In what ways do the elements of the Caribbean curriculum encourage/ support the teaching of higher order thinking in mathematics?

by

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Abstract

Mathematics teachers have been widely criticized for not teaching their students to think critically. The purpose of this paper is to determine the cognitive level of thinking in the curriculum based on the Anderson and Krathwohl Taxonomy. The Caribbean Secondary Education Certificate (CSEC) mathematics syllabus for one strand was analyzed to determine the cognitive levels of the specific objectives and their corresponding teaching and learning activities. The majority of the objectives were skewed towards lower order thinking skills while the learning activities included a variety of higher order thinking skills.

Introduction

Since the early 20th century, the mathematics curriculum has been shaped periodically by concerns about preparation for the workplace and for life outside of school (Stanic & Kilpatrick, 1988 as cited in Hiebert et al 1996). Curriculum developers have been revising, revisiting and revamping elements of the curriculum, in a bid to prepare students for the 'future'. Although certain elements of syllabus content, which according to Braslavsky (2003), is a narrow view of the curriculum, can or may be constrained by institutional policy, they are all considered to be "powerful indicators of what takes place in classrooms" (Bers, Davis, & Taylor 2000 as cited in Hiebert et al p. 899). The syllabus, serves several constituents, namely, the teacher, the student and the school; it specifies what is expected of the various constituents through an articulation of rules, regulations, roles and responsibilities. It also contains several elements that can be used to infer the knowledge and skills that students should learn and acquire in a course. The inference is based on a careful evaluation and analysis of the key elements in the syllabus. Some of these key elements include the course purpose or goals (Peer & Martin, 2005), course learning outcomes (Sulik & Keys, 2014), assessment methods and tools (Diamond & Grunert, 1997; Habanek, 2005 as cited in Karanja, & Malone, 2020) and course topics/outline (Littlefield, 1999). These components according to Hiebert et al, should serve as a guide in enhancing the quality of students' learning.

Over the years, there have been numerous calls for teachers to transform their classroom so that students can develop the skills to think and reason effectively. Additionally, mathematics syllabi have been implementing goals that include higher order thinking as a foundation. Within the Caribbean, the Caribbean Secondary Education Certificate (CSEC) mathematics syllabus emphasizes the importance of students becoming problem solvers and decision makers. Specifically, it states that "the syllabus aims to help students apply the knowledge and skills, (which are presumed higher order thinking), acquired to solve problems in everyday situations". These higher order thinking skills, according to Lewis & Smith (1993), "occurs when a person takes new information and information stored in memory and interrelates and/or rearranges and extends this information to achieve a purpose or find possible answers in perplexing situations" (p. 136). Since students are required to become critical thinkers, then the key or core skills of thinking, creativity and problem solving which lay at the heart of successful learning, should be embedded in primary and secondary school curricula (Fisher, 2005).

Background to the Problem

I will begin by briefly discussing the history of the Caribbean education system as it relates to the curriculum, and then move into scholarly views about the performance of students which led to the purpose of the study.

Kesidou & Roseman (2002), states that many teachers depend on curriculum documents for content and pedagogical content knowledge. Although documents such as the syllabus, might not be valued equally by all educators (Kesidou and Roseman, 2002) they "have a major role in teaching and learning" (p. 522). This was looked upon by the Caribbean community, who bargained for a shift in the curriculum in most Caribbean schools which mirrored that of schools in Great Britain, prior to colonization. In 1972, the Caribbean Examinations Council (CXC) which constitutes two distinct exams, the Caribbean Secondary Examination Certificate (CSEC) and the Caribbean Advanced proficiency Examination (CAPE); was established by the Caribbean Community (CARICOM) to introduce and administer a regional curriculum in the English-speaking Caribbean. During this stage Jamaica and other Caribbean countries saw it fit to "caribbeanize" the curriculum at the secondary level. They focused on fashioning a better fit between the educational system and the development needs of the ex-colony. In some aspects, this enabled these regional exams to have distinctive West Indian elements which were aimed at establishing identity and creating a sense of unity among Caricom Member States. This has been looked upon as both a local and a regional imperative, since many of the ex-colonies in the Caribbean Basin have experienced similar problems with educational systems that were not geared towards enhancing the knowledge, skills, and values which helped students live more productive lives in their own societies (Whiteman 1994 as cited in Jamaica Educational System - Overview n.d.).

