



**ORIGINAL RESEARCH PAPER**

**On the Psychology of Teaching Physics and Mathematics**

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**ABSTRACT**

**Keywords:**

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It is evident to any skilled physics and mathematics teacher that the process of student education should systematically involve students' particular elements including abilities, capacities, interests, culture and the nature of their cognitive structure and creativity. In this paper, we focused on educators' personality influence on forming their scientific perspectives of student education while teaching physics and mathematics and making educational decisions for students. Psychology of teachers is an important component in teacher education, curriculum planning, and curriculum implementation process. We aimed to introduce mathematical models for different personalities of teachers and discuss how these models can be used in classroom and in curriculum planning.

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## **1. Physics and the study of the nature**

The complicacy of teaching in classroom is due, not only to teacher's personality and belief system, but also to social aspects of teacher's conceptual and mathematical communication. Internal psychological aspects are discussed in an earlier paper where mathematical models for mathematical communication are introduced [2]. A good source for finding important factors taking part in the social aspects of teaching can be borrowed from sociology of science. The amount of similarity between the scientific community and the process of education of students in classroom depends on how natural the process of learning is implemented by teacher.

In this paper, we focus on the psychology of physics and mathematics teachers, with particular attention to social aspects of learning. We try to give mathematical models for teaching mathematics and try to understand the behavior of teachers using these models.

## **2. Different models for a classroom**

Field study has indicated that the meaning of doing, teaching and learning physics and mathematics varies in different classes. This variation is partially due to the perspectives of teachers towards mathematics and towards the role of teacher in communicating concepts and education in general, and these perspectives are affected by teacher's background knowledge and their professional abilities as a teacher. Both could be strengthened by teachers' education programs, but promotion of the level of abstractness of teacher's knowledge and his/her professional abilities takes time and is not easily achieved. Therefore, not every teacher could teach every style. We must introduce different models for a classroom, so that different teachers with different levels of sophistication in teaching could find a model which is appropriate for their professional capacities.

### **2-1-Teacher as a source of information**

Knowledge in such a classroom is nothing but raw information and teaching and learning are nothing but transformation and communication of information. Teacher either orally explains the information to the class or writes the information on board or shows students demonstrations on computer or on data show. Some other information is made available to students by handing them books and papers. Student's access to information is not always in full detail. Most of the time teacher chooses the key information and makes it known to his/her pupils. Teacher also gives some explanations on the meaning and the relations between the packages of information. The role of such a teacher could be easily played by computers. Information technology could provide students with more detailed, accurate, advanced, and accessible information.

The role of student in such a class is taking notes and trying to memorize them. Repetition helps students to keep information in mind for a longer period.

Decisions that a teacher should make in such a classroom are very formal and can be modeled to be performed by a computer. Teacher decides about the language and tools in which each piece of information shall be demonstrated to the class, and also chooses the exercises which help students internalize the information. Teacher must choose the key information and decide about appropriate references to introduce students for further study. Teacher must decide about how to assess a piece of information too. We shall introduce models for different personalities of teachers in making such decisions.

### **2-2-Teacher as a physician**

In such a classroom, teacher is trying to give special treatments to the minds of his/her students. For this kind of teacher, knowledge is only used as a means of communication to get information on how students think. A teacher tries to replace an unorganized mind by an ordered healthy mind. This is why he/she demonstrates some examples of truthful deductions and accurate reasonings to the class. The main occupation of the teacher in this classroom, is discovering the mental weaknesses of students and trying to bring them to a normal position in which all their different abilities demonstrate a coherent progress during the process of education. Only a very well-trained experienced teacher can play this role in the classroom. There is some chance that someday a detailed classification of learner's behavior plus a well-developed theory of information engineering could partially replace the role of these teachers in the educational system. We plan to use machine learning techniques for this purpose, which is work in progress.

In this classroom, students try to awaken the abilities of their mind, by learning and imitating examples of deductions and reasonings presented in class. They try to cooperate with their teacher in discovering their mental weaknesses.

