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Full Length Research Paper

Wise decisions in mathematics education

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For dynamic situations, a system of dynamic decision-making is needed; a system which is being refreshed all the time by the decisions of its elements or members. We call it wise decision system or WDS. Our purpose for suggesting such a system is creating some criteria in order to consider whether the decisions made in the field of mathematics education and mathematics curriculum planning are wise or not. First, some specifications of this model have been introduced. Then an example from teacher training courses in district 1 of educational ministry in Tehran, Iran has been discussed. By the criteria which WDS suggests, decisions in the mentioned example have a room for improvement.

Key words: Mathematics education, wise decisions, situated decision, society, culture, self organization.

INTRODUCTION

Mathematics education is an evolving social enterprise, a part of a whole, (rather than a distinct part) which could be influenced by social events. As Popkewitz (1988) says "our social conditions contain a host of elements that interact in ways that are never fully specified, predetermined, anticipated, or willed". Brooks (1978) also argues: "The recognition that the world is changing rapidly casts doubt on any program which depends on rigidly defined propositions embodied in a static educational theory not capable of responding to environmental change."

Brown (2001) categorizes the strands of change in mathematics and its education as following: "changes in mathematics as utilized by society; the composition of mathematics itself, understood as a discipline supporting human endeavors in the physical world, is constantly on the move, as the procedures through which we apply it.… Changes in mathematics as seen by specialist mathematicians. Research in "new" areas and popularization of others shift the relative emphases received by the various topics within mathematics.… Changes in mathematics as described in school curriculums….Curriculums are a function of many forces and interests created by variously perceived needs. …Changes in adult-child relations; the teacher increasingly trains the child for a world of which the teacher has little knowledge. …. Evolution of learning theories and teach-ing practices; Learning theories and their implementation are themselves increasingly susceptible to the intellect-tual turmoil that surrounds us and impinge on the way teachers conceptualize and carry out their practice.…"

Non-stopping interaction between changing world, education and mathematics does not mean that the role of human decision for designing successful plans has reduced, but it means that we need more intelligent and efficient decisions to increase desired effects of changes, reduce negative, unwilled ones or/and change the undesired effects to desired and positive effects.

For dynamic situations, a system of dynamic decision-making is needed; a system which is being refreshed all the time by the decisions of its elements or members. We call it wise decision system or WDS.

Our purpose for suggesting such a system is creating some criteria in order to consider whether the decisions made in the field of mathematics education and mathematics curriculum planning are wise or not.

This is only a model rather than practical guidance for wise decision making in mathematics education.

Main concerns of wise decisions

In "MAPS" model introduced by Hingginson (1980), mathematics education is supposed to be a point whose position changes each time among the inner space, edges

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or vertexes of a polygon. Vertexes are “M” for mathematics, “A” for anthropology, “P” for psychology and “S” for society, as affecting factors on mathematics education. We claim that this point never locates exactly on edges or vertex but only inside the polygon. There are fuzzy boundaries between the affecting factors on mathematics education. However, we improve and use these factors as the aspects which might be concerned in “wise decisions”.

The important concerns of wise decisions seem to be:

i.) Mathematics
ii.) Psychology
iii.) Anthropology
iv.) International trends
v.) Society and Culture

We have added the “international trends” as an affecting factor on mathematics education, because approaches and attitudes in Mathematics and mathematics education differ in many aspects in international societies. There might be even many contradictions between mathematicians and mathematics educators’ views, but both, the international accepted results of studies in mathematics education and universal Mathematics introduced by mathematicians, affect mathematics education in a society.

The link between these items is “education” which has caused more interaction between the affecting factors on mathematics education. Even in content- orientted approaches, such as “new mathematics”, no content of mathematics could be applied in lesson books without being” chosen” or “modified”. On the other hand, the recent “new-new mathematics” which was strongly criticized because of paying less attention to the basics of mathematics in education, still needed some mathematics to be taught in so called” new-new” methods.

Kemmis and McTaggart (1998) have argued that in the case of mathematics education and cultures, the main criteria to be employed for choosing a culture and then improving it, should be “rationality and justice”.

However, these items should be in conformity with “rationality” and “justice”, that is, any wise decision considering the main concerns of mathematics education (mathematics, society, values...) should pass “rationality” and “justice” filters.

