School mathematics education through the eyes of students in Ghana: Extrinsic and intrinsic valuing

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1256 students from 18 primary and secondary public schools across urban and rural settings in the Cape Coast Metropolis of Ghana responded to the "What I Find Important (in my mathematics learning)" questionnaire. The data analysed suggested that students in Ghana valued in their mathematics learning: achievement, relevance, fluency, authority, ICT, versatility, learning environment, strategies, feedback, communication, fun, connections, engagement, applications, and accuracy. The students' embracing of these attributes is explained by reflecting on the societal and pedagogical norms in Ghana. When compared to high performing economies in East Asia, it was found that most of the Ghanaian attributes represent extrinsic (versus intrinsic) valuing. Implications and suggestions for policy-making and for classroom teachers are provided.

Keywords: Values, Ghana, extrinsic/intrinsic valuing, East Asia, WIFI.

Mathematics education in Ghana

Students value attributes of mathematics learning (e.g. *practice* and *understanding*) differently, with implications for the quality of mathematics learning that takes place (Matthews, 2001). The extent to which a student values *understanding*, for instance, may influence how relational understanding may be preferred over instrumental understanding, the extent to which the development of algorithms is important, and indeed, the extent to which s/he is interested – and perseveres – in knowing how these algorithms or formulae came about. In other words, what and how much an attribute of (mathematics) learning and teaching is valued influences a student's development and/or application of cognitive knowledge and skills, as well as the maintenance of affective states.

Drawing from relevant seminal literature, Smith and Schwartz (1997) have argued that, while values are abstract concepts, they are not so abstract that they cannot motivate behavior. The ability to identify, review and facilitate/modify what students value in their mathematics learning should optimise the cognitive and affective-based pedagogical strategies that support learning.

This paper reports on Ghana's participation in a 19-country study on what students valued in their mathematics learning experiences. Focussing on this West African country, and analysing and interpreting the data collected there, was aimed at achieving an understanding of the Ghanaian mathematics education system, both in its own right and also through comparisons with other countries. This is especially significant, since Ghanaian students' mathematics performance has been low by global standards (Enu, Agyman & Nkum, 2015). For example, in the TIMSS 2011, Ghanaian eighth grade students ranked last amongst 45 participating countries in mathematics achievement (Mullis, Martin, Foy, & Arora, 2012).

Ghanaian students' transitions between school and out-of-school mathematics have not been without its issues. In the home context, the units of measurement of money and of capacity are different from the metric ones being taught in schools. The schools' language of instruction from

Grades 4 and above is also different from the languages used by students at home and outside in public. A further complexity when considering school mathematics education in the Ghanaian context is in the way students there experienced fractions differently in school and in out-of-school contexts. For example,

> the majority of the students were able to identify half in the out-of-school activity perhaps due to that fact that it is the only unit fraction that has local name (fã). However "fã" does not mean equal halves, it means about mid point. Thus three-fifths may also be categorised as "fã". Students' difficulty in naming the other units fractions may be due to the fact that in out-of-school setting they do not differentiate unit fractions. Thus with the exception of half which could mean about midpoint all the fraction are described as less than whole (sin). (Davis, Seah, & Bishop, 2009, p. 69)

Values in Mathematics Education

Values are "the principles and fundamental convictions which act as general guides to behaviour, the standards by which particular actions are judged as good or desirable" (Halstead & Taylor, 2000, p. 169). Essentially, then, values reflect what we think are important to us, and are thus distinct from beliefs, which reflect what we think are correct. Values can be viewed as a form of culturally-based tools with which we mediate our actions and behaviour in the learning process.

In the field of mathematics education, we adopted Seah and Andersson's (2015) definition that

> values are the convictions which an individual has internalised as being the things of importance and worth […]. Valuing provides the individual with the will and determination to maintain any course of action chosen in the learning and teaching of mathematics. They regulate the ways in which a learner's/teacher's cognitive skills and emotional dispositions are aligned to learning/teaching in any given educational context. (p. 169)

What are valued by the individual, as these are shaped and refined by life's experiences (including classroom learning experiences), impact on subsequent decisions and actions. They do so by affecting the ways the individual reasons and feels about the task or problem at hand. As the quote above suggests, this volitional force can be quite powerful, manifesting themselves in the form of will and determination.

