EQUITY-IN-QUALITY: TOWARDS A THEORETICAL FRAMEWORK

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The paper addresses the concepts of equity and quality as they apply to mathematics education and argues that the two concepts of equity and quality are interdependent and are only meaningfully understood in a specific socio-cultural context. The paper argues that meaningful comparisons across different socio-cultural contexts can be achieved by focusing on the relationships of the two concepts to each other and to contextual factors. To underline the interdependence of equity and quality and their relationships to contextual factors the paper introduces a framework based on activity theory and activity system as developed by Engeström. The last part of the paper uses data from TIMSS 2003 to demonstrate empirically the relationship between equity and quality, and their relations to contextual factors.

INTRODUCTION

Context

Educational equity and quality are not only research issues which cut across different disciplines but are presently, as evidenced by the annual reports of the United Nations Development Program (UNDP), major determinants of socio-economic and human development in both industrial and developing countries. The status and role of mathematics, a subject which has long enjoyed a privileged status in school curricula worldwide due to its perceived role in science and technology, render equity and quality in mathematics education at the heart of human development. This is reflected by the governments' relatively large investments in improving the quality of mathematics education and extending it to marginalized and underprivileged groups.

Mathematics was described as a filter and gateway to the professions and science and technology. Research in the last four decades has focused on the identification of inequities in mathematics education, the factors that contribute to them (gender, socio-economic class, ethnicity, location, special needs…) and the contexts (school, national, global) that impact equity and social justice, and the modalities through which teachers and schools deal with such inequities. The attention given to issues of equity and quality in mathematics education is reflected by recent books on the subject (Atweh, Forgasz, & Nebres, 2001; Burton, 2003; Secada & Byrd-Adajian, 1995; Valero & Zevenbergen, 2004) and comparative studies based on international or regional mathematics achievement databases (Hanushek & Luque, 2003; PISA, 2005; Jurdak, 2006). However, there is a need for more theoretical and comparative studies for a better understanding of the complexities of the equity issues in mathematics education.

J.F. Matos, P. Valero & K. Yasukawa (Eds.) (2008). *Proceedings of the Fifth International Mathematics Education and Society Conference*. Lisbon: Centro de Investigação em Educação, Universidade de Lisboa – Department of Education, Learning and Philosophy, Aalborg University.

Numerous calls and proposals have been made, and many projects implemented, to improve quality in math education. The impact of such efforts on the quality of the learning outcomes has, though positive in many instances, created disparities which in fact increased, and even created, inequities in math education. The risk that math education quality enhancement may result in different levels of mathematical literacy, and consequently increase the potential of marginalizing certain individuals and groups in the same society, has become a real concern.

The growing roles of globalization and Information and Communication Technology (ICT) have increased the tension between equity and quality in mathematics education. The demands of the global economy have increased the gap between developed and developing countries and thus made equity in mathematics education not only a within-country phenomenon but also a global one. On the other hand the disparities in access to and ownership of ICT which has become an essential tool for quality improvement in mathematics education rendered the developing countries at a disadvantage in benefiting equitably from quality improvement in mathematics education.

To demonstrate the different conceptions of equity and quality and the tensions between them, I have selected four quotations from the research literature in mathematics education for the purpose of illustration and discussion.

Quotation 1: Inside and Outside School

> "This study examines the computational strategies of ten young street vendors in Beirut by describing, comparing, and analyzing the computational strategies used in solving three types of problems in two settings: transactions in the workplace, word problems, and computation exercises in a school-like setting. The results indicate that vendors' use of semantically-based mental computational strategies was more predominant in transactions and word problems than in computation exercises whereas written school-like computational strategies were used more frequently in computation exercises than in word problems and transactions. There was clear evidence of more effective use of logico-mathematical properties in transactions and word problems than in computation exercises. Moreover, the success rate associated with each of transactions and word problems was much higher than that associated with computation exercises." (Jurdak, 1999, p. 155)

Do the street vendors have a better "quality" in their use of mental computational strategies? Did their disadvantage as far as access to school affect their opportunity to learn mathematics beyond the context of their work?

Quotation 2: In the Same Classroom

> "In this paper I explore the structuring of English children into learning and life trajectories and the part that mathematics has in this process. Using case reports of two ten-year olds in their final year of primary school education, I examine how broader family social milieu impact upon mathematics learning trajectories. Stacey and Edward

live not far from one another in a city in the midlands of England and have been in the same class from age 5 to 11 yet their social distance is considerable. Through the mobilization of various classed and classifying responses to school mathematics they have developed two very different perspectives on the value of mathematical study. This examination of mathematical marginalization and misrecognised meritocracy raises questions about the extent to which teachers can disrupt such processes.” (Noyes, 2007, p. 35)

Is the quality of mathematics learning affected by factors outside the school control (such as family social milieu), even for students who have been in the same school and in the same class for six years? Is the social distance a determinant of the quality of mathematics learning regardless of equal opportunities in school?

Quotation 3: Inside and Outside a Country

> “In this paper, I discuss some links between mathematics education and democracy, what these links could imply to what and how we teach, and the issues that arise from trying to further these links. I first suggest three links between mathematics education and democracy formulated on the basis of experiences in Denmark, in particular: learning to relate to authorities’ use of mathematics, learning to act in a democracy, and developing a democratic classroom culture. The first two are discussed in relation to narratives from real life, with a focus on the tensions which they reveal. From the discussion following the first narrative, it is clear that what is a competency in one context may not be so in another. This is supported by the second narrative which also questions what is most relevant to students in South Africa and thereby gives rise to the formulation of a fourth connection between democracy and mathematics education, related to issues of access. The third narrative informs a discussion of what it means to be critical. It also continues to address the potential tension between wanting to promote students’ critical skills and a democratic classroom culture versus wanting to support students in learning what others have developed and what is required in order to succeed in the schooling system…”. (Christiansen, 2007, p. 49)

Is it the case that what is valued as significant mathematics learning in one context is perceived as irrelevant and may be offensive in another context? Are the criteria by which we judge the quality of mathematics universal? Consequently, what is the basis for comparing the quality of mathematics learning across countries?