For example, paying attention to values in mathematics education should not contradict rationality. On the other hand, conformity with national trends is rational but it should be justified through social, cultural and anthropological concerns of a region or a nation. Whatsoever, the frequent balance and interaction between “rationality” and “justice” would be the final passing filter for any decision, and is mostly due to human conscious.

Wise decision identifications

The lack of wise decision system (WDS), results in undesired effects in the system of mathematics education.

International trends and decisions in mathematics education impose themselves to local educational system. Any conflict between adopted curriculum from international societies in one hand, and culture and society in the other hand, makes embarrassing situations for teachers and students. In this situation, neither problems nor solutions are identified or predicted.

In the case of poor decisions, problems may be identified or predicted but are not defined by local decision makers.

Some solutions and decisions might be dictated to the local educational system, including teachers and students. These would be, as Clements and Elerton declare, top-down decisions. But it is not always easy to separate the decision makers from the processes of decision-making and any separation would be artificial. In fact, each part of the mathematics education system could be a potential decision maker.

In real situations, the entire system of mathematics education (researchers, administrators, teachers, students...) deals with frequently renewed problems and solutions. Teachers and students are more influenced by the rapid changes in educational systems. They should be equipped and trained to act in non-stable situations. As Brown (2001) says: “Teachers must assume some sort of professional identity if they are to build up resistance to increasing pressure and conceptualize the changes they face, the teaching environment has become too complex for all demands to be compiled with and so teachers are forced into making choices, both constrained and enabled by the structural framework they meet.”

The events and processes in human life at whole and mathematics education system in particular, are characterized by complex nonlinear dynamics - they arise, evolve and disappear as a direct result of interaction of many interwoven factors. These are the same factors which influence human decision-making in WDS.

WDS dictates no certain solution, nor even problem, but it can aid decision making by providing information relevant to the decision and to the decision makers.

According to Vladimir (1998), decision making requires division and separation. The decision maker needs to extract out of the available information (related to a decision situation under concern) at least three independent constituents:

i.) Set of alternatives to choose from.
ii.) Set of criteria to satisfy.
iii.) A goal (or set of goals) to achieve.

After analyzing the above constituents, a specific procedure is sought in an attempt to connect them in an 'optimal' way. These are general characteristics in any domain of decision making including mathematics education. Many goals and sub goals as well as alternatives for decision making, in the case of mathematics education might be identified, the main criteria for justifying decisions, as was argued before, might be rationality and justice.

WDS includes all these constituents but specifically it provides facilities for decision making in real dynamic and unpredictable situations. In such conditions, there might be few alternatives to choose from and even the goals might be emerged in situation.

As a matter of fact, in real situations, as Vladimir Dimitrov (1998) declares, 'decision emergences' are needed rather than decision making. He says: "Decision emerging does not require division and separation - on the contrary, it depends crucially on the ability of the decision-initiators (persons or groups responsible for initiating the process of decision-emerging) to fully experience decision situations. And decision situations are simply critical life situations. Without experiencing *in vivo* these situations, no decision emergence can occur. The emergence is never in past or in future. Decision emerges now - in parallel with the act of experiencing the enfoldment of life. That is why the personal (or group) awareness (alertness, vigilance) is a vital factor in decision emergence."

Similarly, in-time decisions of teachers emerge from in-time interaction between teachers and students. WDS is responsible to prepare and train teachers for confronting decision emergences.

Briefly, WDS should provide the following five capabilities for all parts of the system:

i.) Situated decision (action in time)
ii.) Prediction
iii.) Communication and interaction
iv.) Awareness
v.) Self organizing and adaptive nature

Self organization, an important capability in WDS, is a common term in some certain kinds of physical, chemical and biological systems; it indicates the capacity in which a collection of initially disordered components become naturally coordinated and come to show patterns as a collective. Self organization is a general phenomenon that is not necessarily related to biological or psychological phenomena (Keijzer, 2002). The patterns generated simply follow general mathematical rules (Stewart, 1998).