When the individual interacts with others (e.g. teachers interacting with their students in the classroom), it is inevitable that there would be differences in what each person values. Such differences can potentially lead to conflicts, and one or more of the people involved will seek to negotiate and resolve these differences, achieving a level of cognitive harmony that is acceptable by most if not all involved.

In terms of the types of attributes of mathematics learning and teaching valued, Bishop (1996) had categorised these into mathematical values (i.e. regarding the mathematics discipline), mathematics educational values (i.e. regarding the pedagogy of mathematics), and general educational values (i.e. regarding the moral and civic virtues). Earlier, Bishop (1988) had conceptualised 3 pairs of complementary mathematical values, namely, *rationalism* and *objectism*, *control* and *progress*, and *openness* and *mystery*.

Prior to 2010, research of values and valuing in mathematics education had focussed on small-scale studies of what teachers valued (e.g. Chin & Lin, 2000). The setting up of the Third Wave Project in 2008 not only brought together a group of researchers internationally to support – and collaborate with – one another on research studies into valuing, but it also shifted attention to the examination of what students value in their mathematics learning (e.g. Seah & Wong, 2012).

On the other hand, much research related to PISA and TIMSS had been conducted by or with education systems which have performed relatively well in these tests, with relatively little research attention paid to mathematics education systems at the other end of the performance spectrum. Yet, the experiences of these countries can also serve as an important reflection on what (else) contribute to effective mathematics learning. As such, a study named "What I Find Important (in mathematics learning)" (WIFI) was designed to investigate what students in 18 different economies value when they were studying mathematics, Ghana being one of these economies. This paper reports on the Ghanaian data of the WIFI study, and how the findings address two of the research questions posed to guide the Ghanaian study, namely:

1. What did school students in Ghana find important when learning mathematics?

2. How might the valuing amongst the Ghanaian students be similar to or different from what their peers elsewhere in the world valued?

Methodology

The first research question suggested a need to 'map the scene' for Ghana (and indeed, for the other participating economies too). As such, the questionnaire survey method was adopted. The validated WIFI questionnaire has four sections. A Likert-type scoring format was used for the first 64 items in Section A, in which students were asked to indicate how important mathematics pedagogical activities such as small-group discussions (item 3), connecting mathematics to real-life (item 12), and mathematics homework (item 57) were to them. A five-point scoring system was used, ranging from absolutely important (1 point) to absolutely unimportant (5 points). Section B consisted of 10 continua dimensions, each related to two bipolar statements and respondents were asked to indicate along the continuum the extent to which their valuing leans towards one of the two statements. Section C consisted of four scenario-stimulated items; and Section D items asked for students' demographic data. The English language version of the WIFI questionnaire was administered, English being the medium of instruction in Ghana. In this paper, only the responses to Section A will be presented.

Student participants were sourced from public schools at the primary, junior high and senior high levels in the Cape Coast Metropolis of Ghana. Stratified random sampling procedure was used to select students from a mix of schools, by achievement levels and by rural versus urban settings. In all, 1256 research participants comprising 414 primary four, five and six pupils, 426 junior high school pupils and 416 senior high school students from 18 schools participated in the study.

In line with the data analysis conducted by the other 18 participating economies, a Principal Component Analysis (PCA) was performed.

Results

The data gathered from the 64 Likert-scale items of the WIFI questionnaire was cleaned prior to data analysis. They were first analysed to identify any missing values. The eleven missing responses identified out of the total possible 80,384 (i.e. 64 X 1256) was acceptable, and each of these was replaced with the value “9”.

The Kaiser-Meyer-Olkin (KMO) (Kaiser, 1970) measure of sampling adequacy was 0.947 and Bartlett’s test of sphericity (BTS) (Bartlett, 1950) was significant at the 0.001 level and so, factorability of the correlation matrix was assumed, which demonstrated that the identity matrix instrument was reliable and confirmed the usefulness of the principal component analysis.

Principal component analysis

A principal component analysis (PCA) with a varimax rotation and Kaiser normalization was used to examine the questionnaire items. The significance level was set at 0.05, while a cut-off criterion for component loadings of 0.45 was used in interpreting the solutions. Items that did not meet the criteria were eliminated. According to the cut-off criterion, 23 items were removed from the original 64. The analysis yielded 15 components with eigenvalues greater than one, which accounted for 52.73 % of the total variance. Each component can be considered to be an attribute that were valued by the students in Ghana, with the relevant questionnaire items regarded as describing the characteristics of the attribute. Accordingly, the three researchers discussed and agreed on the value labels for the 15 components based on the nature of the corresponding items.