Quotation 4: Across Countries

> “With these findings in mind, case studies from eleven countries provide insights into how both rich and developing nations have tackled the quality issue. Four of the eleven – Canada, Cuba, Finland and the Republic of Korea – have achieved high standards of education quality, as measured by international tests. The Republic of Korea is ranked first for science and third for mathematics in PISA, Canada comes second for reading and Finland has the highest overall scores, while in Cuba students’ average performance topped countries in the region surveyed in 2002 by OREALC1/UNESCO.” (UNESCO, 2005, p. 13)

> “Several common strands emerge in the four high performing countries. All hold the teaching profession in high regard and support it with investment in training. There is policy continuity over time and a strong, explicit vision of education’s objectives.” (UNESCO, 2005, p. 14)

How could such four countries, in four different continents and at varying distances from each other economically, socially, culturally, and politically, have achieved ‘high standards of education quality’?

The questions that were posed on the quotations do not have easy answers. One might say that these quotations are eclectic summaries of larger papers or that the questions are pointed to suggest certain answers. Despite all of this, the fact is that we do not have reasonable answers to such disturbing questions. At least these questions point to a problem manifested in our lack of sufficiently adequate conceptions of quality and equity and the relationship between them. I hypothesize that the discrepancies we tried to underline in the previous questions concerning equity and quality in mathematics education can not be adequately explained by the conceptual model of the school as a production system. In the next section, we introduce the school as a production system and demonstrate how these discrepancies relate to the conceptions of equity and quality in it.

EQUITY AND QUALITY IN A PRODUCTION SYSTEM

A well known conceptual framework is that of the school as a productive system (in the industrial sense) where education within schools is viewed as the transformation of inputs into outputs through school processes within a social context. Figure 1 represents the model of the school education as a system (PISA, 2005). The notions of equity and quality that are presented in this section assume the system model.

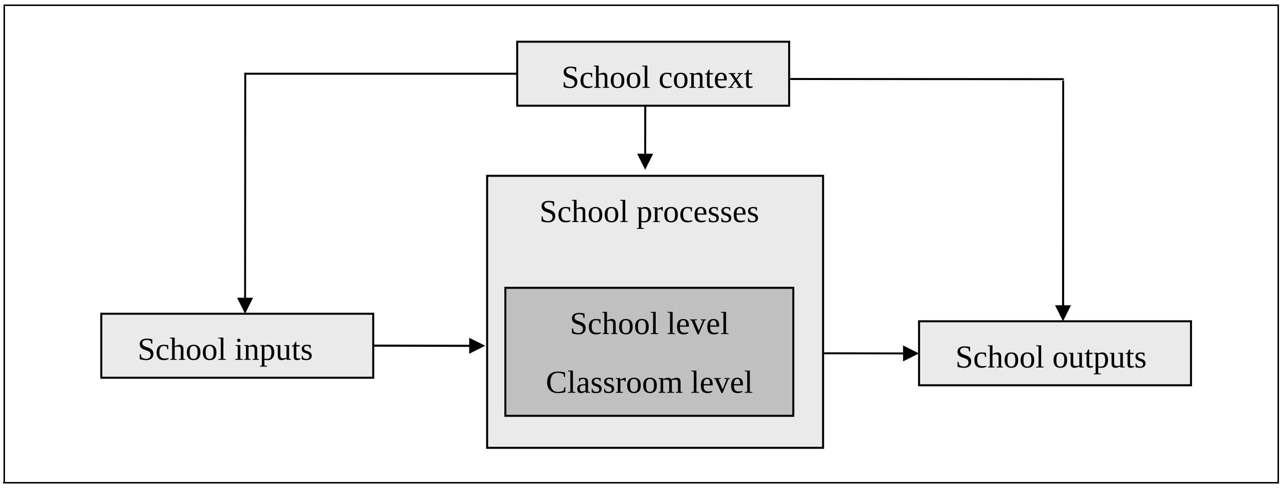

Figure 1. Model of how schools function

Equity

Educational equity is a fundamental concept which has its bases in ideology, sociology, epistemology, and psychology. It is not surprising therefore that educational equity has assumed different meanings over the years (Sriraman, 2007). Both the concept "equity" and its label have been challenged lately by many researchers who proposed "social justice" as an alternative on philosophical and ideological grounds (Burton, 2003).

Berne and Stiefel (1984) proposed a framework for school systems. The framework consists of three components: Targets of *equity concerns* (gender, socioeconomic status, ethnicity, disability status...), *objects of equity* (access, resources, and outputs), and *principles of equity* (principles to analyze equity across individuals, regions, countries…). Berne and Stiefel (1984) provided three different principles- horizontal equity, vertical equity, equal opportunity. Horizontal equity requires students who are equally situated be equally treated by ensuring that they experience similar levels of human and material resources and hopefully achieve similar outcomes. Vertical equity requires differentiation of provision of resources according to individual characteristics in the sense that students who are differently situated would be provided with unique resources (e.g. support programs) to achieve similar results. Equal Educational Opportunity (EEQ) is based on the notion that all students should be given equal chances to succeed. This requires that students should have access to resources that equalizes their starting point and to provide the conditions to allow the possibility of success to all.

This framework seems to be applicable to mathematics education with the equity concerns and equity objects defined to suit mathematics education. The equity concerns in education (gender, socioeconomic status, ethnicity, disability status...) apply to mathematics education. Objects of equity in mathematics education may differ somewhat from those of general education and include access to and participation in mathematics education, continuation in studying mathematics education, and achievement. The three principles of equity apply to mathematics education and we have many examples of policy and school practices that follow the principle of horizontal equity, vertical equity, or equal opportunity principle.

