their scores in the Multiple Choice test. Students who are taught using the developed approach have better grasp of scientific concepts and they perform better when tested with questions written in General discourse of in specialist language. Student from the private schools would perform better also in these type of questions. There are two emerging results in this analysis, Students who are affiliated with Roman Catholic scored better than students with other religious affiliations. Female students have better performance compared to their male counterparts.

Fig 3: Predictors of Post test Scores in Science Multiple Choice test

Similar patterns emerged in the Open-Ended test. After employing the intervention to students, they have better understanding of Science concept and grasp of both General Discourse and Specialist language as shown in their regression coefficients. Students from private and urban schools would have advantage over their counterparts in expressing themselves in Open- Ended test. In addition, sex, age and religion registered significant effect only to their scores in General Discourse questions. This implied further that female, younger students and belonging to Roman Catholic religion have better use of General Discourse to express scientific concepts.

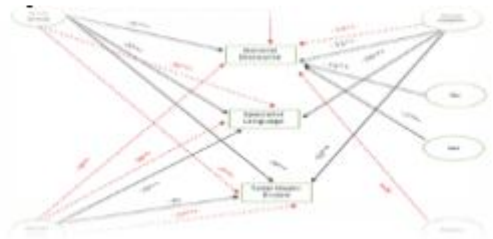

Fig 4: Predictors of Post test Scores in Open Ended test

VII. CONCLUSIONS

Based on the analysis presented, students taught using the disaggregated approach demonstrated an improved conceptual and linguistic understanding of Science and Mathematics. The result further made clear that student ability to use and think in the specialist language of the field of learning is largely influenced by the teaching approach.

Student answers to questions written in General Discourse indicate their ability to engage with specialist concepts in everyday English, while answers to questions written in Specialist Language indicate their grasp of that style. Answers to Multiple-choice questions indicate student concept recognition, while their answers to Open-ended questions suggest their ability to correctly express Scientific and mathematical concepts.

EDWIN appears to have had substantial impact on Mathematics achievement. For instance, the experimental group demonstrated remarkably greater conceptual understanding in the Multiple Choice sections of the test, whether the questions were expressed in General discourse or Specialist language forms. Unexpectedly, the greatest impact was found on students' ability to identify correct concepts in Specialist language, although undeniably it has impacted also their ability to identify correct concepts in General discourse. The same pattern occurs in Open-Ended questions: students from the EDWIN experimental group were able to express correct Mathematic concepts and processes using its Specialist language.

This is congruent with the assumption that learning in content- rich courses would be improved through disaggregation of concepts and words but with emphasis on subtle transition to and formal instruction of Specialist words and processes. Moreover, this result is on contrast to previous studies conducted in Science subject with English speaking students and with minority students in dominantly English speaking class. Previous studies showed that the greatest impact was on conceptual understanding as expressed in everyday language which is not the case in this investigation of Mathematics learning.

The intervention has improved students' conceptual understanding in Science as communicated both in everyday and scientific style. Moreover, we found out that students were more likely to use Specialist language than General discourse when asked to express or identify correct Science concepts. This result supports the previous studies that a disaggregation approach had greatest impact on students' ability to express their understanding in Science language which lead to improved students' conceptual understanding.

Since this study was conducted in a learning environment which has potential to offer rich information, other factors were tested to find out their significant effect in learning Science and Mathematics. We found out that, aside from the very strong influence that teaching approach had on achievement, factors such as school type and school location had a direct effect on student understanding of Mathematical concepts and processes. Students studying in private schools have potential to perform better than other students. Students from rural places are able to identify correct concepts and follow Mathematics processes using General Discourse. But in general, it is evident that students from urban schools may perform better in Mathematics and based on our analysis, male students would likely perform better in Mathematics especially with highly conceptual questions and complicated tasks.

We can further conclude that the intervention had considerably impact on student Science achievement. Predictors such as school type, school location, sex and religion significantly affected conceptual understanding and linguistic ability in Science learning. This findings show that, similar to Mathematics, students from private schools are more likely to achieve higher Science scores. Conversely, female students are better performers in Science than male students specifically in using General Discourse to express scientific ideas.

These initial results suggest that using a disaggregated approach to teaching Science and Mathematics yields greater conceptual understanding and improves student ability to use and understand Specialist language of these two fields. This may be particularly true for English Language Second Language Learners (ELLs), as it lessens the difficulty such students experience in learning in content-rich courses, specifically the difficulty of learning concepts embedded in Specialist language.