The first component consisted of 17 items that together accounted for 13.31% of the total variance. Questionnaire items included in this component included “doing a lot of mathematics work” (item 37), “knowing the steps of the solution” (item 56), “knowing which formula to use” (item 58), and “understanding why my solution is incorrect or correct” (item 63). Guided by our Ghanaian collaborator’s recommendation, we subsequently labelled this component as *achievement*.

The second component is made up of 6 items which together accounted for 6.64% of the total variance. The questionnaire items included ”stories about mathematicians” (item 61), ”explaining where rules / formulae came from” (item 40), ”mystery of mathematics” (item 60), ”stories about recent developments in mathematics” (item 18), and ”using concrete materials to understand mathematics” (item 48). Given these items, we propose to name this component as *relevance*.

The third component is made up of 2 items which together accounted for 4.35% of the total variance. The questionnaire items were ”explaining my solutions to the class” (item 19) and ”practicing how to use maths formulae” (item 13). So, we named this component as *fluency*.

The fourth component is made up of 3 items which together accounted for 3.40% of the total variance. The questionnaire items were ”learning maths with computer” (item 23), ”learning maths with internet” (item 24) and ”explaining by the teacher” (item 5). It was named *authority*.

The fifth component is made up of 2 items which together accounted for 3.04% of the total variance. The questionnaire items were ”using calculator to check the answer” (item 22) and ”using calculator to calculate” (item 4). Given these items, we named this component *ICT*.

The sixth component is made up of 2 items which together accounted for 2.75% of the total variance. The questionnaire items were ”looking for different possible answers” (item 16) and ”being lucky at getting the correct answer” (item 27). We named this component *versatility*.

The seventh component is made up of one item which accounted for 2.69% of the total variance, it being ”mathematics debate” (item 9). It has been named *learning environment*.

The eighth component is made up of 2 items which together accounted for 2.69% of the total variance. The questionnaire items were ”shortcuts to solving mathematics problems” (item 55) and ”given a formula to use” (item 38). Given these items, we named this component *strategies*.

The ninth component is made up of one item which accounted for 2.50% of the total variance. The questionnaire item was ”investigation” (item 1). We interpreted this component as *feedback*.

The tenth component is made up of one item which accounted for 2.22% of the total variance, which was ”outdoor mathematics activities” (item 34). We named this component *communication*.

The eleventh component is made up of one item which accounted for 2.00% of the total variance. The questionnaire item was ”mathematics games” (item 25). It was given the label *fun*.

The twelfth component is made up of one item which accounted for 1.92% of the total variance: ”relationship between maths concepts” (item 26). We named this component *connections*.

The thirteenth component is made up of one item which accounted for 1.80% of the total variance: ”stories about mathematics” (item 25). We named this component *engagement*.

The fourteenth component is made up of one item which accounted for 1.77% of the total variance: ”looking out for mathematics in real life” (item 39). We named it *applications*.

The fifteenth component is made up of one item which accounted for 1.66% of the total variance: ”getting the right answer” (item 50). Given this item, we named this component *accuracy*.

Discussion

1256 primary and secondary school students from 18 public schools located in both urban and rural areas of the Cape Coast Metropolis had responded to the WIFI questionnaire, thus allowing us to map the attributes of mathematics pedagogy that were valued by these students. The PCA has led to the identification of 15 attributes which the students valued in their mathematics learning in Ghanaian schools, explaining 52.73% of the total variance. These attributes are *achievement, relevance, fluency, authority, ICT, versatility, learning environment, strategies, feedback, communication, fun, connections, engagement, applications, accuracy.*

Most of the students in Ghanaian schools come from a farming background, where all available helping hands are needed on the farms especially during the harvesting periods. That the respondents of the WIFI questionnaire were still in school might explain why *achievement* was so highly valued by these students. For them and their families, it is thus not surprising that *relevance, applications, engagement* and *connections* of what is taught at school in relation to the knowledge and skills that are needed at home and in the farms are valued. Given the frequent use of expository teaching in schools (Enu et al., 2015), the students have probably learnt to value *authority*, *fluency* and *accuracy*. Yet, this dominant teaching style is not likely to meet the expectations of students and their families if they have chosen to continue staying in school. Novel and effective learning styles will be important, and these are likely to involve the valuing of *ICT, versatility, learning environment, strategies, feedback, communication* and *fun*.