We take nearly the same general concept and process of biological and cognitive self-organization in WDS. Keijzer (2002) specifies the self-organization in biological and cognitive systems by adding an extra ingredient to self-organization process as it occurs in general term. This ingredient consists of a factor that 'steers' the pattern-forming processes into specific directions. In biology, DNA plausibly performs this role, while in psychology and cognitive science notions like internal representations and intentions come to mind. In the case of social phenomena such as WDS whose components are human participants, knowledge, beliefs, general and specific intentions of groups and individuals and government policies act as steering factors besides the environmenttal and situated conditions which a participant encounters. Therefore decisions in mathematics education are not merely situated, without any background of individual or social attitudes and intentions. Both "steering" and "situated conditions" are involved in self organization. Keijzer (2002) explains the act of "steering" in biological and cognitive systems as follows: "The notion of steering takes on a different meaning when it involves a self-organizing process. Steering is not a matter of imposing order onto a system where there is no order to begin with. The system that is being steered is not a passive matter waiting to be molded into shape. On the contrary, the steered medium provides itself the pattern forming process. Steering is much less direct and rather takes the form of modulating a set of ongoing processes. When a system is in the position to develop into two different directions at a certain moment, steering consists of nothing more than to give a little push into one direction rather than another."

The same thing occurs in WDS. WDS should not impose any prescribed decision or fixed program to the components, rather it should provide grounds for decision making of participants in their own authorities.

Informing each component by what might be considered as main goals, concerns and common attitudes in mathematics education and providing facilities for putting these concerns and attitudes into practice, creates a "steering" but not "controlling" factor in situated conditions and situated decisions.

That is mostly through "steering" factors and their manipulation in self-organization of participants that WDS is able to change the undesired effects of a situated condition to desired ones.

Communication also plays a key role in WDS. Mathematics education researchers, mathematicians, administrators, teachers and students should frequently interchange information and experiences to be aware of the recent problematic of mathematics education and suggesting solutions.

The importance of communication is that it potentially supports capability of awareness through interaction and exchanging information between parts of the WDS, which subsequently results in capability of self organization and prediction.

Capabilities of awareness and prediction are necessary but not sufficient pre-requisites for situated decisions made by different components of WDS. The skill needed for making best situated decisions might be obtained via training and education.

Figure 1 shows a model for communication between some parts of the mathematics education system; there are certainly much more interacting components in the system of mathematics education in reality.

It may seem that this diagram represents an ideal and impractical situation. Of course the links between modern approaches and academic societies is not the same as mo-

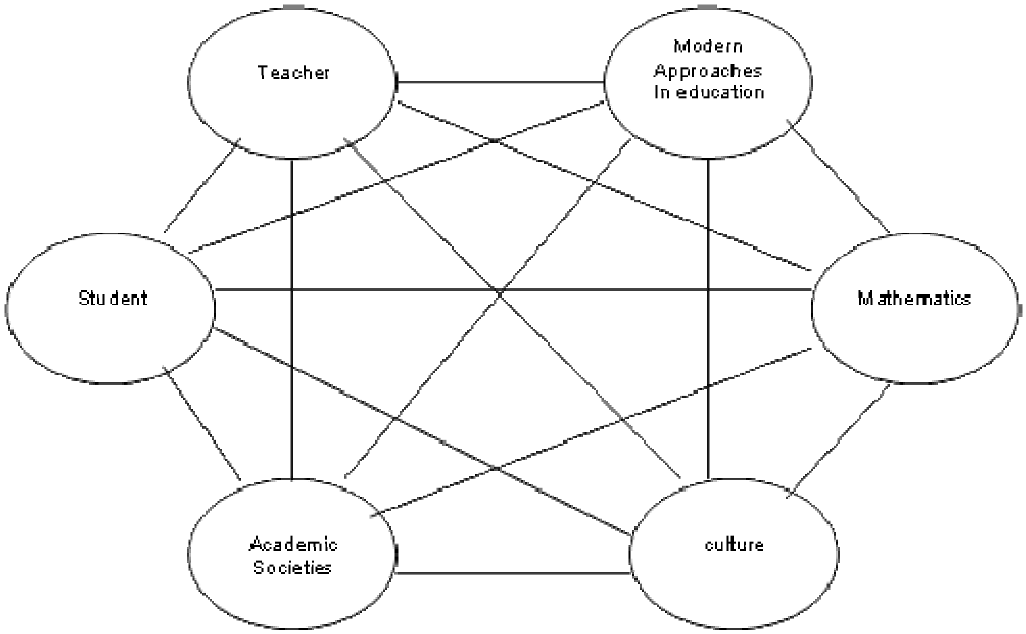


Figure 1. Diagram of WDS communication.

dern approaches and students. In fact there may be no direct link between modern approaches and student, but this connection is not either impossible. So the connecting links between components might be assumed weighted.