Teacher must have a classification of human cognitive personalities so that he/she can decide each student belongs to which class and then comparing student's abilities with the particular class he/she has chosen, decide about weaknesses and strengths of the student. Classification of weaknesses is an abstract procedure, because unnormal situations are exceptions; but teacher must put similar students in the same class, so that he/she be able to study them by their symptoms. Making such decisions is very abstract and complicated.

### **2-3-Teacher as a coach**

In this classroom, teacher is trying to discover his/her students' personal talents and train them in direction of perfection of these talents. The characteristics of the knowledge being discussed in class has an important role in this training. Teacher makes determining decisions in choosing the material to be discussed in class. Different examples demonstrated in class are aimed to train different groups of students with different talents. Teacher shall be able to teach students the practices and exercises which help them in perfection of their talents. Teacher supports and protects

his/her students in the storm of their mental contradictions. He/she must provide an appropriate atmosphere in classroom for treatment of students' mental contradictions.

The role of student in this classroom is making students do physics and mathematics in front of him/her and other student's eyes. Student's personally gets actively involved in enrichment of his/her knowledge up to a level in which he/she be able to overcome mental contradictions leaning on his/her own personal abilities. Students also cooperate with teacher in the process of discovery of their talents.

Teacher must introduce a classification of talents and decide about the manners in which these talents show off so that he/she can decide about talents of students and exercises which can lead students to perfection of their talents. Teacher must decide about different levels of student's access to each of these talents.

#### **2-4-Teacher as a role model**

In this classroom various forms of mathematical knowledge are discussed. Teacher tries to openly demonstrate the process of thinking to the class. Students could learn how to solve problems, only if they can openly watch their teacher wrestle with hard problems. Teacher must be able to think loudly so that students could imitate his/her skills of problem solving. Teacher could serve as a good role model, only if students can watch his/her thoughts inside out. In this classroom, teacher shall do a material which he/she is not familiar with, in front of the students. Teacher tries to make students involved in his/her process of problem solving. If this role could be successfully played in classroom, students have been given the best possible education for group thinking. A teacher for this class should be very experienced and knowledgeable in material.

The role of students in such a classroom is doing physics and mathematics while keeping the teacher in mind as a role model. Students can construct form their scientific abilities personally and guide the direction of progress in their mental skills.

Most of the decisions that such a teacher should make are personal decisions which he/she makes in problem solving and the class is supposed to imitate him/her in making personal decisions.

#### **2-5-Teacher as a life companion**

In this classroom, teacher tries to apply physics and mathematics to students' everyday life situations. To this teacher, knowledge is what is practically useful. Teacher tries to introduce science as a human endeavor. The aim of teacher is to translate problems of everyday life situations to the abstract language of mathematics and solve them using the machinery developed in physics and mathematics, and then translate the solution back to the language of everyday life. This ability should be internalized in students, so that they use their scientific skills outside school. In such a class, the human history of evolution of concepts is under focus. Also, the process of discovery in problem solving

should be recorded carefully by students. Strategies of problem solving and skills of decision making in course of discovery are taught carefully in this classroom.

Students engage in groups in solving everyday life problems using physics and mathematics. Learning is a group activity, but each student has a particular interest and perspective in doing physics and mathematics. Every student helps his/her colleagues during the learning process and takes advantage of the helps offered by other colleagues.

Teacher must decide about different skills that students should learn and about different levels of sophistication in these skills. Teacher must decide about the skills which each of the students could learn better by having a classification of students' learning strategies.

### **2-6-Teacher as a scientist**

In this classroom, teacher unveils the mathematical order of the universe we live in. For this teacher, knowledge is based on ideas borrowed from nature. Teacher makes sure his/her students learn to observe nature, discover ideas from it and use them in development of physics and mathematics. History of science is under focus. Students should learn how ideas are borrowed from nature and have affected human civilization. Proposing reasonable conjectures based on scientific methodology is an important skill which students should learn. The aim of teacher is not only familiarizing students with applications of physics and mathematics to other branches of science, but also teaching them skills of discovering new applications to other areas of science. These applications do influence the practice of scientists in other areas.

Students in such a classroom search in groups for ideas in nature. They recognize mathematics as the language of nature and try to get a better understanding of nature through this language. Student also tries to apply what they learn to other branches of science.