Quality

There are different definitions of quality in education on different philosophical, psychological, social, and discipline specific perspectives. Quality is closely related to our conceptions of learning. Sfard (1998) proposed that learning theories fall under two learning metaphors, acquisition and participation. In the acquisition metaphor, the individual mind is viewed as a container and thus learning is a matter of acquisition of knowledge and outcomes which are realized in the process of transfer. In the participation model, learning is viewed as a process of participation in cultural practices and shared activities and the emphasis is on the process of knowing and on participating in it, rather than on products such as knowledge and outcomes.

The quality of the output is at the core of the quality of the school as a production system. Three variations of quality in the production system are often cited. The first is the productivity view, which translates in the case of mathematics education to saying that the quality of mathematics education depends on the degree of the attainment of the desired outcomes. The second is the instrumental view which assumes that the quality of mathematics education is contingent on the optimal selection of inputs, processes, and contexts that increases the chances of improving performance on outcomes. The third perspective is the efficiency view which defines quality in terms of achieving the highest output at the lowest possible cost.

Re-visiting the Quotations from the Perspective of the Production System

The discrepancies in the conceptions of equity and quality in the four episodes do not seem to be satisfactorily explained by the school as a production system. Quotation 1 illustrates that the production system does not adequately explain the superior performance in computational strategies of young street vendors, compared to students since it is not capable of explaining learning mathematics in a social context.

In quotation 2, seemingly, Stacey and Edward had equal opportunities to learn mathematics but have different valuation of their mathematics learning because of the difference in their cultural capital due to differences in family social milieu. Thus the seemingly equitable inputs and processes in the school did not result in comparable quality of their mathematics learning trajectories. Thus, even in the same school differences in quality, due to social factors, can not be accounted for by the school as a production system.

Episode 3 illustrates the difference in conception of quality in two different cultures. What is valued as mathematics goal in Denmark (learning to relate to authorities' use of mathematics, learning to act in a democracy, and developing a democratic classroom culture) is not considered valuable in South Africa which has a hard-earned democratic political system. This difference in the democracy-related goals of mathematics education reflects different conceptions of quality attributed to ideological factors not accounted for in the school production system framework.

Episode 4 illustrates that quality, even if is narrowly defined as the performance on achievement test, is not necessarily dependent on material resources of the country but rather on cultural values (holding the teaching profession in high regard and support it with investment in training) and the political system and vision (policy continuity over time and a strong, explicit vision of education's objectives).

Comments on Equity and Quality in the School as a Production System

The issue with the production system is that it does not capture the complexity of the social, cultural, and political contexts of mathematics education. First, the school context in the production system has a one-way contribution to the system (Figure 1) and does not encompass the broader social-cultural context. Second, the system is not cognizant of the community of learners and the cultural capital they bring to the learning process. Third, placing so much emphasis on the quality of the outcomes is likely to make it a closed system with limited responsiveness to change and innovation because its ultimate aim is in improving the productivity and the efficiency of the system. Fourth, the ability of the system to manipulate inputs and processes seemingly makes it responsive to equity concerns. However, this responsiveness remains constrained to surface and macro level indicators such as access, resources, and processes and does not extend to socially and culturally equity concerns of individual students.

I suggest that the former apparent discrepancies in conceptions of quality and equity and the relationship between them emanate from two sources. First, equity and quality in mathematics education are aspects of a complex social-cultural-political activity, and second, the absence of a theoretical framework that captures the nature of mathematics education as a social-cultural-political activity. We suggest a theoretical framework that will hopefully reduce the complexity of the equity–quality issues and consequently enhance our understanding of them. This framework is based on activity theory as developed by Leont'ev (1981) and activity system as developed by Engeström (1987).

ACTIVITY THEORY AND MATHEMATICS EDUCATION

Because the production model does not seem to capture the nature of mathematics education as a social-cultural-political activity, we propose the activity system model as an alternative model. We first introduce activity theory (Leont'ev, 1981) on the basis of which the construct of activity system (Engeström, 1987) was built. Then we demonstrate how we can look at mathematics education as an activity system.

Activity theory

Activity theory was developed by Leont'ev (1981). He defined activity as:

> "…the unit of life that is mediated by mental reflection. The real function of this unit is to orient the subjects in the world of objects. In other words, activity is not a reaction or aggregate of reactions, but a system with its own structure, its own internal transformations, and its own development." (p. 46).

A central assertion of activity theory is that our knowledge of the world is mediated by our interaction with it, and thus, human behavior and thinking occur within meaningful contexts as people conduct purposeful goal-directed activities. This theory strongly advocates socially organized human activity as the major unit of analysis in psychological studies rather than mind or behavior.

Leont'ev (1981) identified several interrelated levels or abstractions in theory of activity. Each level is associated with a special type of unit. The first most general level is associated with the unit of activity that deals with specific real activities such as work, play, and learning. The second level of analysis focuses on the unit of a goal-directed action that is the process subordinated to a conscious goal. The third level of analysis is associated with the unit of operation or the conditions under which the action is carried out. Operations help actualize the general goal to make it more concrete.

Human activity can be realized in two forms: “mental” activity or internal activity and practical objective or external activity (Leont’ev, 1981). The fundamental and primary form of human activity is external and practical. This form of activity brings humans into practical contact with objects thus redirecting, changing and enriching this activity. The internal plane of activity is formed as a result of internalizing external processes.

> “Internalization is the transition in which external processes with external, material objects are transformed into processes that take place at the mental level, the level of consciousness” (Zinchencho & Gordon, 1981, p. 74).

Three types of actions in mental activities had been identified: perceptual, mnemonic, and cognitive (Zinchencho & Gordon, 1981). Perceptual actions are those by which the human being maintains contact with the environment. They are initiated by stimuli from the environment and enriched on the basis of prior experience. Mnemonic actions refer to actions, which involve recognition, reconstruction, or recall (Piaget & Inhelder as cited in Zinchencho & Gordon, 1981). Cognitive actions involve thinking in terms of images of real objective processes (Gal’perin cited in Zinchencho & Gordon, 1981).