In addition to Whiteman's view, Wolff & Castro, (as cited in Lam, 2007), asserts that education in Latin American and the Caribbean is 'inadequate' by international standards. What constitutes this inadequacy? Maduabum & Odili (2006) believe that students' lack of interest in the subject may be the major factor, while Ross, McDougall & Hogaboam - Gray

(2002), highlighted the fact that, teacher's reluctance to adapt to more radical and reformed math is a challenge that most schools are facing. However as it relates to teaching and learning of mathematics, Omodu & Eghrie (2020) cited in their article that Osarenren and Asiedu (2007) submitted the claim that "the reason for the continued poor performance of students could, among others, be attributed to the students inability to think critically and analyze mathematical concepts systematically, "they are not able to interpret, explain and evaluate questions posed to them" (p. 81). Although researchers have attempted to identify the problem of poor performance in mathematics and what should be done to improve the performance, little attention has been given to the manner in which the key elements of the syllabus "can influence knowledge sharing" (Peacock, 2010 as cited in Wong & Tseng 2014, p. 374). For the purpose of this study, I will be paying close attention to the Mathematics Syllabus for CSEC to determine its impact on students' higher order thinking skills in the teaching of mathematics. This paper will therefore seek to determine the cognitive levels of thinking, as manifested in CSEC mathematics syllabus,

Positionality

I am an educator in the Caribbean school system, teaching secondary school mathematics for over twenty years. On many occasions I would find myself reflecting on my teaching strategies, my students' learning orientation, the classroom environment and my students' backgrounds. Being an educator in the field of mathematics, I have always wanted my students to learn how to think critically about the subject matter they are studying and to learn to think about the world in terms of the subject matter (Nosich, 2001, p. vii). I have also strived to ensure that they are not passive recipients of information absorbed from their teacher or the text, but rather they are active learners, who pay attention to critical elements of reasoning in a way that meets the required standard of a 21st century learner.

For over fifteen years I have been working with the Caribbean Examination Council (CXC) as an assistant examiner, making external examination scripts. Throughout this period, I would participate in discussion sessions with examiners from different regions, on certain challenges that students may face that can have an impact on their learning. Two of the main challenges cited had to do with stereotypes and the inability for some teachers to complete all the strands outlined on the syllabus. The stereotype that was mentioned was the fact that most students believed that "only smart people can be successful in mathematics" (Brad, Glasson, & Green, 2006). Secondly, it was noted that some teachers have and continue to voice their opinions about not being able to teach effectively due to external or internal factors, such as limited resource materials, student's lack of motivation or simply not being able to complete certain topics due to the compact syllabus or time constraint.

Although I am a teacher, and have been working with the CXC body for a number of years, I lack understanding of the nature in which a curriculum is developed. I don't know what it's like to be a part of a team who critiques this component which is such an integral part of our school system. I do understand that the aims and the rationale should be at the core of any syllabus but I need to inquire and understand more as it relates to the impact it might have on students' higher order thinking skills. Using this notion, the following two questions will be addressed in this research paper,

(1) To what extent are various levels of thinking represented in the CSEC Mathematics syllabus?
(2) What is the level of correspondence between the elements of the CSEC Mathematics syllabus and characteristics of higher order thinking?

Within this case study, I will seek to explore ways in which the learning objectives and suggested teaching activities of the Caribbean mathematics syllabus supports/encourage students' thought process. I will be reviewing scholarly literature as well as using my own experiences as an educator to support or disclaim any findings that may arise. I do believe that my pedagogical approaches, my experiences with my students, my background as a Caribbean educator will influence this research process; “hence my research agenda will have a personal, academic and a professional meaning to me” (Jett, 2019, p.320).