Teacher must decide about how he/she can motivate students to become interested in nature and its order. Teacher must decide about the branches of science that a student is fascinated by, so that he/she could insert ideas in classroom material to teach the student how to apply what they learn in different branches of science.

### **2-7-Teacher as a philosopher**

In this classroom, physics and mathematics is an abstract knowledge independent of nature which is governed by the mathematical essence of the world of creation. Ideas could be borrowed not only from nature, but also from beyond. Teacher tries to discover the mathematical order with the aim of demonstrating his/her students unity in the essence of creation. Teacher tries to find similar ideas in different parts of physics and mathematics and use them to unveil the unity beyond these ideas. In such a class, the abstract sciences of physics and mathematics are formulated independent of nature. Mathematics has many abstract layers and teacher tries to connect these layers by

unifying different theories in each layer. This is a new perspective to learning in which each student learns in a particular layer of abstractness.

Student tries to structure the abstract mathematical nature of his/her mind and is interested in knowing the essence beyond the ideas. Relating different branches of physics and mathematics and performing computations and comparing them in different branches are tools which students use to extend the abstract structure of their mind. Learning and doing physics and mathematics is no longer possible in groups because of the high level of abstractness of this kind of mathematical activity. Student is learning for reasons beyond what he/she learns. So, again the particular content of knowledge does not play any important role in such a classroom.

In such a classroom, teacher must decide about the particular level of abstractness each student could handle. Teacher also must make sure if unification of a few different examples and creation of a more abstract generalization has occurred for a particular student. Teacher must have a personal knowledge of different layers of abstractness and be able to decide that each particular content belongs to which of these abstract layers. Teacher chooses a particular content which he/she is most familiar with its abstract layers.

### **3. Personality of teachers in decision making**

Many different decisions must be made by teachers and the examples we have already mentioned is by no means a complete list. Nor are the different models we introduced for a mathematics classroom. Therefore, we shall find a way in which mathematical modeling of the personality of teachers in decision making be independent of the decisions that they have to make. Otherwise, classification of their behavior in class would be a complicated task. To do this, we shall focus on the social aspects of learning. This will help us to understand the personality of the teacher independent of the meaning of learning in different classes.

### **4-The social aspects of learning**

Learning physics and mathematics and problem solving in classroom has a completely different nature from individual attempts in doing them. When working in groups, not only decision making in different stages of problem solving is influenced by group discussions, but also diversity of perspectives towards the solution of the problem smoothens the process of individual learning. Human forms of communication force the process of learning and its content, to be considered in more human perspectives. For example, mathematical arguments instead of being considered as abstract human independent truth, seem like a street address which is directing our mind to a particular place. Different addresses could lead to the same conclusions and at the end, the new places discovered are of main importance, not the nature of the addresses leading to that place. In better words, different minds could be satisfied with arguments of different natures. Students eventually develop different personalities in accepting arguments and the teacher will not be able to force them to think the same about the

truth of a proposition or claim. Teacher can only focus on skills of students in applying the knowledge they learn to different aspects of their life.

### **5-The Management of Group Learning**

Management of learning in a classroom is very similar to management of development of science in a scientific society. Different social aspects of science [4], could be regarded as different aspects of group learning in classroom, and the teacher must make decisions about each of these aspects for the good of his/her students' learning. Teacher's decision making is affected by many external factors. Here we mention a few of them:

The subject which is to be discussed could have numerical, geometric, algebraic or analytic nature. This could cause different decisions of teacher in his/her approach in teaching the subject matter.

Students' motivation in learning could be of many different levels of abstractness. Students with different motivations could not be treated the same and this affects the process of teacher's decision making.

Different learning strategies of students, and their mental process of thinking calls for different educational treatments and different styles of teaching. Efficient decision making of teachers could cause a more fruitful education for each of student's minds.

The goals and points of view of the educational system towards education of students force limitations in the teachers' personality in educating students. They must follow a predetermined path in developing students' scientific skills.

The particular shape and direction of historical movement of the educational system which is not personal, and is headed forward, reducing the value of previous systems, forces the teachers to keep themselves up to date in their teaching style and personality in decision making in classroom.