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33

Appendix

Table 1: Comparison of Mean Scores between Pre Test and Post Test (Math 5)

Achievement Test Types	Groups	N	Pre test Mean	Pre test SD	Post test Mean	Post test SD	Raw Gain %	T-Value Pre-Test	T-Value Post Test	Effect Size
General Discourse Multiple Choice	Control	173	3.66	1.67	4.10	1.92	12			.3
	Experimental	144	3.20	1.52	3.92	1.68	23	2.49	.89	.4
	Control	173	2.93	1.77	3.43	1.80	17			.3
Specialist Language Multiple Choice	Experimental	144	2.87	1.82	4.04	1.60	41	2.89	3.15	.7
	Control	173	6.59	2.56	7.53	2.82	14			.3
Total Multiple Choice	Experimental	144	6.07	2.45	7.96	2.59	31	1.78	1.39	.7
	Control	173	.52	.84	.42	.63	19			-.1
General Discourse Open Ended	Experimental	144	.78	.80	1.02	1.20	31	4.30	4.32	.3
Specialist Language Open Ended	Control	173	.18	.50	.70	1.06	288			.5
	Experimental	144	.20	.52	.89	1.07	345	.34	1.51	.6
Total Open Ended	Control	173	..70	1.14	.86	1.40	22			.1
	Experimental	144	1.22	1.34	1.67	1.48	36	3.72	3.35	.3

Table 2: Comparison of Mean Scores between Pre Test and Post Test (Math 7)

Achievement Test Types	Groups	N	Pre test Mean	Pre test SD	Post test Mean	Post test SD	Raw Gain %	T-Value Pre-Test	T-Value Post Test	Effect Size
	Control	145	3.63	1.71	3.31	1.74	-8.81	1.75	4.16	-.2
General Discourse Multiple Choice	Experimental	172	3.26	2.08	4.13	1.90	27			.5
	Control	145	3.08	1.69	3.68	1.70	19	.63	2.47	.4
Specialist Language Multiple Choice	Experimental	172	3.20	1.74	4.15	1.81	29			.5
	Control	145	6.71	2.80	6.99	2.79	4	.77	4.29	.1
Total Multiple Choice	Experimental	172	6.46	3.03	8.28	2.80	28			.7
	Control	145	.04	.23	.04	.23	0	3.26	7.16	0
General Discourse Open Ended	Experimental	172	.18	.52	.39	.65	116			.3
Specialist Language Open Ended	Control	145	.63	.90	.83	1.10	32	1.26	2.73	.2
Total Open Ended	Experimental	172	.78	1.14	1.14	1.06	46			.5
	Control	145	.68	.96	.86	1.15	27	1.85	4.48	.2
	Experimental	172	.93	1.45	1.46	1.36	57			.4

Table 3: Comparison of Mean Scores between Pre Test and Post Test (Science 5)

Achievement Test Types	Groups	N	Pre test Mean	Pre test SD	Post test Mean	Post test SD	Raw Gain %	T-Value Pre-Test	T-Value Post Test	Effect Size
	Control	153	4.96	2.24	5.18	2.53	4	1.75	4.16	.08
General Discourse Multiple Choice	Experimental	144	5.62	2.21	7.31	2.69	30			.6
	Control	153	6.31	2.49	6.99	3.17	11	.63	2.47	.2
Specialist Language Multiple Choice	Experimental	144	6.34	3.12	8.83	3.15	39			.8
	Control	153	11.27	3.86	13.12	4.29	16	.77	4.29	.4
Total Multiple Choice	Experimental	144	11.98	3.41	15.13	4.54	26			.7
	Control	153	.56	.99	.84	1.01	50	3.26	7.16	.3
General Discourse Open Ended	Experimental	144	.82	1.1	1.96	1.59	19			.7
	Control	153	1.22	1.83	1.26	1.91	3	1.26	2.73	.02
Specialist Language Open Ended	Experimental	144	.76	1.13	1.91	2.88	151			.5
Total Open Ended	Control	153	1.78	2.35	2.10	2.15	18	1.85	4.48	.2
	Experimental	144	1.57	1.56	4.38	3.10	179			.9

Table 4: Comparison of Mean Scores between Pre Test and Post Test (Science 7)

Achievement Test Types	Groups	N	Pre test Mean	Pre test SD	Post test Mean	Post test SD	Raw Gain %	T-Value Pre-Test	T-Value Post Test	Effect Size
	Control	135	5.42	2.22	6.02	2.72	11	1.75	4.16	.2
General Discourse Multiple Choice	Experimental	146	5.59	2.05	7.65	2.55	37			.8
	Control	135	6.26	2.15	6.69	2.51	7	.63	2.47	.2
Specialist Language Multiple Choice	Experimental	146	6.83	2.07	8.12	2.46	19			.5
	Control	135	1.69	3.11	12.73	4.22	9	.77	4.29	.2
Total Multiple Choice	Experimental	146	12.41	2.96	15.78	3.76	27			.8
	Control	135	.29	.64	.64	1.13	120	3.26	7.16	.3
General Discourse Open Ended	Experimental	146	1.02	1.31	2.32	1.92	127			.7
Specialist Language Open Ended	Control	135	.25	.54	.87	.91	241	1.26	2.73	.6
Total Open Ended	Experimental	146	.59	.85	2.27	2.15	284			.8
	Control	135	.54	.82	1.51	1.63	179	1.85	4.48	.6
	Experimental	146	1.60	1.57	4.60	2.97	187			1