Method

As mentioned before, I am a Caribbean educator, and therefore I am familiar with the CSEC mathematics syllabus. The key elements of this regional syllabus includes aims and objectives, topics to be taught, suggested teaching strategies, teaching resources, format and weighting of external assessment. The syllabus caters for students from grades 7 through to 11 and addresses “the personal development and educational needs of the Caribbean students" (p. 1). I will be selecting one strand from the CSEC Mathematics syllabus (Number Theory and Computation) and the Revised Bloom's Taxonomy, which will be referred to as Anderson and Krathwohl (2001) Taxonomy to analyze the objectives and the suggested teaching strategies.

Literature review and Discussion

This section will expound on scholarly definitions of higher order thinking in mathematics education. It will focus particularly on data gathered from the CSEC mathematics syllabus and the cognitive level of thinking taxonomy put forward by Anderson and Krathwohl. The following statement from the rationale will also be examined.

> "The syllabus addresses the personal development and educational needs of Caribbean students by encapsulating a variety of skills integral to everyday life and prerequisites for entering environments of work and academia. These skills include critical and creative thinking, problem solving, logical reasoning, modelling ability, team work, decision making, information communication and competencies for life-long learning"
>
> (An extract from the rationale of CSEC mathematics syllabus 2015, p. 1)

Defining Higher Order Thinking

Definitions of higher order thinking vary across studies, therefore it is important to highlight the views from the two scholars central to this study. First and foremost, Newman (1990), points out that thinking should be categorized as higher order and lower order thinking. He distinguishes between them by stating that;

> lower order thinking demands only routine or mechanical application of previously acquired information such as listing information previously memorized and inserting numbers into previously learned formulas, while higher order thinking, "challenges the student to interpret, analyze, or manipulate information (p.44).

Brookhart 2010, (as cited in Collins 2014) on the other hand, identifies definitions of higher-order thinking as falling into three categories: first; those that define higher-order thinking in terms of *transfer*, secondly; those that define it in terms of *critical thinking* and third those that define it in terms of *problem solving*.

In the category of transfer, Anderson, Krathwohl et al (2001) define transfer in how it differs from retention. He claims that two of the most important educational goals are to promote retention and to promote transfer (which, when it occurs, indicates meaningful learning); however, retention requires that students remember what they have learned, whereas transfer requires students not only to remember but also to make sense of and be able to use what they have learned. It must be noted that, while learning for recall requires thinking, the higher-order thinking is in 'transfer'. That is, students not only acquire the knowledge and skills, but also can apply them to new situations.

The critical thinking category includes definitions that refer to 'reasonable, reflective thinking that is focused on deciding what to believe or do' (Norris & Ennis, 1989 as cited in Collins 2014). It also entails 'artful thinking', which includes reasoning, questioning and investigating, observing and describing, comparing and connecting, finding complexity, and exploring viewpoints (Barahal, 2008 as cited in Collins 2014). In critical thinking, being able 'to think' means students can apply wise judgment or produce a reasoned critique.

The third and final stage is the problem-solving category. Problem solving skills may include remembering information, learning with understanding, critically evaluating ideas, formulating creative alternatives, and communicating effectively. Brookhart provides the following definition:

> A student incurs a problem when the student wants to reach a specific outcome or goal but does not automatically recognize the proper path or solution to use to reach it. The problem to solve is how to reach the desired goal. Because a student cannot automatically recognize the proper way to reach the desired goal, she must use one or more higher-order thinking processes. These thinking processes are called problem solving (Nitko & Brookhart, 2007).

