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Comparative Study of Secondary Mathematics Curriculum between Uganda and the United States

Lawrence Ssebaggala[1]

[1] *Illinois State University, United States of America*

ABSTRACT

This is a report on a preliminary study which attempted to compare the current Ugandan and U.S. secondary mathematics curricula. The study analyzed the content and the level at which content is introduced in the two countries. Results from the study indicated that although the curriculum followed in Uganda offered its students an opportunity to learn high-level mathematics before enrolling in college, there is need to revise it in order to enable students in Uganda to have the capacity to apply mathematics into other disciplines at higher levels. A summary of findings regarding the U.S. curriculum will also be presented.

Keywords:
Curriculum; Mathematics; Secondary School

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Introduction

This study attempts to compare Uganda's secondary mathematics curriculum with the 8th-to-12th grade secondary mathematics in the United States of America. The report scrutinizes the mathematics content and the level at which the content is introduced in the two countries.

Uganda is a landlocked country in the eastern part of Africa. Mathematics education in the East African region, just like in many parts of the world, "faces many challenges and opportunities associated with population growth, technological advancement, regional interdependence, and globalization" (Kakuru & Tennant, 2016, p. 9). Formal school education was introduced into Uganda by a religious organization—the Church Mission Society of London— in 1886, and since then several curricular reforms in mathematics education have been implemented. Originally, the curriculum was instituted by the colonial masters for the purpose of educating "a small, select minority of academic high achievers" (Clausen-May & Baale, 2014, p. 57). Almost always, the curriculum is delivered with a "dominant pattern of expository, whole-class teaching" (Center for Global Development through Education, 2011, p. 156). On the other hand, the United States of America is a developed country with an education system that has been tested and shaped by decades of research and practice. It has undergone several changes, the latest of which is the publication of the Common Core State Standards for Mathematics (CCSSM) in 2010.

Survey of Curriculum Expectations

This study is based on curriculum statements set out by the Uganda National Curriculum Development Center (NCDC) (2017), and the U.S-based Center for the Study of Mathematics Curriculum (Reys, Dingman, Nevels, Teuscher, 2007).

[1] Corresponding author's address: Department of Mathematics, Stevenson Hall 313, Campus Box 4520, Normal, IL 61790-4520
Telephone: +1(309) 438-3392
Fax: +1(309) 438-5866
e-mail: lssebag@ilstu.edu

Overview of the Structure of Education Systems

United States of America. Unlike Uganda, the USA is a federation of states, each of which has substantial sovereignty. The education requirements for schools are therefore a mandate of both the state and local authorities. In the United States, the term "secondary school" covers 9th through 12th grades. The final years of education necessary for graduation are provided in high school, usually including Grades 9-12 (in which students are aged 14 to 18).

Uganda. The Ugandan education system has not changed much since the colonial era. Emphasis is on academic achievement and preparation for white-collar jobs. The structure of the education system is as shown in Table 1:

Table 1.*Summary of Structure of the Education System in Uganda*

Level	Duration (years)	Qualification
Primary	7	Primary Leaving Certificate
Lower Secondary (Ordinary Level)	4	Ordinary Level Certificate (O-level)
Higher Secondary (Advanced Level)	2	Advance Level Certificate (A-level)
Tertiary	3–5	Diploma / Degree

In addition to the "levels" shown in Table 1 there is a pre-primary level (nursery and kindergarten) level. This level, which is not compulsory, is designed for children 3–6 years of age. Attendance is usually dependent on the financial ability of the parents to pay. Although education at this level, like at all other levels, is regulated by the central government, it is conducted privately, by private individuals or groups.

The primary level is divided into; (a) lower primary, and (b) upper primary. Apart from the privately-owned schools, education at this level is run by the central government, which also develops and implements the curriculum through the National Curriculum Development Center (NCDC). Children join at age six, and attendance is compulsory for every child of this age and older. Emphasis at this level is on literacy, numeracy and life skills.