Activity System

Engeström (1987) developed the construct of activity system to describe and account for the collective human activity in the broad historical-cultural-social contexts. Figure 2 is a schematic diagram of the activity structure as developed by Engeström (1999).

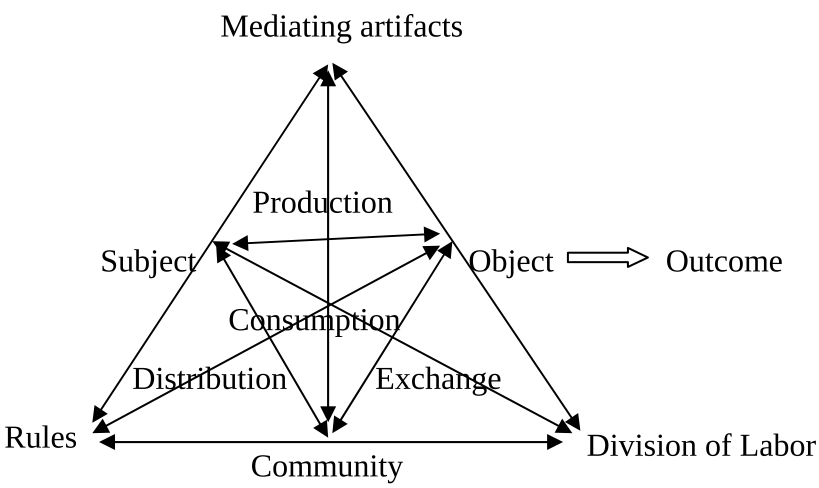

Figure 2. A schematic diagram of the activity system (Engeström, 1999

In the model the subject refers to an individual or a group in an organization. The object is the problem space targeted by the activity of the organization and this goal – object is transformed into outcomes with the help of mediating artifacts which consist of physical and symbolic, external and internal mediating instruments, including both tools and signs.

The community represents those individuals and /or subgroups that share the same general object and, as part of that organization, define themselves as distinct from other communities. The rules are the explicit and implicit regulations, norms, and conventions to regulate and control the actions and the interactions within the activity. Finally, the division of labor refers to both the division of tasks between members of the community and to the division of power and authority within the activity.

Mathematics Education as an Activity System

Figure 3 is a schematic diagram of mathematics education if viewed as an activity system at the classroom level. It is to be noted that the model of activity system may be used to describe and analyze mathematics education at different levels: Classroom, school and state or national level. In the next paragraph we illustrate how the activity system may be used to describe mathematics education at the classroom level.

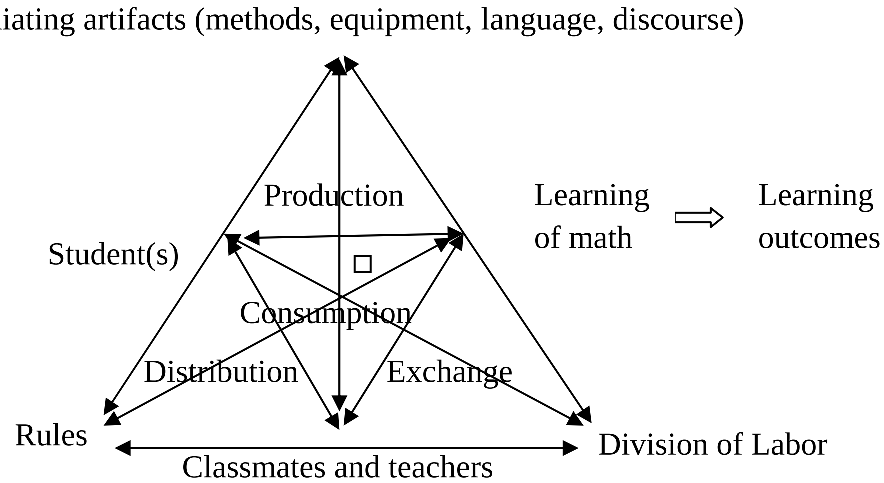

Figure 3. Mathematics education as an activity at the classroom level

The object of mathematics education as an activity system is the learning of mathematics, both at the individual and group levels. The learning of mathematics is transformed into learning outcomes by the help of the mediating artifacts which are used in the classroom and include mathematical and non-mathematical physical tools such as the computer or symbolic tools like language and mathematical symbols. The community which consists of those individuals which share the same object of learning mathematics includes the students in the class as well as the teacher. The division of labor refers to division of tasks as well as division of authority among the students and teachers while trying to achieve the object of the activity. The rules consist of explicit regulations of the school as well as implicit school and wider-scale social norms and conventions.

The school system can be viewed as an activity system in which the classroom activity systems are sub-systems. Thus the elements of the school activity system will be expanded to include the respective elements in the classroom system. For example, the community in the school activity system includes all students in different grades in the school who share the same object of learning mathematics. This hierarchical structure applies also to the national level, which can be viewed as an activity system in which school activity systems are sub-systems.

Having compared and contrasted the production and activity systems of mathematics education, we compare and contrast the concepts of equity and quality in the two systems and re-visit the four quotations from the perspective of the activity system.

EQUITY AND QUALITY IN THE ACTIVITY SYSTEM

In this section, we present the conceptions of equity, quality, and the relationship between them from the perspective of the activity system model.

Equity

As a descriptive framework, the activity system helps in identifying and rationalizing the source of inequities. For one thing, the activity system may help in rationalizing inequity concerns that have been identified so far (gender, socioeconomic status, ethnicity, disability status...) as well as in identifying additional equity concerns. For example, in the activity system framework, gender as an equity concern may be viewed as an unfair distribution (the triangle in Figure 3, whose vertices are student, community, and rules) of resources in the classroom. In the activity system, rules include, among other things, social norms and conventions. So, inequities that are associated with gender in the classroom are the result of carry-over from the cultural context.