Resnick, (1987), states that higher order thinking skills can be recognized when it occurs and describes it as; complex, non algorithmic, sometimes lends itself to multiple solutions and involves uncertainty. This definition proves that Brookhart's three categories should not be looked at separately but combined in order to fully define higher order thinking. Higher order thinking in mathematics includes explaining, deriving, investigating, analyzing and interpreting data. Given that higher order thinking is thought to be an important part of learning in mathematics, it is necessary to determine the cognitive levels of the objectives or any other components that are in the syllabus that teachers are expected to use.

Thinking and Curriculum Objectives

A learning objective is defined as a written statement that articulates what a successful student should be able to do after engaging in a course (Adam, 2004). Recognizing the importance of such a component, Paul Hirst (2010), takes a particularly strong stance on the necessity of objectives in any planned curriculum, by stating that “there can be no curriculum without objectives” (p. 2). This stance was supported by Fitzpatrick and Schulz (2015): if students' achievement is based on their cognitive level of higher order thinking, then the curricular objectives should correspond to those cognitive levels. Seeing that the cognitive processes are pertinent to deciding the level of thinking required by curriculum objectives (FitzPatrick & Schulz, 2015), and that learning objectives are usually articulated using taxonomies, the Anderson and Krathwohl (2001) taxonomy will be the focus.

Anderson and Krathwohl (2001) taxonomy, a revision of Bloom’s taxonomy, it is widely used in mathematics education and is “strongly grounded in theory and practice” (Mosely et al. 2004 p.3). The Anderson and Krathwohl (2001) taxonomy provides a useful approach to analyzing curriculum objectives and classifying educational goals (Mosely et al., 2005). It is a two dimensional model that specifies cognitive processes and domain and knowledge. Unlike the framework of thinking put forward by Benjamin Bloom et al. which contain six main categories: knowledge, understanding, application, analysis, synthesis, and evaluation, Anderson and Krathwohl (2001) uses verbs. Thus “for thinking ability; learners are grouped in six stages, namely; remember, understand, apply, analyze, evaluate, and create” (Ernawati & Baharullah 2020 p. 317). The first two categories of the taxonomy posed by Anderson and Krathwohl are generally thought to represent lower order thinking, and the remaining four categories represent higher order thinking (Churches, 2008), as represented below:

Level in Revised Taxonomy	Description
Remembering	Retrieving, recognizing, and recalling relevant knowledge from long term memory;
Understanding	Constructing meaning from oral, written, and graphic messages through interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining;
Applying	Carrying out or using a procedure through executing, or implementing;
Analyzing	Breaking material into constituent parts, determining how the parts relate to one another and to an overall structure or purpose through differentiating, organizing, and attributing;
Evaluating	Making judgments based on criteria and standards through checking and critiquing;
Creating	Putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning, or producing.

(Table 1: Anderson and Krathwohl, 2001, p.67)

Analyzing Curriculum Learning Objectives

Learning outcomes describe what students need to do with or to subject content being taught; it is represented on the syllabus with the initiating statement “student should be able to”. The table below shows a correspondence between cognitive levels of Anderson and Krathwohl’s (2001) taxonomy and examples of specific objectives for the strand of Number Theory and

Computation, as recorded on the CSEC mathematics syllabus. In using Anderson and Krathwohl's taxonomy, the "verb will help us to focus on the behaviour of the learner as opposed to content of the material" (Cochran, Conklin, 2007, p. 23). This section contains information that will answer the research question: "To what extent are various levels of thinking represented in the CSEC Mathematics syllabus?"

Table 2: Cognitive levels of Anderson and Krathwohl's (2001) taxonomy and Objectives from the CSEC mathematics syllabus.