These 15 values may be compared with the attributes of mathematics learning that students in high performing PISA2012 economies which took part in the WIFI study valued (e.g. Zhang et al., 2016). Students in these high performing economies (all of whom are East Asian, since Finland did not participate in the WIFI study) valued *connections, understanding, communication* and *recall*. Though students in Ghana also valued *connections* and *communication*, they were less valued than at least 9 other attributes, such as *achievement*, *relevance* and *fluency*.

This distinction above had invoked in us the notions of intrinsic and extrinsic motivations. Emerging from the analysis we were reminded of Ryan and Deci's (2000) assertion that "intrinsically motivated behaviors […] are performed out of interest […] [whereas] extrinsically motivated behaviors […] are executed because they are instrumental to some separable consequence" (p. 65). In the context of our data here, we can interpret the top performing East Asian economies' valuing as being intrinsic to mathematics itself (*connections* and *understanding*, for examples, deepen the students' mathematics knowledge), and that the top values that were held by the students in Ghana to be more extrinsic to the mathematics discipline. Although *achievement, relevance*, *fluency* and *authority* were also attributes of mathematics learning and teaching, they were not so much about what was important about mathematics, but rather, what was important about what can be done with mathematics.

The contrast thus seems to be that of extrinsic versus intrinsic valuing. The top performing East Asian economies are located in places where mathematics study has traditionally been taken up for its own sake, and where problem solving and the study of proofs are regarded as tasks that maintain one's mental agility. Against this sort of tradition, then, it would not be surprising that East Asian students appreciated the structure and form of the discipline, and grew to value aspects of mathematics which reflect the nature of the discipline. On the other hand, education systems such as Ghana's might emphasise the utility function of the mathematics discipline, perhaps to satisfy the needs of local economies. Thus, the aspects of mathematics learning that are regarded as important would reflect this utility function and extrinsic valuing.

Given the large sampling size in this Ghanaian study, the findings above raised the question of the extent to which Ghanaian students' extrinsic valuing of mathematics and mathematics pedagogy might affect their mathematics performance. At the same time, how might the students' intrinsic valuing in places such as Shanghai, Hong Kong, Korea and Singapore be related to the high level of mathematics performance shown in TIMSS and PISA? To what extent might the attributes of mathematics education valued in the international assessment exercises be aligned with intrinsic valuing associated with the East Asian students?

Conclusion

Primary and secondary public-school students across both urban and rural settings in the Cape Coast Metropolis of Ghana valued *achievement, relevance, fluency, authority, ICT, versatility, learning environment, strategies, feedback, communication, fun, connections, engagement, applications,* and *accuracy* in mathematics learning. Comparing these against what students in high performing East

Asian countries valued, we propose that many of the attributes that were valued by Ghanaian students represented extrinsic valuing (versus intrinsic valuing in East Asia). Might the Ghanaian students' valuing of extrinsic attributes in part explain their relatively poorer performance in mathematics? Further analysis is being carried out, such as to investigate how the valuing differed according to student gender and school locations.

These and other related questions will be especially meaningful for Ghanaian policy-makers to consider. If extrinsic/intrinsic valuing is indeed a key variable of mathematical performance and achievement, the inculcation of intrinsic valuing amongst students would require strong and determined leadership at all levels of the society to model these values across the intended, implemented and attained curricula. In the meantime, the classroom teacher can be more mindful about espousing the intrinsic valuing of mathematics education. For example, teachers often do not sound very convincing to students that the content taught in class can be applied in life. Instead, it may be worthwhile for teachers to explain how the experience of learning mathematics might instill in students such attributes as *rationalism*. *openness* (see Bishop, 1988) and/or *understanding*. These are the very things which can be applied in life.

This knowledge should also be valuable to overseas (including European) researchers/experts who are involved with development work in Ghana, such as the British government's Transforming Teacher Education and Learning Project. Not only does it lead to a greater understanding of the local context, understanding what Ghanaian students value can also develop meaningful perspectives upon which culturally-appropriate and effective programs are designed and delivered.

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