The particular mother tongue of students and the scientific language in which the subject matter is being discussed, affects teachers' decision making as a means of communication. The scientific language is usually internationalized but must be made compatible with the mother tongue of students. Students learning in second language have to get particular educational treatment which affects the teaching personality of educators.

The social hierarchy of the educated, for example engineers, affects the perspective of students towards science and directly affect the teaching personalities of teachers.

The social role of physics and mathematics in the society which is changed by time does affect the practical meaning of knowledge in classroom and in term could cause affections in teachers' decision making.

The actual sites of learning and practicing science like schools, universities, research institutes, government organizations, and their scientific structure defines a culture which affects the ways teachers decide in classroom.

The social human personality of a teacher also puts limitations on teachers' behavior in classroom, which in turn affects their educational decision making.

## **6-Development of knowledge in classroom**

Under all the above-mentioned limitations and governing rules, the process of teachers' decision making is aimed towards development of knowledge in classroom. To gain a better knowledge of the social structure of students' scientific progress, the essential factors of development of science in society could be modeled in a classroom. The history of development of science contains detailed information about the social structure of scientific progress [1]. Here we list a few important factors which teachers could regard as the subject of decision making in mathematics classroom.

### **6-1-Distinction of social and mental roles of students**

Teachers shall try to distinguish the role of each student in group learning. Also, the mental habits and learning schemes and cognitive structures of all students shall be made clear to them. The philosophical and scientific aspects of the mathematical subject matter shall also be separated. Each of these distinctions, supports the development of knowledge in classroom.

### **6-2-Structural values**

Many of the modern values in classroom play an efficient role in progress of group learning. Valuing rationalism against traditionalism, liberationism against authoritarianism, getting actively involved against inactive indifference, equity against injustice, supports development of different components of knowledge in classroom.

### **6-3-Instrumental needs**

Many students have instrumental perspectives towards learning and gaining knowledge. The environment around them, and opportunities available to them makes them have opportunistic motivations for learning. Teacher can use these instrumental motivations to guide the process of group learning in classroom.

### **6-4-Economical factors**

One may think that economical motivations for development of science contradicts the innocence and purity of science. But modern history of science has shown that if a modest budget be available to the teachers, they can use it for the well-being of the



education of their students. Making right decisions about economic issues could help the process of learning.

### **6-5-Political structures and needs**

Financial matters and issues of school politics usually have the tendency to combine in affecting the education of students. School has political needs and would be happy to get support from its students in this direction. Matters of politics could be directed by teacher to motivate improvement knowledge in classroom.

### **6-6-Religion**

In every society, values and religion have a very close relationship. A religion that its values support the progress of science could be used in guiding the classroom. It should be pointed out that religion and science have a complicated relationship which could be contradictory in many societies. Using religion as a motivation is a complicated and delicate art that only few teachers are capable of.

### **7-The social structure of classroom**

If development of group thinking in classroom is emphasized in an educational system, and particular social structures could be engineered in classroom to support development of mathematical knowledge, teacher can guide students' education by making correct decisions in engineering the working groups and the ways in which they scientifically communicate.

### **8-Mathematical modeling of social decision making**

All the above factors are ways in which a teacher can motivate a social behavior. What the teacher has to decide about is if an action will have the effect which he/she expects, and if his/her decisions will find social ground. The easiest way is trial and error and gaining experience about the social behavior of students in a society. But this is not an efficient way, since in this period, social structures are under constant reconstruction and development. Experiences that a teacher gains soon will be useless because of social evolutions. So, every teacher has a mental model which he/she uses for prediction of social behavior of students. If we could approximate teachers' mental models with mathematical models, such mathematical models not only could replace the experience of teachers, but also would give information about decision making of teachers for different generations. One could predict the social behavior of students via these mathematical models and make decisions according to one's predictions.

Teachers have different mental models, because they have different philosophies for a social phenomenon taking shape. It is these different philosophies which shall be the subject of our field study. Here we list a few perspectives which is by no means a complete list:

### **8-1-Philosophy of influential individuals**

Many teachers believe that classroom is socially following a few influential individuals. These individuals could be the teacher or a few students. According to this philosophy, a group behavior in classroom is accepted by students, only if a few influential individuals follow it. Teachers who believe this philosophy, try to be influential in classroom, or at least influence the social leaders of students who are among them. Sometimes, they try to choose individuals and make them role models, so that in time they become influential.