	Categories and Verbs	Specific Objectives
Lower Order Thinking	Remembering (Identifying) (Recalling) (Listing)	-State the value of a digit of a numeral in a given base; place value and face value of numbers in base 10. - Define a factor -list the set of factors and multiples for a given integer
	Understanding (Comparing) (Exemplifying)	-Distinguish among sets of numbers -Express a value to a given number of decimal places and significant figures. -convert from decimal to fractions -compare quantities: ratio, proportion and rates -divide quantity into a given ratio
Higher order Thinking	Applying (Using) (Carrying out)	-Use approximations/estimations in transactions. - express one quantity as a fraction or percentage of another. -Use properties of numbers and operations such as closure, associativity, additive and multiplicative identities and inverses, commutativity and distributivity in computational task
	Analysing (Finding)	Derive an appropriate rule given the terms of a sequence
	Evaluating	None visible
	Creating	None visible

As mentioned earlier, students' academic achievement is highly dependent on their thinking, “which has been identified as having higher and lower order complexity” (Anderson & Krathwohl 2001); and learning objectives should include high cognitive levels of thinking that require active student engagements. From the table above it can be seen that the number of objectives decreases as it approaches the highest level of the taxonomy. A number of objectives seem also to fall within the category of remembering and understanding. When thinking back at the rationale, all skills that were mentioned are situated within the last four categories of the taxonomy. Although Brookhart suggests that retention is important for transfer to take place, evidence of how to identify the skills associated with transfer through the objectives were sparse.

I did experience some challenges categorizing the objectives, because on some occasions, I have realized that using the categories from the taxonomy, does not necessarily match the verbs listed in the specific objectives. For example the verb “to express” can be used in the category of understanding (lower order thinking) as well as applying (higher order thinking).

Teaching Thinking in Mathematics

In this section I will be focusing on three areas; teaching approaches, teaching & learning activities and group work as stipulated on the syllabus. The discussion will also contain information that will seek to answer the research questions “What is the level of correspondence between the elements of the CSEC Mathematics syllabus and characteristics of higher order thinking?

The success of developing higher order thinking in learning mathematics is influenced by the choice of models, approaches, and learning strategies used in developing students' higher order thinking skills. The ability to think and reason at a higher order has been attempted to “develop with various forms of models, approaches, and learning strategies, including the Problem-based Learning" (Şendağ & Ferhan Odabaşi, 2009; Alrahlah, 2016; Gholami et al., 2016 cite in Prabawanto, Darhin, & Susilo, 2020, p 104) and Mathematical Problem Posing (Bonotto, 2013). These two strategies fall into Brookhart’s third category of higher order thinking; problem solving, but according to Beyer, (2001), many teachers are uncertain of how to teach thinking. They typically rely on curriculum documents to ensure that appropriate levels of thinking are part of instruction often without consciously thinking about higher order thinking (FitzPatrick & Schulz, 2015). For example: Patterns is a mathematical problem-based topic that normally asks students to determine a way to get from what is known to what is sought. An example from the CSEC mathematics syllabus indicates that there are two objectives that are related to Number Sequencing/Patterns ; Students should be able (1) *compute* terms of a sequence, given a rule and (2) *derive* an appropriate rule given the terms of a sequence (p. 24). In alignment with Anderson and Krathwohl taxonomy the verb compute is rated at the lower level of understanding, and the derive is rated at the higher level of analysing.

Facione (1990), believes that students' higher order thinking skills can be enhanced if they are required to actually perform the intellectual skills of higher order thinking; which are “predictions (evaluating) and designing methods (creating)” (Ernawati, & Baharullah, 2020) and this can be done in Patterns and Sequencing. Students can be encouraged to investigate and draw conclusions that will support their argument or even design methods and organize structure that had never existed before, example: [see table 3 below, Key: analyzing (C4), evaluating (C5), and creating (C6)].

Table 3

Basic Competence	Competency Achievement Indicators	Indicators	No	Level of Cognitive
3.1 Make generalizations from patterns in a sequence of numbers and a sequence configuration object	Apply patterns and generalizations to make predictions	Students can investigate/parse the information to take the conclusion as well as find the reasons that support it	1	C5
4.1 Solve problems that relate to a pattern in a sequence of numbers and a sequence configuration object	Solve the problem related to pattern number, row, series; use to solve real problems	Students can analyze the tribe to-*n* of a sequence of numbers and determine the *Sn*	2	C4
3.1 Make generalizations from patterns in a sequence of numbers and a sequence configuration object	Conduct experiments to generalize the patterns of numbers or configuration of the object	Students can design a method to solve the problem and organize the existing elements into the structure of the new that had not existed before	3	C6

