

INTERACTIVE TEACHING METHOD OF SOLID – STATE PHYSICS IN LYCEUMS

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Abstract. This paper deals with the new teaching method of solid – state physics in lyceums of Azerbaijan. Absence of definite physics curriculum in lyceums will enable to propose unique model based on curriculum standards for this topic. Analyzing important driving factor of lyceum student's possessing impressive basic knowledge potential one can conclude to teach them topic of solid - state physics more interactively, and it requires from teacher a great effort and purposefulness to organize that lesson perfectly. In this paper, it is presented example of new teaching method for basic properties of solid - state physics is presented.

Keywords: *lyceum, solid – state physics, solid object, interactive method, curriculum.*

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This paper examines the significance of interactive method in the rise of effectiveness of understanding of the main solid matter' properties in lyceums. Before proceeding to examine teaching method of this topic, it will be necessary to mention several essential events regarding Azerbaijan Education System. So the "Education Reform Program of Azerbaijan Republic" was approved on the 15th of June in 1999 in Azerbaijan. This reform program is implemented on the basis of the first Loan Agreement between Azerbaijan and the World Bank's International Development Association. As a continuation of it, National Curriculum - Education Concept was accepted in 2006 in our Republic. Then in 2010 "State Standards and Curricula of the General Education Level" have been approved. Thus, these reforms make an important contribution to the field of education and by the implementation of these reforms a new era in Azerbaijan's Education System is established. Furthermore, subject curricula for all subjects have been created. These curricula provided an important opportunity to advance the understanding of subject teaching technology. Physics curriculum being as a part of a national curriculum has been approved in 2013. Physics subject according to physics curriculum is educated on three content lines:

1. Physical phenomena, laws and regularities;
2. Matter and field, interplay impact, related systems;
3. Experimental physics and modern life.

Furthermore, physics curriculum comprises the following contents:

1. Learning Outcomes for grades
2. Content lines of the subject
3. Learning outcomes on content lines
4. Action lines
5. Content standards for grades

6. Intra-and interdisciplinary integration

As a result of these reforms, specific features such as form and structure of the physics teaching were identified. Moreover this led to the hours number decrease of some topics in physics, as well as even some topics have been removed from the program.

It has commonly been assumed that the lyceums have their indispensable place in educational institutions in Azerbaijan. As it has mentioned in Education Law of Azerbaijan Republic: lyceums is educational institution providing educational services for talented students in secondary education. Lyceum's administrative staff in order to "discover" capable students with bright knowledge potential organizes a certain superior selection exam or competition. These students possess basic scientific potential, practical skills and creative abilities. One of the most topical issues in physics teaching in lyceum includes providing lyceum student with the most modern learning technologies.

However, the absence of a single system of physics education in lyceums has had a negative effect on teaching process of some of the topics in physics course. Thus, in many lyceums, students are given knowledge based only facts. However, taking into account of the lyceum students' scientific potential, it should be acceptable to teach them physics subject through systematic knowledge comprising logical, critical, and creative thinking.

In term of effectively understanding by students, one of the most difficult and unclear topic of physics is solid – state physics. Topic of solid – state physics investigation is one of the fundamental themes of physics and has become a target of researchers in the world. As an example of a solid object teacher may interpret crystal consisting of only one type of atoms. However in the center of the large number of investigation stands compound containing at less two types of atoms. Analyzing properties (Seyidov *et al.*, 2008, 2009, 2011, 2017) of that type solid object such as ferroelectric - semiconductor indicates dualism feature of these crystals. So that crystal under 120K acts likes ferroelectric, however above that temperature act like semiconductor. This phenomena leads to observation of thermal memory effect on it. Due to improvement of student's entirely understanding about crystalloid structure, the student should be spoken about the crystal of that type. As regards semiconductor physics education, particularly, introduction method of it in secondary education has been shown by Garcia – Carmonia (2009). But Ryan (1990), studied college students' understanding concepts of states of matter. As a data it was taken first-year college American Physics and Chemistry students. He has shown even among college students are not able to realize definite structure solid and behavior of it atoms during phase transition. Furthermore the relationship between physics teaching and computer technology has been widely investigated by Griffiths and Preston (1992) and they explored misconception regarding molecules and atoms with Canadian students. A great deal of article dedicated to teach physics subject through computer technology. Thus, in articles (Trick *et al.*, 1994; Stoney *et al.*, 1999; Galib, 2018) authors pointed out using computer programme such as simulation and also computer 3D modeling to illustrate physics process completely in the mind of students. Unique approach of modeling phase transition like the liquid to solid has been implemented by Jorge Fonseca e Trindade (2005). Using 3D modeling he explained phase change in terms of moving of water molecules. He noticed that teaching topic of states of matter together with computer modeling will play important role in understanding of this topic in student mind.