The activity system framework widens the scope of equity concerns in mathematics education. In the production model, the equity concerns were limited to access, resources, and outputs. In the activity system framework, equity concerns are widened to include equitable participation in the processes which result from the tri-lateral interactions among the nodes of the system and these are the production, distribution, exchange, and consumption of knowledge (Figure 3). For example, language as a mediating artifact in the uneven production of knowledge in the learning of mathematics may be an equity concern because it is a factor which may discriminate among students coming from socio-economic strata of society. In the same way, the use of technology in teaching and learning of mathematics may be viewed as an equity concern. Along the same lines, additional equity concerns may arise from discrepancies in the exchange process in the activity system (the triangle whose vertices are division of labor, community, and object). The discrepancy between the goals of mathematics teaching and the expectations of the community may result in new equity concern.

Quality

Quality in the activity system is closely related to the knowledge creation metaphor of learning which differs from the other two metaphors: the acquisition metaphor and the participative metaphor (Paavpla et al., 2004). According to Paavpla (2004) the ultimate aim of the knowledge creation models (including Engeström's activity system) is the development of innovative knowledge communities through learning:

> Learning is not conceptualized through processes occurring in individuals' minds, or through processes of participation in social practices. Learning is understood as a collaborative effort directed toward developing some mediated artifacts, broadly defined as including knowledge, ideas, practices, and material or conceptual artifacts. The interaction among different forms of knowledge or between knowledge and other activities is emphasized as a requirement for this kind of innovativeness in learning and knowledge creation. (p. 569)

In the case of activity system, Engestrom (1999) introduced the model of expansive learning in work teams which is based on a learning cycle with seven stages. The learning cycle in expansive learning starts from some dialectical tension between the different nodes in the activity system and stabilizes with the re-conceptualization of the activity system in relation to the participants' relation to the shared objects, mediating artifacts, rules, and /or division of labor. A new tension between the nodes of the system will eventually lead to a new process of adaptation. Thus not only the activity system is transformed but more importantly the activity system will be "expanded" by creating new activity systems. Consequently the quality of an activity system is dependent on the responsiveness of the system to expand and create new activity systems that meet the emerging needs of the community.

An example of expansive learning in the context of mathematics education is in order. Let us look at the reform activity in mathematics education that took place during the last 15 years. Of course this activity took different forms in different countries and communities. Let us consider a certain country where there was a need to change the object of mathematics education as embodied in the mathematics curriculum. Through debate and criticism of the existing system, the community arrived at new shared expected outcomes of mathematics learning. Soon after, a tension is expected to be created between the expectations of learning outcomes (say, mathematical sense) and the mediated artifacts (say, methods of teaching which do not promote such expectations). If sensitive to change and improvement, the educational system responds to the tension between outcomes and mediated artifacts not only by re-conceptualizing the mathematics education system, but also by creating a new activity system (such as a new teacher education). On the other hand if it fails to respond to such tensions, the system will not improve and consequently will not create new activity systems. It should be noted that inequities, being sources of tensions and conflicts in the activity system, may act as factors which trigger the process of change and improvement of quality in the system.

The Activity System and the Social-Cultural-Political Nature of Math Education

The criterion of quality of mathematics education from the perspective of an activity system does not reside in the quality of its output (learning outcomes) or in the quality of the inputs or the processes of the system but rather in: a) the ability of the system as whole to respond to emerging needs by re-conceptualizing the relationships of the participants (learners) to the elements of the activity system (improvement), and b) by creating new activity systems (innovation).

The dialectical relationship between equity and equality in the activity system seems to capture the social-cultural-political nature of mathematics education. From the perspectives of activity system, the inequities that appear in the system because of social, cultural, or political reasons act as de-stabilizing factors, thus producing tensions which, according to expansive learning, will render the system more responsive to social-cultural-political concerns of mathematics education. This responsiveness takes the form of re-structuring the system to address these inequities.

Re-visiting the Quotations from the Perspective of Activity System

In this section we re-examine the quotations from the perspective of the activity system to find out whether this system, compared to the production system, contributes to a better understanding of the discrepancies we identified earlier. In Quotation 1, the discrepancies regarding equity and quality between street vendors and students may be accounted for, from the perspective of activity theory, by the observation that equity and quality are not comparable in the two cases since the street vendors and students are operating in two different activity systems. In the case of vendors, the workplace activity system consists of subjects (vendors) who are working in a community of other vendors and customers whose object is selling and buying produce, using all mediated artifacts (calculations and other physical tools), utilizing agreed upon division of labor, and operating within the rules of the local market and the acceptable social norms and conventions. On the other hand, the school activity system consists of a community of students and teachers whose object in the mathematics classroom is the learning of mathematics, using mediated artifacts and division of labor determined and limited by the school, and operating within the rules and policies of the school and social conventions of the larger school community.

In Quotation 2, the fact the equal opportunities to learn mathematics afforded to Stacey and Edward did not lead to a comparable valuation of their mathematics learning may be accounted for by the impact of social-cultural capital (rules)and the relation of each of Stacey and Edward to the object of learning mathematics.

In Quotation 3, the difference in conception of quality in the two cultures of Denmark and South Africa may be also explained by the activity system framework. What is valued as desirable object for learning mathematics in Denmark (learning to relate to authorities' use of mathematics, learning to act in a democracy, and developing a democratic classroom culture) is not considered a valuable outcome of the activity of learning mathematics in South Africa.

In Quotation 4, the four countries – Canada, Cuba, Finland and the Republic of Korea –have achieved, according to UNESCO, high standards of education quality, which was attributed to the fact that these countries shared some cultural similarities (holding the teaching profession in high regard and support it with investment in training) as well as political similarities (policy continuity over time and a strong, explicit vision of education's objectives). However, what was considered as a quality factor (policy continuity) from the perspective of the production system (quality of learning outcomes) is considered as a liability from the perspective of activity system since it constrains the ability of the system to adapt and innovate.