An example from mathematics education in Iran

Now we consider one of the main concerns of mathematics education, that is, "mathematics for all" and "mathematics for elite" and the local and international possible reactions, decisions and possible problems related to these matters, as an example. Meanwhile, we show that most related decisions are not wise decisions in the case of local situations.

C1- International trend: equity in mathematics education, non- elite mathematics

Decision: international conferences, meetings, plan (UNESCO report in 1984; NCTM standards, Mathematics for all; designing and directing research for developing non-elite curriculum).

WD: attempting to internationalize the results of studies, seeking for more communication ways between different countries.

C2- Academic Mathematics: mathematics knowledge has decreased among college students.

Possibility: most students have not been qualified enough in mathematics before entering universities and colleges. They are not interested in mathematics.

Decision: more and more students should fail in final exams of universities to take the matter seriously.

Decision: examinations should be easier in order so that more students could pass the exams.

WD: setting more communication opportunities between mathematics professors and mathematics education experts, seeking for the roots, and trying to modify students' attitudes (Communication, situated action).

C3- Educational administration: the majority of the high school students show little interest in mathematics.

Possibility: Teachers can not motivate students to learn mathematics.

Possibility: Students are not successful in mathematics examinations.

WD: setting more in- service teacher training courses to inform teachers from newest approaches of mathematics education and the results of researches [that is, Mathematics for all, developing non-elite curriculum (communication)/ changing the format of school examinations (studies shows that there might be a relation between elitist views on education and achievement tests].

C4- Teachers: most high school students are not interested in mathematics/ few students are able to use their mathematics knowledge in real life/mathematics is science of elite.

Decision: taking more difficult exams in order that the majority non- elite try their best to pass the final exams.

Decision: taking easier exams in order to satisfy school principals and students' parents by the results of the exams.

Decision: do nothing at all and waiting for top-down decisions.

WD: consulting with experts, getting information about equity in mathematics or non- elite mathematics from different resources, trying to modify students' attitudes toward mathematics. One simple way is to tell some stories about the mistakes that great mathematicians have done in history .This may break the huge wall of the elite which does not allow students to learn mathematics (situated action).

C5- Local mathematics education researchers: awareness of recent educational reforms, mathematics for all. Mathematics should not be concerned as an elitist discipline any more.

Decision: Doing their own studies without any concern of the realities in schools of Iran.

Decision: Doing something about the teachers' and students' attitudes toward mathematics as a solution for increasing the interest in mathematics, among the students.

WD: Giving consultations to educational administrations, /conducting pre/in- service teacher training courses to inform teachers/ being mediation between international and local societies of education/ designing and conducting studies related to this subject and reporting the results to all.

C6- Parents and students: Mathematics is necessary for students' future progress in society / mathematics is the science of elite.

Decision: parents blame their children for not being talented in mathematics and forces them to try hard, / parents encourage their children to attend out-school institutions for increasing their mathematics knowledge.

Decision: students try their best/ they become disappointed. They feel that they are not able to learn mathematics and give up.

WD: getting consultations from experts in the field of mathematics education through communication.

Many Iranian teachers and students think very high about mathematics. A recent study (Savizi and Shahvarani, 2007) in the district 1 of Tehran education department shows that about 80% of mathematics teachers believe that "Mathematics is the science of Elite" (C4). Iranian students and educational administrators believe more or less the same (C1 and C3). This belief affects teachers' behavior and has a negative effect on their teaching. Teachers with this attitude do not attend to make decisions for changing the top- down elitist mathematics program for the benefit of the non-elite majority. In these circumstances situated decisions are meaningless. By this view, students who are not elite (nearly most of them), do not deserve to be well qualified in school mathematics and do not try hard, and educational administrators do not make serious decisions for the benefit of the majority non-elite, because it is useless! Parents also do nothing except blaming children for being not talented and hard working (C6).