(Image taken from Ernawati, & Baharullah 2020, p. 319)

Teaching & Learning Activities and Thinking

Mathematical tasks and activities have the potential to be powerful tools to help students develop an understanding of mathematics (Weinberge & Wiesner, 2011). The resources that are needed to carry out these tasks will therefore be of paramount importance. Herman and Webb (2007) state that "if classroom teaching and learning activities are to help students attain the standards; they must be aligned with the standards" (p. 2). Similarly, if curricular objectives include higher order thinking, then the cognitive level of the activities used should correspond to the cognitive level of these objectives. According to Roach, Niebling & Kurz (2008), the alignment of objectives and learning tasks and activities has "the potential to have a positive impact on all students' "learning and achievement" (p. 158).

Throughout the CSEC mathematics syllabus there are suggested teaching and learning strategies and teaching resources for each strand that should assist teachers in developing classroom instruction with the aim "to prepare students for the use of mathematics in further studies" (CSEC mathematics syllabus p. 2). The table below is an extract from the syllabus that highlights teaching and learning activities for the Number Theory and Computation strand.

<u>Table 4</u>

Suggested Teaching and Learning Activities : NUMBER THEORY AND COMPUTATION
To facilitate students' attainment of the objectives of this Section, teachers are advised to engage students in the teaching and learning activities listed below. *1. Encourage the use of:* (a) games and quizzes; (for example, to investigate whether a given number is rational or irrational) (b) appropriate software; (c) examples of computation drawn from current affairs; (d) recipes in teaching ratio and proportion; *and,* (e) online demonstrative videos. *2. Explore the link between mathematics and other disciplines, for example:* *a) Music: the octave;* *(b) Sciences and Nature: periodic tables, counting petals, leaves and other random natural events;* *(c) Architecture: number patterns and lighting patterns, ratio of width to length to height of a building or building part;* *(d) Art and Geography: enlargement of photos as compared with ratio and proportion;* *3.* Teachers can ask the students to conduct research on the history of numbers. *4. Teachers can engage students in the process of "mental computation" including divisibility*

tests and other ready reckoners and properties such as associativity. 5. *Provide oral or written questions and encourage students to explain how they arrived at their answers and to compare their problem-solving strategies with those of their classmates..*

Table 5:

Alignment Examples: Syllabus Components and Characteristics of Thinking.

Suggested teaching and learning activities	Characteristics of thinking
a) games and quizzes; b) appropriate software; c) computation from current affairs	Analyzing, interpreting, manipulating information, exploring, applying, investigating. (Higher order thinking skills of transfer, critical thinking and problem solving)
linking math with other discipline	Applying information to new situations, connecting, exploring, and interpreting. (Higher order thinking skills of transfer, critical thinking and problem solving)
provide oral and written questions, and encourage students to explain and compare strategies	Reasoning, questioning, describing, critiquing, and communicating effectively. (Higher order thinking skills of transfer, critical thinking and problem solving)
Mental computation	Recall; mechanical application (Lower order thinking skills)
Research on the history of numbers	Did not correspond

Correspondence between Elements of the Syllabus and Thinking

First, I identified the suggested learning and teaching activities from the CSEC mathematics syllabus and the characteristics of thinking, using Newman's (1990) and Brookhart's (2010), definitions. I then determined the characteristics that correlate with each strategy. Some of the strategies correspond with more than one characteristic, for example; quizzes can have characteristics of interpreting, which are a higher order thinking skill, but it can also entail only recall questions which then will transform it to retention, which is a lower order thinking skill.