Mathematical modeling of this system is very easy. It is enough to record the actions of students and discover which of the students show influential social roles in classroom.

### **8-2-Philosophy of majority**

This philosophy suggests that classroom follows the majority. If most of the students are prepared to accept a social behavior in classroom, the minority will follow them. To predict the social behavior in such a classroom, teacher has to be familiar with many of the students so that he/she could predict individual reactions of students to the social behavior.

For mathematical modelling of this system, one can decide if the majority accepts a social change, by asking students to fill a questionnaire which shows students' particular opinions in this regard.

### **8-3-Philosophy of coherence of social structures**

According to this philosophy, the classroom follows the dominant global social structures outside the classroom. Teachers following this philosophy, try to model the social behavior they want to suggest to the classroom, inside the global society, and try to verify if it will find social ground or not.

Mathematical modeling of this kind of decision making is going to be very difficult. Because a natural dictionary between the social phenomena in classroom and social equivalents in the outside society does not exist. One shall make the task of decision making very abstract to be able to find an equivalent form of it in the outside society.

### **8-4-Philosophy of social evolution in time**

Some teachers believe that if one is supposed to guide the students towards predetermined goals, very rarely the classroom is naturally prepared to move in the direction suggested by the teacher. In fact, a social change should occur so that the teacher be able to guide the classroom to new social order. But social change is a continuous slow process which takes time and constant supervision. In this philosophy, decision making is a long term process.

Mathematical modeling of this system of decision making is possible if the teacher can list a few behavioral goals for the changes he/she suggests. Then constant recording of instances that these behaviors are shown in classroom, can give us information on the extent to which the classroom has had progress in achieving the behavioral goals.

### **8-5-Philosophy of social character**

Following this philosophy is an abstract practice. Some teachers believe that one can regard the classroom as a whole and define a character for the classroom as one defines a character for an individual. In fact, one is modeling the society by an individual. Teacher in the process of making decisions, considers the abstract individual in his/her mind and tries to predict this individual's reaction towards the social suggestions. Then he/she translates back this behavior to the social language of classroom.

This intuitive abstract process is very hard to be modeled by a mathematical system. Because it is not at all mathematically clear in which ways a society is similar to an individual. Also, it is not possible to predict individual's behavior by a mathematical model.

### **9-Suggestions for curriculum planning**

As one can see from the above different personalities of teachers, there is no way that a curriculum could plan for a single model of mathematics teacher. But what can be done, is to implement a social structure in classroom for which every teacher could easily communicate socially with this structure and guide the process of development of knowledge in classroom.

On the other hand, the implemented social structure in classroom should not cause limitations on the social character of classroom. Because such un-natural limitations make the structure unacceptable to students.

We suggest that the curriculum should insist on coherence of the social structure of the classroom, in a way that the social system could be approximated by the character of an individual as close as possible. This approach seems natural, because character of an individual is in its own right, a superposition of internal personalities which communicate inside the individual's personality.

Curriculum planning and educational system can support the coherence of the social structure of the classroom by insisting on the growth and complicity of the social structure of the classroom. More precisely, the more the social structure of the classroom becomes advanced and mature, the more coherence between the subsystems of the classroom is implemented.

The easy way is to try to model the whole social structure of the global society inside the classroom. But this way, educational system loses ground in influencing the global social structure, which is one of the main roles that a pioneer educational system should play in the society. The correlation of educational systems and the social

scientific structure is studied in an earlier paper [3]. We have tried to give a mathematical model for an educational system and for scientific research and study their correlation using these mathematical models.

### **References:**

- [1] Barber B.: "The sociology of science", International Encyclopedia of the Social Sciences, 1968, vol 13-14, pp 92-100.
- [2] Rastegar A.: "Psychology of communication in mathematics", preprint 2000.
- [3] Rastegar A.: "Engineering the correlation of educational systems and scientific research", preprint 2000.
- [4] Tavakkol M.: "Sociology of knowledge"-theoretical problems, Sterling 1987.