The current secondary education system is divided into two levels; (a) lower secondary, and (b) higher secondary. 42 subjects are offered at secondary level, and cover the areas of science, humanities, mathematics, and life skills. The system is examination-oriented and at the end of four years, learners are subjected to nationally set and graded level exit examinations. Based on the grades a student obtains on these examinations—which are nationally graded by anonymous course expert educators—one can get admitted into the higher level of secondary school. Learners are expected to sit examinations for between 8 to 10 courses (referred to as "subjects") from the categories Humanities, Mathematics, Sciences, Languages, and Art and Cultural studies. If students happen to continue beyond this level, they will have two more years of higher secondary education—in which they only take three subjects with subsections in each subject, and a general knowledge course—after which they will sit for level exit examinations, scores of which are used by universities, and other institutions of higher learning to make admission decisions. It should be noted that, the courses one takes at the higher secondary level usually determine the type of career profession students will pursue. Therefore, admission to higher institutions of learning is career-specific. I will not report on the nature of post-secondary education as it is not the focus of this report.

The Secondary Mathematics Curriculum

Studies have been documented to show that students who exit secondary schools and are presumably ready for post-secondary education often lack "basic math skills in trigonometry, algebra, and even arithmetic, and high dependence on calculators" (Ibrahim & Othman, 2010, p. 351). The purpose of this article is to report on an analysis made after a comparison of the secondary mathematics curricula of Uganda and United States. This was done by the author for the sole purpose of comparing the Ugandan curriculum with U.S. secondary school curricula.

Uganda. Clausen-May and Baale (2014) observed that "following the introduction, in 1997 and 2007, of Universal Primary and Secondary Education Policies— [education for all]—the Ugandan curriculum became increasingly irrelevant and inaccessible to the majority of learners (Clausen-May & Baale, 2014, p. 57). The main form of instruction is chalk-and-talk, and almost all instruction is teacher-dependent (CGDE, 2011;

Opolot-Okurut, Opyene-Eluk & Mwanamoiza, 2008; World Bank, 2008). The teacher stands at the front of the class, textbook in hand, and writes notes and examples on the board. The "silent learners" copy it all down (Clegg, Bregman, & Ottevanger, 2007). Mathematics, as with languages, is allocated a high mean percentage total of instructional time in the world (Benavot, 2006).

In Uganda, the mathematics curriculum for schools is issued by the Ministry of Education in collaboration with the National Curriculum Development Centre. They both work in collaboration with the Uganda National Examinations Board whenever they are to review the curricula. Curriculum revision is not periodic but rather done whenever there is a political demand. This fosters the views of few players who may not even be aware that the curriculum is, or is not in line with the national objectives**.** The breadth and depth to which the mathematics topics are taught at a given year level differs and depend on the teacher's ability, but it is supposed to be homogeneous across the country, with no regard to students' backgrounds, interests, or interests. In Uganda (Karp, Opolot-Okurut, & Schubring 2014), every student must take mathematics each year, up to the end of their ordinary secondary education. By the end of the lower level of secondary school (equivalent to 11th grade in the U.S. system), a student must have had 11 years of compulsory mathematics education.

The main topics in lower level secondary mathematics comprise of three strands namely Numbers and Algebra, Geometry and Measurement, Trigonometry, Business Mathematics, Linear Programming and topics on Statistics and Probability. For the advanced level section, the main topics include: Advanced algebra, Calculus, Geometry, Statistics, Probability Theory, Mathematical Physics, and Numerical Methods. The outline of the syllabus for advanced level secondary mathematics is shown in Table 2, Table 3, and Table 4 below. Each period is 40 minutes long.

United States of America. The status of secondary mathematics curricula and graduation requirements in the USA was described by Reys, Nevels, and Teuscher (2007) in their report at the Center for the Study of Mathematics Curriculum.

> The federal No Child Left Behind (NCLB) Act has prompted increased activity at the state level in the specification of mathematics curriculum learning goals in the United States. As a direct result of NCLB, 39 states have replaced or revised their mathematics curriculum standards since 2002 (Reys, 2006). Along with the NCLB requirements focusing on curriculum, states have also increased graduation requirements in order to engage their students in more mathematics throughout their secondary education. The information in this report illustrates that states vary with respect to required mathematics credit hours and courses for graduation. (p. 4)

Under the common core standards—which are the main guiding force behind pre-college mathematics—the first of the eight practice standards guarantees that students "make sense of problems and persevere in solving them" (CCSSM, 2010, p. 6). Mathematical content is comparatively analogous to the content listed in the 2000 *Standards* (NCTM, 2000) and standard algorithms are expected to be established in students' comprehension of the fundamental mathematics.