Table 5 shows that 4 out of the 5 areas or 60 % of the teaching and learning strategies corresponds with characteristics highlighted in Newman's (1990) and Brookhart's (2010) definitions of higher order thinking; that 60 %, shows evidence of Brookhart's (2010) three categories of higher order thinking; transfer, critical thinking and problem solving. Twenty percent (20 %) of the teaching and learning strategies were associated with retention and the remaining 20 % did not correspond to either higher or lower order thinking.

Group Work and Thinking

One of the skills required in the rationale is 'teamwork', which is aligned with the syllabus's aim of helping students to "foster a spirit of collaboration" (p. 2). Collaboration and communication within group work provides learners with the opportunity to build community and thus, creates an opportunity for effective learning. Jenkins (2009), states, through various forms of participatory learning, "young people are acquiring skills that will serve them in the future" (p. 9). In addition, studies have found that working in groups develop critical thinking, creativity, and enhance social and communicative skills. These skills according to Brookharts' definitions are characteristics or traits of higher order thinking skills.

Discussion and Conclusion

FitzPatrick & Schulz, (2015), indicates that although critical thinking is one of the main keys in developing other skills, and it is the result of a long learning process, it is only "a part of high-order thinking skills" that requires thinking activities of analyzing, evaluating, and making conclusions (Asyari et al., 2016 p. 37). This is a very important statement, as the term critical thinking has long been used interchangeably with higher order thinking. If this is not stated clearly in the syllabus, for example in the rationale, then it will be solely left up to the teachers to use their knowledge of thinking to determine how to proceed with their students. In reiterating the portion of the rationale mentioned in the literature review; "skills students need to acquire includes critical and creative thinking, logical reasoning, problem solving etc", but at no stage the term higher order thinking was mentioned.

The CSEC mathematics syllabus reflects features of both lower order and higher order thinking; however, there are discrepancies with the alignment of the learning objectives and their corresponding teaching and learning activities. Most of the objectives were categorized at the lower level of Anderson and Krathwohl taxonomy, but approximately sixty percent of the learning and teaching activities which are associated with these objectives can be situated in the last four categories of the taxonomy. For example, two of the objectives for Ratio and Proportion are: students should be able to "compare quantities: ratio, proportion and rates and divide quantity into a given ratio." In contrast, the suggested activity requires students to transfer their knowledge to different disciplines, Art and Geography, where they will be focussing on "enlargement of photos as compared with ratio and proportion" (CSEC mathematics syllabus p.

25). Here again the onus is on the teacher to decide whether or not they would like to include that objective as a part of their teaching plan.

I have mentioned earlier that teachers use the curriculum to guide their instructions. “Thus the curriculum guide ought to provide a substantial representation of higher and lower order thinking outcomes” (FitzPatrick & Schulz, p 149). If these verbs are not embedded in the syllabus as seen with the teaching strategies or do not correspond, then there will be less likelihood for consistency among students if each teacher had to decide. If higher order thinking is not made clear on the curriculum document and teachers are not given much guidance, can it be said then that this is a contributing factor as to why some Caribbean countries continue to experience a decrease in passes in mathematics at the Caribbean Secondary Education Certificate (CSEC) examinations? Aoiki, Ted, T. (1991) states that many teachers are dwelling between two zones, the “curriculum as planned” and the “curriculum as lived.” Can it be concluded that most teachers are guided by the “lived curriculum” because of these deficiencies in the curriculum?

A limitation to this study is the use of only one thinking taxonomy, the Anderson and Krathwohl taxonomy (2001) in the analysis of the objectives. The use of more than one taxonomies to compare and contrast the objectives may have skewed the results, for example, “the cognitive process of executing/carrying out is considered to be higher order thinking based on Anderson and Krathwohl but lower order according to Marzano and Kendall (2007)” (as cited in FitzPatrick & Schulz, 2015, p. 150). The focus of the study was also geared towards one strand, Number Theory and Computation, which is the first of ten strands highlighted on the syllabus. This is a minor research on the elements of the syllabus and its influence on students' higher order thinking skills in the teaching and learning of mathematics. The results can provide guidance to teachers in the use of thinking taxonomies.

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