RELATIOSHIP BETWEEN EQUITY AND QUALITY: AN EXAMPLE FROM TIMSS 2003

The relationship between equity and quality is a complex one in the production system and even much more so in the activity system. I shall present an example to illustrate an approach to investigating the relationship between equity and quality taken from the Trends in International Mathematics and Science Study TIMSS 2003, which is modeled after the production system. Forty eight countries participated in TIMSS 2003 of which eight Arab countries participated at the eighth grade. Jurdak (2006) conducted a study commissioned by UNESCO to identify and compare the effect of student-level variables, teacher-level variables and school-level variables on mathematics achievement of Grade 8 students in the eight Arab countries which participated in TIMSS 2003. The TIMSS database was the source of data for the two statistical analyses that were done: 1) The variance component analysis was done to compare the variance accounted for by the school as a random variable; and, 2) stepwise multiple regression with the student, teacher, and school background variables as predictors and the Average Mathematics Plausible Score as dependent variable. The percentage of variance in mathematics achievement (a measure of quality) accounted for by a variable is an indicator of equity regarding that variable. For example, the between-school variance indicates the size of variation among schools. The larger the between-school variance in mathematics achievement, the larger the extent to which schools contribute to overall performance differences, and hence to potential inequity among schools in this country.

Between-school variation

The percentage of between-school variation to total variance in mathematics achievement by country is shown in Figure 4. Lebanon and Egypt have the highest percentage between-school variation among the Arab countries in math achievement due to school (Figure 4). This suggests that the school in Lebanon and Egypt contributes more than other Arab countries to the variation in student mathematics achievement. Consequently in these two countries the variation in school quality (an inequity factor) contributes more to quality variation in mathematics education.

Variations accounted for by student-, teacher-, and school-level variables

Figure 5 represents the percentage of variance in mathematics achievement accounted for by student, teacher, school variables and by country. Compared to teacher-level and school-level variables, the student-level variables' relative contribution to the within-country variance in mathematics achievement was the highest in all countries except Bahrain. Again the lowest relative contribution to within-country variance in mathematics achievement came from teacher-level variables for all countries except in Bahrain.