Even with this advent of the common core standards, secondary mathematics curricula differ from one state to another. However, a survey of several state requirements for high school graduation reveals a common theme in the mathematics taught at high school level. To make this point clear, I will borrow Hodgen, Pepper, Sturman, and Ruddock's (2010) colorful language;

> The areas of U.S. curricula are [largely referred to by the labels] Algebra I, Geometry, Algebra II, and Pre-calculus. These are each comprised of strands with specific learning standards. The strands are: number sense and operations; patterns, relations and algebra; geometry; measurement; data analysis, statistics and probability. Overarching and running through all these strands and courses are key competencies: problem solving, communicating, reasoning and proof, making connections, and representations (Hodgen, Pepper, Sturman, & Ruddock, 2010, pp. 92–93).

Analysis of state requirements for a high school diploma revealed that 25 of the 50 states consider mathematics a prerequisite for graduation. Moreover, in some states the learners have to complete specific mathematics classes as part of their course of study if they are to exit high school with a diploma.

Table 2. *Uganda Advanced Level Secondary Mathematics Syllabus – Pure Mathematics*

Term	Topic	Periods
One	• Indices, Logarithms and Surds	8
	• Equations & Polynomials	18
	• Partial Fractions	6
	• Trigonometry	22
		54
Two	• Vectors	24
	• Coordinate Geometry I	6
	• Differentials I	24
		54
Three	• Integration I	22
	• Series	12
	• Permutations and Combinations	10
	• Binomial Theorem	10
		54
One	• Trigonometry (Calculus)	8
	• Exponential and Logarithmic Functions	10
	• Maclaurin's Expansions	4
	• Integration II	18
	• Differential Equations	14
		54
Two	• Inequalities & Further Curve Sketching	14
	• Coordinate Geometry II & III	40
		54
Three	• Complex Numbers	24

Table 3. *Uganda Advanced Level Secondary Mathematics Syllabus – Applied Mathematics*

Term	Statistics and Probability	Periods	Mechanics	Periods	Numerical Methods	Periods
One	• Descriptive Statistics	16	• No Mechanics		• Linear Interpolation and Linear Extrapolation	6
	• Index Numbers	6				
	• Correlation and Scatter Graphs	6			• Location of Roots	8
	• Probability Theory	12				
		40				14
Two	• Discrete Probability Distribution	8	**Dynamics I**		• Error Analysis	6
			• Linear Motion	6		
			• Newton's Laws	12		
			• Resultant and components of Forces	6		
			• Momentum	6		
			• Connected Particles	10		
		8		40		6
Three	• Binomial Distribution	6	**Dynamics I**		• Error in Functions	4
	• Continuous Random Variable	12	• Work, Power and Energy	6		
			• Resultant Velocity			
			• Relative Motion	6		
			• Vector Mechanics	6		
			• Projectile Motion	4		
				10		
		18		32		4

Table 4. *Uganda Advanced Level Secondary Mathematics Syllabus – Applied Mathematics II*

Term	Statistics and Probability	Periods	Mechanics	Periods	Numerical Methods	Periods
One	• Normal Distribution	10	**Statics I**		• Trapezium Rule	4
	• Normal approximation on to binomial	6	• Friction	8		
			• Moment of a Force	8		
			• Coplanar Forces	18		
		16		34		4
Two	• Sampling Distribution	10	**Dynamics III**		• Iterative Methods	12
			• Circular Motion	8		
			• Elasticity	8		
			• Simple Harmonic Motion			
				16		
		10		32		12
Three			**Statics II**		• Flow Charts	12
			• Center of Gravity	10		
				10		12

Findings

When comparing the Uganda secondary mathematics curriculum with that of the United States, the Ugandan curriculum does not differ much in terms of the topics covered. The noteworthy variance is in the grade level, at which given content is introduced and taught, and the depth to which the teachers go in each topic. Refer to Table 5 for grade level comparison and Table 6 for a detailed curricula comparison through the grades.