The problem that "Mathematics for Elite" has caused in education has been an international concern since 1980s' and is not a new one (C1).

D'Ambrosio (1985, 1989) have argued that, in the past, school mathematics has been an elitist affair, especially suited for the preparation of middle- class males for prestigious professions such as engineering and natural sciences. According to Clements and Elerton, what is needed, D'Amborsio (1984, 1994) has argued, is a totally new approach whereby different mathematics curricula are developed, always with the specific needs of existing group and potential learners in mind. The NCTM curriculum and evaluation standards for school mathematics advocates "mathematics for all" as a central idea in education reform. The Draft for "Standards 2000' from the NCTM (NCTM 98) calls for increased equity by exposing all students, not just the elite, to challenging mathematics. (Decisions on C1)

Figure 2 shows the possible communication diagram in the case of the problematic of "mathematics for all" and "mathematics for elite".

Obviously, some links in WDS communication network are more significant than the others. For instance, the connections:

Figure 2 shows the lack of some important links between components such as C5 and C6. WDS must improve the links of communication between the components the components whose interaction have the most influence on mathematics education.

Decision making in mathematics education system of Iran

In short, many of the decisions in mathematics education in Iran are not wise decisions. Teachers are obliged to implement the top-down decisions in their classrooms. The apparatus of government policy seems increasingly to be shaping the college experience of being a teacher. Teachers' capacity for working on their own professional development in a way that relates to their own more aspiration of what is to be a teacher is neglected. For this reason they have little opportunity to make decisions and act due to the occurred situations on their own authority. Almost the entire teachers 'in-service training in Iran deals with developing teachers' scientific or professional

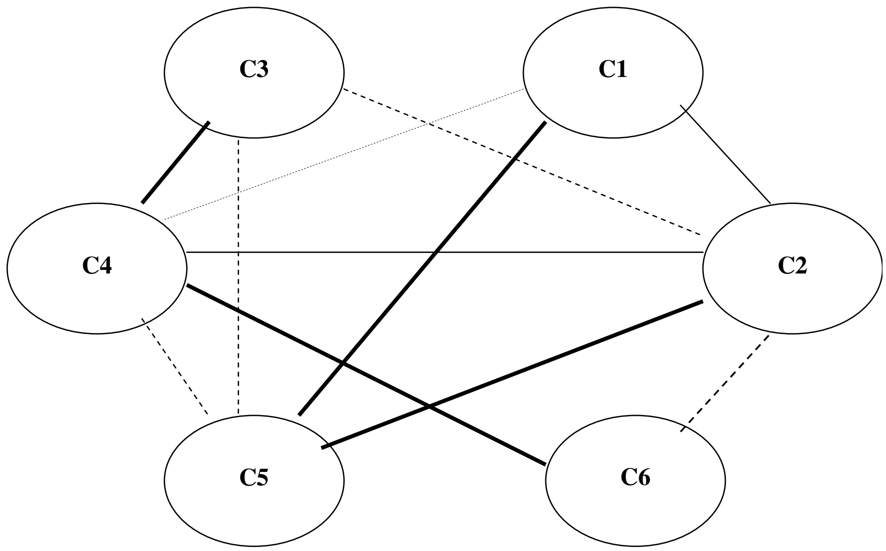
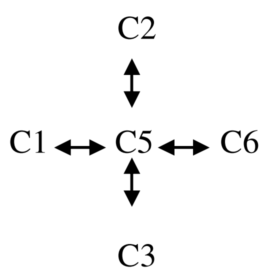


Figure 2. Diagram of WDS communication in Iran, for the problematic of "mathematics for all".



might be more significant than the connection: .

C1 ↔ C6 ↔ C2

knowledge domain. Pre-service and in-service training courses give little information about recent educational approaches in the world. Teachers do not even have much communication with local academic societies and mathematicians.

The top-down decision-making is even more common among education administrations. Tehran education organization gives legal ground for in-service teachers' training courses and prescribes the titles of these courses to the districts of education departments*. Among several prescribed titles, district one of Tehran education department usually, because of limited opportunities, organizes only two, three or four courses, along with the needs of the teachers in each year. But most of the time the needs of the teachers completely defers from existing facilities.