Therefore it is desirable for lyceum students, particularly for X grade student to obtain basic knowledge and practical issue of some immense properties of solid objects. In other words, their possessing such a number of information may challenge them to believe themselves to may be as a excellent researcher

According to the curriculum, scientific data on solid bodies express in the following sequence in the classroom:

- Aggregate states of the substance and their distinctive features in VI grade;
- Heat expansion, special heat capacity, melting, crystallization processes in solids, electrical conductivity of solid objects in VIII grade;
- Electrical conductivity in metals and semiconductors, its classical electron theory, magnetic properties of solid objects and its radioactive properties in IX grade;
- In grade X, information about the thermodynamic laws and some properties of solid objects;
- In grade XI electric and magnetic properties of solid objects are given.

As discussed above, to the study of aggregate states changing, anisotropic, isotropic, crystalline cell of solid bodies were displayed in the X grade within the theme "Solid objects and its some properties". It has been allocated only one academic hour for this topic. Effective teaching of all these solid objects properties in one hour i.e. 45 minutes requires certain, perfect pedagogical skill from a physics teacher. On the other hand, because of the fact that most of the lyceums pass through the textbooks intended for general schools, lyceum students encounters some hardships to comprehensively understand this topic. As an example of the teaching method of solid - state physics it would appropriate to display structure "Solid objects and its some properties" interactively in X grade in lyceum. The aim of this example is to clarify several aspects of teaching method of solid matter and in lyceums we propose a unique teaching method of this topic.

Taking into consideration one essential fact that it is impossible to teach properties of the solid structures such as crystalline, amorphous, melting, solidification, sublimation, desublimation, anisotropy, isotropic properties during a lesson lasting 45 minutes and accepting lyceum student being more logical it will be useful for physics teacher to follow strictly each stage of a lesson and organize this lesson only in the basis of the most up-to-date method of interactive teaching topics.

As noted, the main properties of solid objects are taught in X grade so one can apply curriculum standard to lyceum, but in terms of content of topic student should obtain more widely understanding for each concepts of this topic. According curriculum being adopted in Azerbaijan sub-standards and the learning outcomes of this topic are shown in Table 1.

The modern interactive lesson is divided into the following stages:

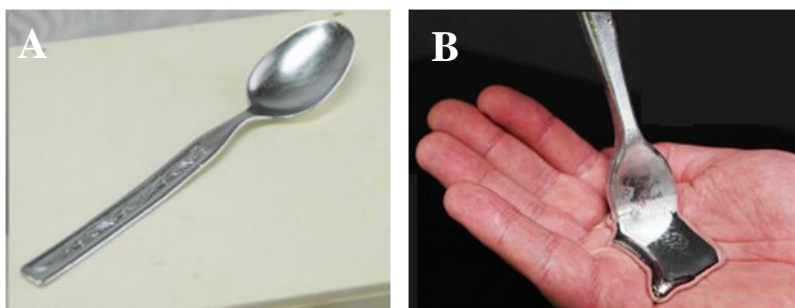
- Motivation
- Conducting investigation
- Information exchange
- Discussion of information
- Creative apply
- Assessment and reflection
- Homework