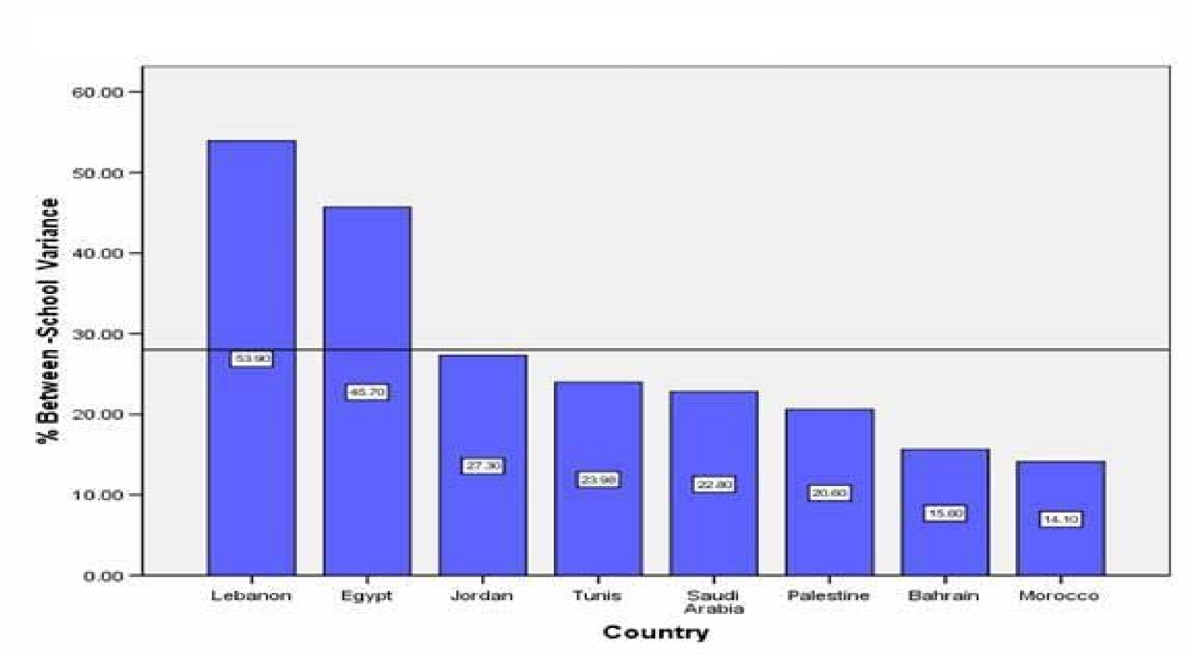

Figure 4. % of total variance in mathematics achievement accounted for by school

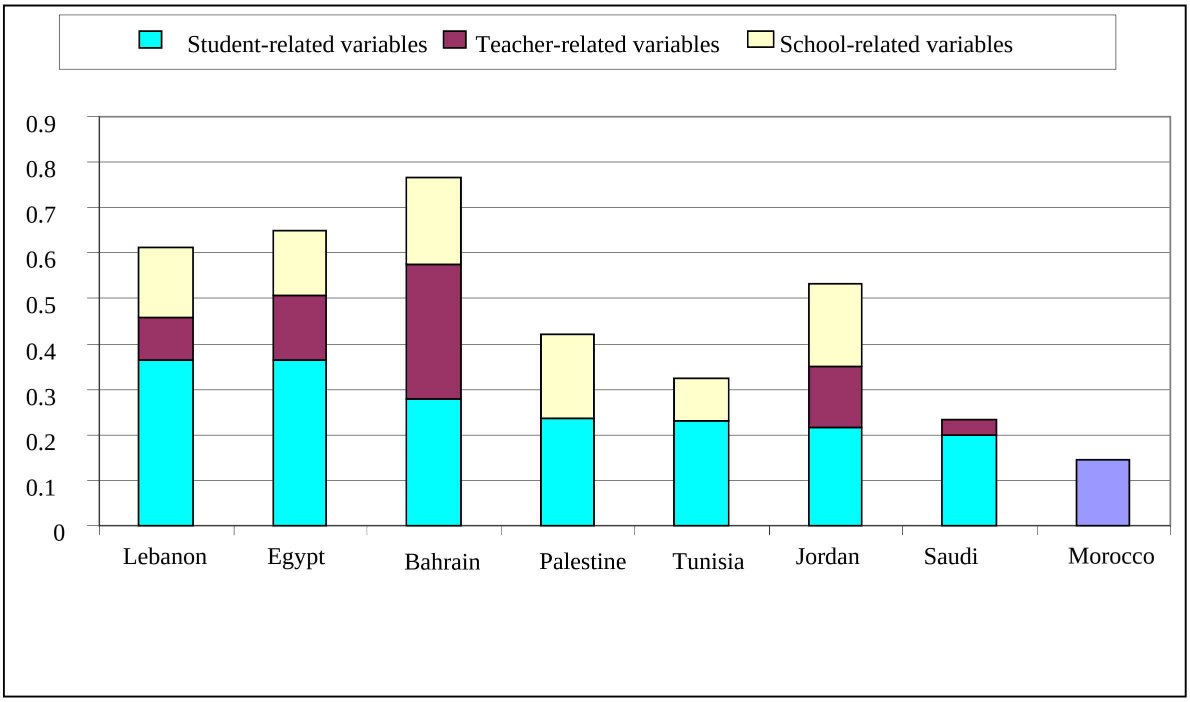

Figure 5. Proportion of variance in mathematics achievement accounted for by student, teacher, school variables and by country

Comparisons of variations in mathematics achievement accounted for by individual student- level variables

Figure 6 indicates that in the seven of the eight countries, an affective student-level variable entitled “Index of Self-Confidence in Learning Mathematics” entered first in the stepwise regression analysis and consequently accounted for the largest proportion of variance in mathematics achievement. The variable “Index of Self-Confidence in Learning Mathematics” is defined by TIMSS 2003 as “student perceives that he/she usually does well in mathematics, mathematics is easier for him/ her than for many of classmates, mathematics is one of his/her strengths, and perceives that he /she learns things quickly in mathematics”. One of two student-level variables related to student home environment ("Parents Highest Education Level” or “Students’ Educational Aspirations Relative to Parents Educational Level”) entered second in the regression equation in seven of the eight countries. It seems that each of the factors of self-confidence in learning and parental educational level impact mathematics achievement differentially and thus may act as contributors to inequity in mathematics achievement.

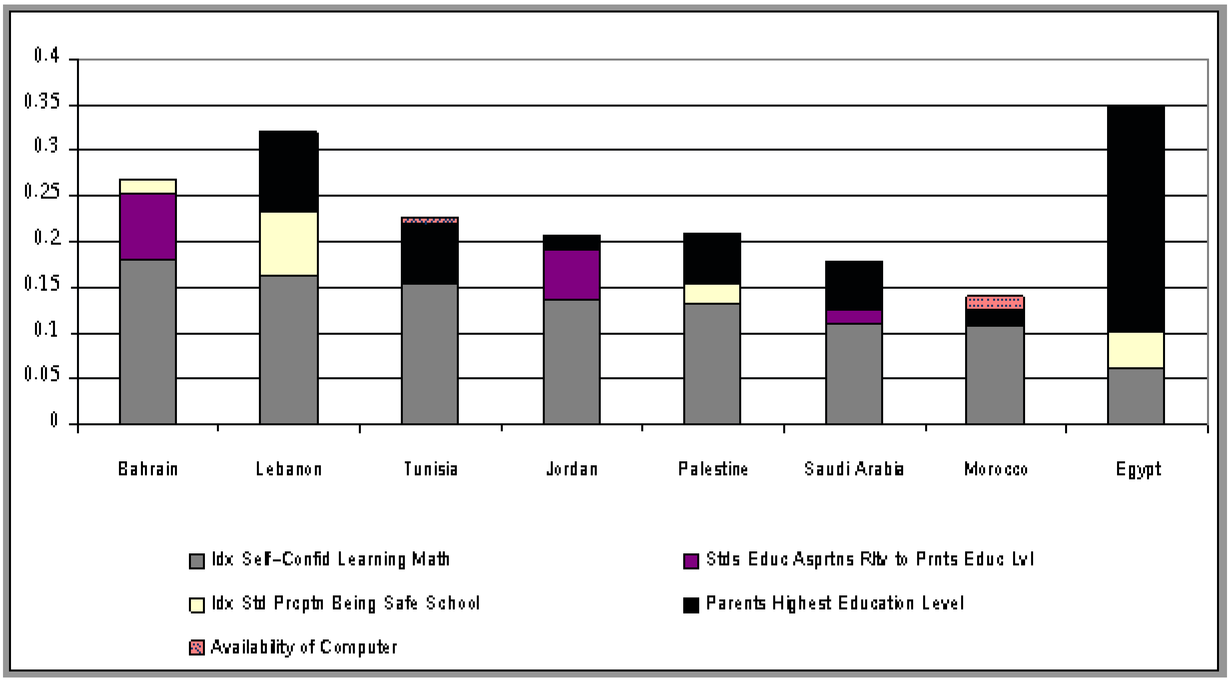

Figure 6. Proportion of Total Variance in Mathematics Achievement Accounted for by Student-level Variables by Country

Comparisons of variations in mathematics achievement accounted for by individual teacher- level variables

The impact of teacher-level variables was quite limited. Teacher-related variables had an impact on mathematics achievement in only five of the eight countries. In those five countries in which one or more teacher-level variable entered the regression equation, three such variables seem to compete for the first place in the order of entry of the variables: “Index of Principals' Perception of School Climate”, “Index of Mathematics Teachers' Perception of Safety in the Schools”, and “Index of Teachers’ Reports on Teaching Mathematics Classes with Few or No Limitations on Instruction due to Student Factors.

