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 state 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.

Mathematics education in Ghana

Students value attributes of mathematics learning (e.g. practice, understanding and achievement) 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 student’s development and/or application of cognitive knowledge and skills, as well as the maintenance of affective states. The ability to identify, review and facilitate/modify what students value in their mathematics learning promises to optimise the cognitive and affective-based pedagogical strategies that would be employed to bring about learning.

This paper reports on Ghana’s participation in a 19-country study on what students valued and found important 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 TIMSS2011, Ghanaian eighth grade students ranked last amongst 45 participating countries in mathematics achievement (Mullis, Martin, Foy & Arora, 2012).
Values in the context of the Cultural Historical Activity Theory

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 other words, the construct of values is best situated in the sociocultural perspective of learning, and may be examined through activity theory. Activity theory provides a useful theoretical framework also in that it explains how the learner’s mediation of objectivised actions is internalised within cultures, characterising him/her in culturally unique ways. In particular, the Cultural Historical Activity Theory (Cole, 1996) models the three-way interaction between ‘subject’, ‘object’, and ‘community’, emphasising the interactions between and amongst activity systems, in which learning takes place through a process of multi-voicedness, difference, and conflict negotiation.

Values in Mathematics education

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. In so doing, perceived differences and conflicts that come about when the individual interacts with others (e.g. teachers interacting with their students in the classroom) are confronted, negotiated and resolved, achieving a level of cognitive harmony that is acceptable by most if not all involved.

According to Bishop (1996), the valuing that takes place in the mathematics classroom may be categorised 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, which are 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 countries such as Ghana, Indonesia, Peru and Qatar whose students did not perform as well as their peers elsewhere in the world can 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 a range of economies value when they were studying mathematics. Ghana was thus invited to participate. This paper reports on the Ghanaian data of the WIFI study, and how the findings address two of the research questions posed by the Ghanaian researchers, 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 WIFI questionnaire**

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 such as, ‘How the answer to a problem was obtained’ versus ‘What the answer to a problem is’. 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.

**Participants**

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. Given the participant to variable ratio of 20:1, this sampling size was deemed sufficient.

**Data Analysis**

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

Data screening

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 and 41 items were retained from the original 64. The analysis yielded 15 components with eigenvalues greater than one, which accounted for 52.73 % of the total variance. We identified the 15 components of the students’ set of values for mathematics learning as follows.

Component 1

The first component (C1) consisted of 17 items that together accounted for 13.31% of the total variance. Questionnaire items included in this component focused on achievement, and 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 collaborators’ recommendation, we subsequently labelled this component as achievement.

Component 2

The second component (C2) 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.

Component 3

The third component (C3) 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.
Component 4
The fourth component (C4) 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). C4 was named authority.

Component 5
The fifth component (C5) 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.

Component 6
The sixth component (C6) 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.

Component 7
The seventh component (C7) is made up of one item which accounted for 2.69% of the total variance, it being ‘mathematics debate’ (item 9). C7 was named learning environment.

Component 8
The eighth component (C8) 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.

Component 9
The ninth component (C9) 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.

Component 10
The tenth component (C10) is made up of one item which accounted for 2.22% of the total variance. The questionnaire item was ‘outdoor mathematics activities’ (item 34). Given this item, we named this component communication.

Component 11
The eleventh component (C11) is made up of one item which accounted for 2.00% of the total variance. The questionnaire item was ‘mathematics games’ (item 25). C11 was given the label fun.

Component 12
The twelfth component (C12) 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.

Component 13
The thirteenth component (C13) 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.
Component 14
The fourteenth component (C14) 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.

Component 15
The fifteenth component (C15) 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 state 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, Agyman & Nkum, 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 economies in PISA2012 which took part in the WIFI study valued (e.g. Zhang, Barkatsas, Law, Leu, Seah & Wong, 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 appeared to be less valued than at least 9 other attributes, such as achievement, relevance and fluency.

Whereas the top performing East Asian economies’ valuing could be seen to be intrinsic to mathematics itself (connections and understanding, for examples, deepen the students’ mathematics knowledge), the top values that were held by the students in Ghana appeared 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 in TIMSS and PISA 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?

**Conclusion**

Primary and secondary state 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 their mathematics learning. Many of these attributes represent extrinsic valuing, and compared to the intrinsic valuing that appeared to be valued by students in high performing East Asian countries, it may be asked if the Ghanaian students’ valuing of extrinsic attributes might in part explain their relatively poorer performance in mathematics.

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 various ways through which such content is presented might privilege and promote the valuing of such attributes such 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 educational development work in Ghana, such as the British government’s Transforming Teacher Education and Learning (T-Tel) Project. Not only does it contribute 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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