Motivation (5 min)

Table 1. Sub-standards and its learning outcomes of topic titled “Solid objects and its some properties” in X grade in Azerbaijan Curriculum

Sub-standards	2.1.1 Interprets interplay transformation of substances 2.1.2 Constructs and solve different type of exercises about interplay transformation of substances 2.1.3 Interprets properties of substances due to inner structure 2.1.4 Constructs and solve different type of exercises regarding inner structure of substances
Learning outcomes	<ul style="list-style-type: none"> • Distinguishes solid object from other states of aggregation due to its structure and property • Interprets properties of crystalline and amorphous solids • Classifies chemical bonds playing important role in the formation of properties of solid object • Constructs and solve different type of exercises about properties of solid object

This stage is considered as the main stage of the lesson, and the main objective of this stage is to activate the interest of students in the lesson. Numerous studies have attempted to outline main advantages of motivation in physics lesson (Fischer *et al.*, 1997; Holubova, 2014). In view of all that has been mentioned, in lyceum in this stage it is proposed to show a picture (Figure 1) on the board:



It is shown a spoon made by gallium on a table and in hand. As you see from the picture that spoon melts in hand. What reason cause that spoon's melting in hand ?

Figure 1. Spoon made by gallium on the table (A), in hand (B)

The students strive to answer this question. In other words, question for motivation must form significance interest on a new topic in physics lesson. However the student should not be informed the answer of this question at this stage of the lesson. In the end of lesson, answering motivation question teacher enlightens additionally the peculiarity of the compound with Ga element. Furthermore, he can estimate that the compound with Ga element such as crystals $TlGaSe_2$, $TlGaS_2$, $TlInS_2$, play important role in scientific investigation in the world. The main goal of teacher's comment would be to originate student's research ambition.

Conducting investigation (10 min)

Students are divided into 4 groups for the purpose of research and nominate each group by the names being related to a new topic: anisotropic, isotropic, amorphous and crystalline. Generally some authors have mainly been interested in questions concerning

corporative work (Milicevic *et al.*, 2016). The main advantage of providing groups with names is to concentrate their attention on the depth of the topic. At this stage, the students are given one main research question and four its sub-questions.

The main research question may be so: What properties of the crystal differentiate each other?

These are the questions that may be given to groups.

Anisotropic group: When the temperature of solid matter reduces, collision of moving electrons with the atoms inside the crystal are reduced by the barriers. How does the electrons move in the crystal if the temperature is necessarily reduced to 0 K? Justify your answer.

This question will present them a key fact regarding crystalloid structure and motion of electrons inside it. In other words, the main aim is to establish for them environment for their thinking about superconductivity.

Isotropic group: The figure 2A shows the arrangement of metal sphere. Connect the center of their gravity. How many minimal number of sphere do we need in order to multiply by duplicating them along x and y arrows? Justify your answer.

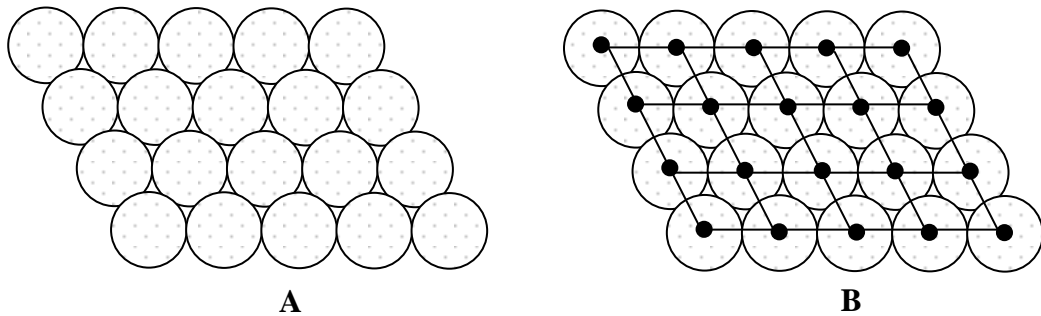


Figure 2. Two group of metallic spheres: (A) is given to group named Isotropic, (B) should be drawn by the group as an answer