Comparisons of variations in mathematics achievement accounted for by individual school- level variables

Figure 8 shows the proportion of variance in mathematics achievement accounted for by each of the mathematics school-level variables in each of the eight Arab countries. Figure 8 shows that in two countries (Morocco, Saudi Arabia), no school-level variable entered the stepwise multiple regression, indicating the weak contribution of school-level variables to mathematics achievement in those two countries. In the six countries in which one or more school-level variable entered the regression equation, variable “Index of Principals' Perception of School Climate” entered first in the regression equation in all countries except Bahrain. Only in Egypt and Jordan, a second variable entered the regression equation and in both of them, this variable was “Trends in Index of Availability of School Resources for Mathematics Instruction”.

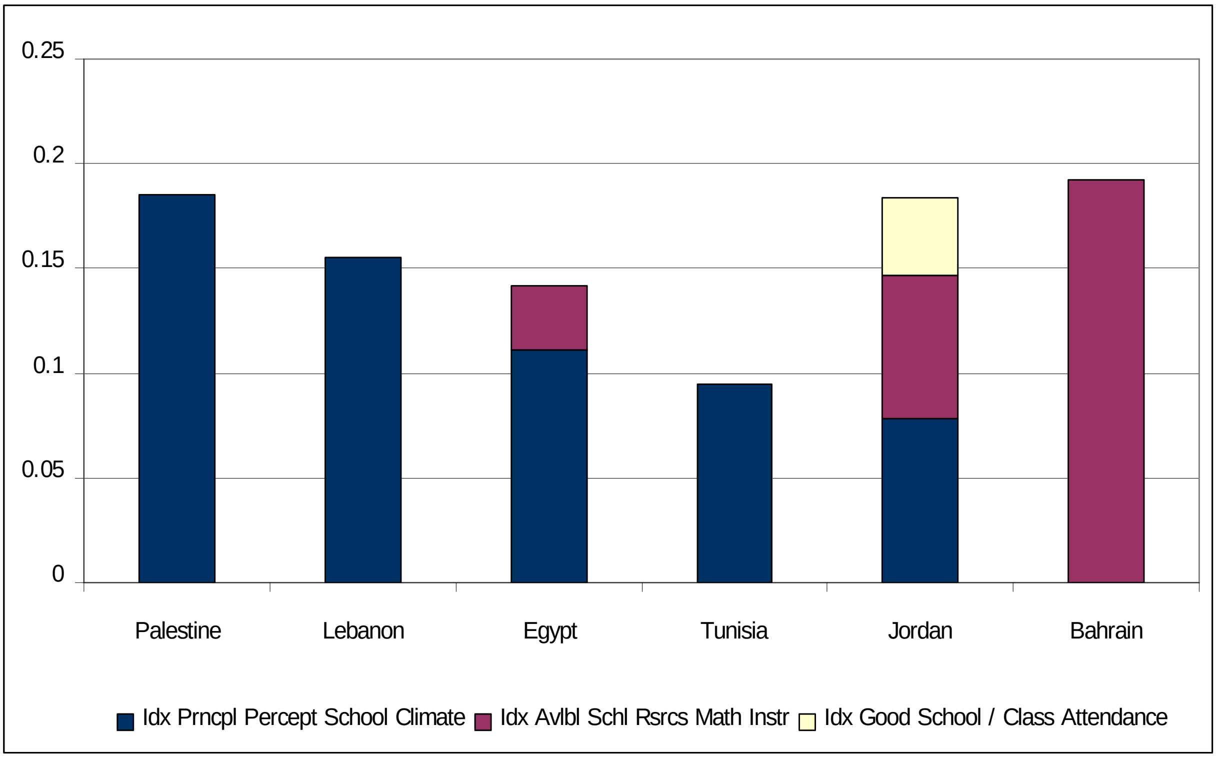

Figure 7. Proportion of total variance in mathematics achievement accounted for by school-level variables and country

The common factors that seem to impact the quality of mathematics education as measured by an achievement score in the eight Arab countries are: Self-confidence in learning mathematics, parental level of education, and student educational aspiration relative to parent's level of education, school climate, and availability of school resources for mathematics instruction. By virtue of producing differential impact on mathematics achievement, these factors are potential inequity-producing factors.

The activity system provides a way to relate each of these factors to the four processes in the activity system: Production, distribution, exchange, and consumption. The self-confidence in learning mathematics, though an individual affective aspect is nevertheless, an attitude that is formed during production of mathematics learning in the classroom i.e. in the triangle formed by subject, object, and mediated artifacts. This puts a special responsibility on the mediating effect of the teacher and related methodology as well as on the targeted learning outcomes. In a similar manner, school climate belongs to the school as a whole i.e. the school activity system. On the other hand, the factors related to parental education and availability of school resources for mathematics instruction are specially affected by the distribution process of the system i.e. in the triangle formed by subject, community, and rules. The latter being a conduit to policies and social norms and expectations.

In conclusion, the activity system framework seems to have comparative advantages for research, policy making, and professional practice. For research, the activity system, being a theoretical framework based on learning by creation as compared to learning by acquisition and by participation, provides a lens with a broader perspective of equity and quality in mathematics education. For policy–makers it provides a framework to see the complexity of quality and equity in the mathematics education as a social-cultural system. For teachers, it provides a framework to analyze the opportunities, challenges, and limitations of their professional practice.

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