During 2000 and 2007, almost 16 in- service courses have been organized by district one of education department for the high school and secondary mathematics teachers. Among the top- down prescribed titles all but three were content-oriented. These content-oriented courses do not even satisfy much of the teachers' need of mathematics knowledge development, so sometimes educators in such classes teach something different from the prescribed title (for example the educator may teach about the first geometry book in the course titled by calculus second book, due to the teachers' needs and suggestions).

The lack of an appropriate communication between education organization of Tehran, districts of education departments and teachers in one hand, and international and local academic societies of mathematics education on the other hand has caused that training courses rarely change the existing situation to a better one or improve classroom practices.

Meanwhile, mathematics education researchers play a poor role in reflecting the realities of mathematics education in Iranian schools.

Mathematics education is a new branch in universities of Iran. The main concerns and purposes of the academic studies in mathematics education are determined by international trends rather than by local situations (Lack of communication).

The first and the most important step for establishing a network of WDS in Iran seems to be communication. Mathematics education researchers should play the role of a media and a coordinator between international trends, and local societies of education. Teachers should be trained and equipped for deciding and acting in unpredictable, dynamic conditions by their own authority. In addition to in- service training courses and workshops, Reciprocal interactions in a community of practice, where teachers can share their professional experiences, may provide an effective means of supporting situated decision-making. The teacher sought information from a more experienced peer with a mathematics background due to her limited background in the content area. Conversely, a teacher learning new skills may be reluctant to interact until she believes that her contributions are meaningful to the learning environment (Glazer and Hannafin, 2006). Teachers might also engage in collegial discourse about ways to resolve issues using higher order reasoning, such as analysis, synthesis, or evaluation. For example, some teachers find it helpful to discuss thoughts and ideas with peers and consider alternatives before making decisions (Clement and Vandenberghe, 2000; Little, 1982). Reflection can stimulate reciprocal interactions (Glazer and Hannafin, 2006).

The other suitable way which may empower the communication links between teachers, university researchers and administrations of education is action research.

It has been usually claimed that findings of mathematics education research have little impact on how mathematics is taught and learned in schools. Researchers may blame teachers for the fact that schools and school system have not been greatly interested in developing programs which incorporate the main message from their research.

On the other hand schools system and teachers may claim that university-based research studies have not reflected much of the reality of what happens in the classrooms. In fact many approaches recommended and funded by ministries of education have been likely to have a greater impact in schools than approaches based on findings from university research studies. In systems driven by government policy, these approaches do not often have a sound research base (Clements and Elerton, 1996).

Irrespective of whether they have had a sound research base, top-down programs decreases teachers' autonomy in the classrooms. Teachers are not involved in decisions about which projects should be funded but they are expected to implement recommended programs. The danger with such a state of affairs, as Clements and Elerton (1996) declare, is that when policies change or funding is withdrawn, teachers go back to doing what they did beforehand.

By action research approach, teachers are involved as voluntary participants in education research projects, and then the research findings are more likely to be integrated into practice.

Clements and Elerton (1996) have characterized ten possibly contentious propositions which define problematics of mathematics education research. Most of these ten propositions are based on suggestions for rejecting top-down authorities and developing mutual communication fields in a way that the majority of contributing participants of different countries and different components of mathematics education system make benefit from. Proposition nine, for instance says:

partners in mathematics education research projects, and the theoretical assumptions and practical approaches in such projects should not be predetermined by outside experts."

and proposition ten declares:

"The present international mathematics education research community needs to move proactively so that full and equal participation is possible for mathematics educators in countries which are currently under- representted in the community."

Putting theses propositions in to practice also develops communication links, as it was suggested in WDS, which subsequently improves the capabilities of awareness, self-organization and situated decisions.

Students will also need to be more equipped to generate and work with their own accounts of the realities they face rather than rely too heavily on the accounts provided by their elders. Curriculum designers, meanwhile, perhaps need to be motivated more by needs and possibilities, based on movement from existing practices.

Technology, as the most important aid for communication in our century and the main way of getting information, needs to be strongly paid attention in our mathematics education system.

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