This kind of question is primarily to examine whether the students know a center of gravity or not, as well as to enable them to find a unit cell from the lattice. By illustrating unit cell, students imagine crystalloid structure of the solid objects. In other words, these questions for group may play main role in an integration that is accepted as a requirement in modern physics lesson

Amorphous group: There are two group of metal sphere in the picture. Which group of sphere shows regular arrangement? Justify your answer.

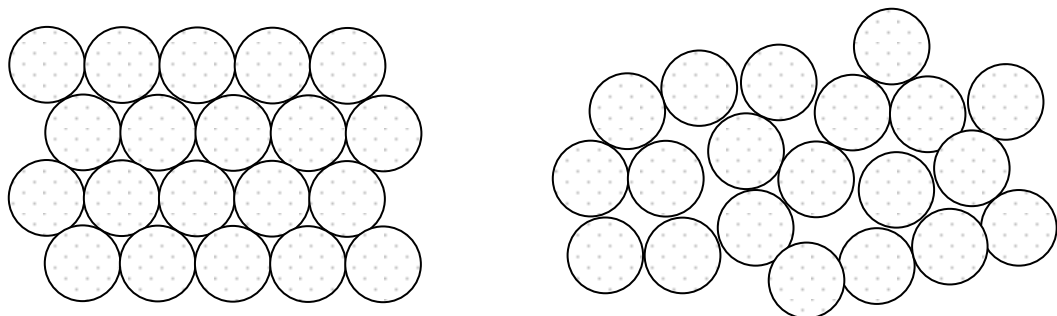


Figure 3. Two group of metal spheres are given to group named Amorphous

The students will enable to student to see and compare a regular and irregular structure in arrangement of sphere, and they will clearly see the difference between them. Overall the students will create a atomic model of crystal in their thinking and this interpretation will help teacher to explain lesson in more detail and improve lyceum student's logical, critical and creative thinking.

Crystal group: As you see from the picture you are given time dependence of temperature of objects. In which part of straight line graph temperature becomes constant? What is the distinction between straight and dotted lines? Justify your answer.

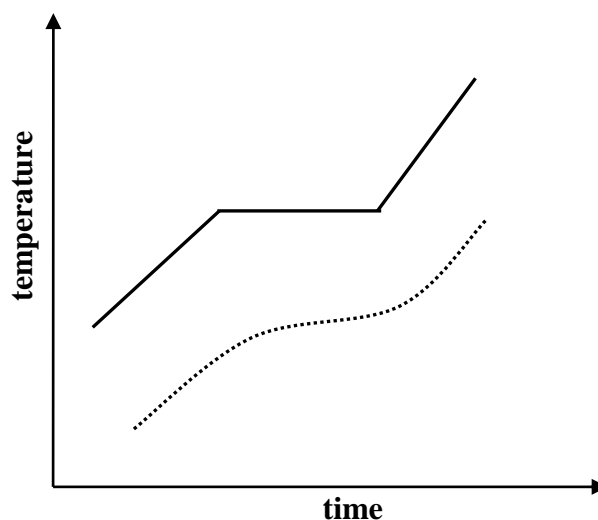


Figure 4. Time dependency of temperature of two objects

As shown in Figure 4, there was a significant difference between the two graphs. Furthermore the term "melting point" is not used for students at this stage of the lesson. At the next stage the teacher mentions the idea that object with dotted line have not a precise melting temperature for the students who are in this group.

It would be essential to note that inside the explore questions given to the group should not be comprised the name of new concepts relating to the new topic. The main task of a teacher is to help the students to discover these concepts themselves.