Table 5. *Comparison of Secondary Education Grade Levels in Uganda and United States*

Grade Level		Age Range (at the start of academic year)
United States	Uganda	
8th grade	Senior 1 & 2	13 – 14
9th Grade	Senior 2 & 3	14 – 15
10th Grade	Senior 3 & 4	15 – 16
11th Grade	Senior 5	16 – 17
12th Grade	Senior 6	17 – 18

Table 6. *Comparison of Secondary Education Grade Levels in Uganda and United States*

Topic / Course	Grade Level	
	Uganda	United States
Numerical Concepts	S.1–S.2	Grade 8
Algebra	S.1–S.4	Grade 8 – Grade 10
Business Arithmetic	S.2–S.3	Grade 8 – Grade 9
Geometry	S.2–S.4	Grade 8 – Grade 10
Trigonometry	S.3–S.5	Grade 10 – Grade 12
Calculus	S.5–S.6	Grade 11 – Grade 12
Probability Theory	S.3–S.6	Grade 8
Statistics	S.1–S.6	Grade 8 – Grade 12
Numerical Analysis	S.6	Not Applicable
Mathematical Physics	S.5–S.6	Not Applicable

Note. S.1 means Senior 1. All grade levels at secondary level in Uganda are referred to as Senior levels.

There are some points worth noting:

- The above preliminary analysis shows that there is an obvious difference at which level certain topics are introduced. For example, in Uganda, apart from calculus, all areas of secondary mathematics are first introduced in Senior 1 (equivalent to 8th grade), and every subsequent year, more content is taught to reinforce what was started before but not starting new content areas at all. Calculus is then introduced in the second last year of secondary education.
- In the United States, there is an emphasis the last years of high school on areas of geometry and algebra, whereas in Uganda, the emphasis is on algebra and calculus.
- Topics in mathematical reasoning (e.g., formal proofs) are not explicitly covered in secondary mathematics in either country.
- Tracking is prevalent in United States secondary school whereas there is no institutionalized tracking in Uganda. With tracking, the mathematics curriculum taught can even differ in the same school—as students in different tracks take different content areas of mathematics. In Uganda, all secondary schools must follow the same curriculum.
- Mathematics in the last two years of secondary school in Uganda is mandatory for all students who intend to pursue careers in any science field, where as in the US it is voluntary.
- Unlike the situation in the United States, the secondary school mathematics curriculum in Uganda includes two years of applied mathematics (which includes topics from mathematical physics, e.g., linear motion, simple harmonic motion, relative velocity) and an introductory numerical analysis course.

Discussion

The Uganda secondary mathematics curriculum is similar to curricula in quite a few other nations which were British colonies e.g., Kenya, Malaysia, Brunei Darussalam, Singapore. The curricula in these nations culminates in "A-level" specialization in mathematics, which is at a much higher level that what is offered in the United States of America except for U.S. students who take "advanced placement" (AP) calculus, or statistics. It is worth noting that there is an ever-increasing percentage of U.S. students taking AP mathematics. At the other end of the scale, most of the students in the ex-colonial countries finish up studying more mathematics than U.S. school students.

Of course, there are many former British colonies that have not followed the English O-level, A-level (and N-level) model. Such countries include the United States, Canada, Australia, New Zealand, and Papua New Guinea. Australia and Canada tend to have more difficult and wider school mathematics curricula for students aged 5 to 17 years than does the United States, Interestingly, in Trends in International Mathematics and Science Study (TIMSS), students from Canada, New Zealand, and Australia who are in grade 8 have tended to outperform students from the United States (and quite a few European students of the same age group). Ugandan students do not participate in TIMSS and/or related international studies.

Conclusions

The author did not set out to determine which of the two mathematics curricula is better, but rather to compare the nature of the US education system and more specifically the setup of the secondary school mathematics curriculum, with the curriculum in his home country, Uganda. Interesting results which have a potential to impact the curriculum of both countries were found. Even with a more difficult and more extensive curriculum in Uganda, there is no evidence that Ugandan youths perform better than their counterparts in the United States of America at college level and beyond. In fact, the opposite may be true.

This preliminary study suggests that further studies should be conducted to look at the details of what constitutes a particular country's secondary school mathematics curriculum and its relevance in present times. However, some limitations of the study, must be noted. There was no in-depth analysis of each topic or course, or textbooks used. Additionally, an analysis of the time spent teaching mathematics in each country was not considered as part of this comparison.

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