Information exchange (8 min)

At this stage, teachers take their work sheets from groups. Afterwards he listens to presentation of group leaders or group members, and encourages other groups to exchange information. According to the pedagogical aspects teacher would pay more attention not to criticize the group's leader or group members. On the contrary, student may be discouraged and their aiming to achieve goodness in their group work would be collapsed. In other words, the group would not fully comprehend that group work will lead them unsatisfactory works. Thus, it can cause great psychological distress or an unhealthy psychological impact on the students.

Discussion of information (8 min)

At this stage, the teacher explains new topic on the basis of the students' presentations. Furthermore teacher starts to name the concepts that student discovered during the research. To put it differently: the main goal of teacher is assemble new ideas from the student and on the basis their ideas he can nominate their "findings" i.e. students conclude that they themselves find concepts of new topic. For example, the

result of the anisotropic and isotropic group's explorations corresponds to finding unit cell, the irregularity of the amorphous crystals in the amorphous group, and the lack of clear melting temperature in amorphous crystals for the crystal group.

Creative apply (8 min)

This stage is considered one of the key stages. So here, students apply their knowledge gained during the lesson. Here, the teacher intend to “construct a bridge” between the new concepts of the lesson and the life. For example, he states various types of precious stones in nature and may show peculiarities in their properties as well as the reasons of their expensiveness in nature Moreover the teacher can also use crossword and mind map. Regards exercise, it is preferred to physics teacher to use a great deal of situative exercises at this stage.

Assessment and reflection (4 min)

As a reflection, teacher may ask students 2 or 4 questions about new concepts of the topic in order to strengthen the new knowledge in their mind. At this stage students are also assessed as group. Assessment is conducted on the basis of the learning outcomes and four assessment criteria that can be seen in the Table 2. Teacher should try to use symbol of stars instead of numbers in rubric assessment.

Table 2. The learning outcomes and four assessment criteria for the topic titled “Solid objects and its some properties” for X grade in the Azerbaijan Assessment System.

I level	II level	III level	IV level
Distinguishes solid object from other states of aggregation due to its structure and property by the means of teacher	Distinguishes solid object from other states of aggregation due to its structure and property making a few mistakes	Distinguishes solid object from other states of aggregation due to its structure and property largely correctly	Distinguishes solid object from other states of aggregation due to its structure and property correctly
Unable to interpret freely properties of crystalline and amorphous solids	Interpret hardly properties of crystalline and amorphous solids	Interpret properties of crystalline and amorphous solids largely correctly	Interpret properties of crystalline and amorphous solids correctly
Unable to classify chemical bonds playing important role in the formation of properties of solid object	Classify chemical bonds playing important role in the formation of properties of solid object by the means of teacher	Classify chemical bonds playing important role in the formation of properties of solid object largely correctly	Classify chemical bonds playing important role in the formation of properties of solid object correctly
Constructs different type of exercises about properties of solid object by the means of teacher and unable to solves them	Constructs different type of exercises about properties of solid object making a few mistakes and solves them hardly	Constructs different type of exercises about properties of solid object basically and solves them largely correctly	Constructs different type of exercises about properties of solid object perfectly and solves them correctly

Homework (2 min)

It is known that the homework assignment in the world is not approached identically. A number of researcher (Cooper *et al.*, 2006; De Jong *et al.*, 2000) have reported an unimportance of homework assignment. According to curriculum in Azerbaijan homework assignment should be creative. The homework for above-mentioned topic may be give as follow: Gather information about the glass and figure out its properties to define whether it is an amorphous or crystalline object and write essay on this issue. Thereby, on the one hand, in the student’s mind will form ideas

about the role of amorphous and crystalloid objects as well as their negative and positive aspects in life. On the other hand, the essay will improve the writing skills of students

In conclusion, it would be expedient to note that in term of psychological and physiological aspects all the senses of younger generation such as lyceum X grade students are in active phase, it is important for them to be taught a more accurate, comprehensive, effective teaching for the most difficult topic such as solid matter and its basic properties.

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