THE SCIENTIFIC, ENGINEERING METHODS AND THEIR INTEGRATION AS PART OF STEM EDUCATION. THE PRACTICAL GUIDE

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The article discusses the application of the scientific and engineering method in the context of the STEM approach in education. The methodical and theoretical comparison of these two methods are given, algorithm of application of scientific and engineering approach at work of students over the decision of tasks of scientific project is given. It is also noted that an important part of any research is the analysis of literary sources that can be carried out using ontologies. An important issue is the correct understanding of the STEM approach in teacher training. After all, the topic of the lesson does not determine the STEM approach, but the methods, methodological techniques used during this lesson. There described the detailed description of scientific and engineering methods to clarify its understanding. The coprarsiong of these approaches is shown. The modern challenges for the implementations of STEM/STEAM-approaches in education are described. In addition, it is noted that STEM-education aims to increase the motivation of the students, to provide an implementation in the education of the new results of science and engineering, to provide research and engineering way of thinking to further specialists, to increase

the cooperation skills and soft-skills in further life.

The article argues that robotics as a fact is not a STEM approach; it can only be part of this technology. The practical examples of the STEM-lessons based on the engineering and scientific methods are developed and presented. The authors provide detailed technological cards for conducting STEM - classes on the topic "Making yogurt" and "Mechanism of muscle contraction. Pneummuscle.

Key words: STEM, STEAM, Scientific method, Engineering method, classes.

Introduction

Improving the quality of education is one of the main goals of sustainable development declared by strategy Europe 2020 and by aims declared by program Education 2030 [Europe 2020: 9, Education 2030]. One of the ways to do it is providing modern approaches in education. STEM is one of the most popular modern approaches in education which based on an integration of Science, Technology, Engineering, and Mathematics [Does the EU need more STEM graduates]. However, it is still a problem of existing practical methods to implement it. STEM-education is used in developed countries such as Australia, China, the United Kingdom, Israel, Korea, USA, Singapore, France, Japan [Kovalenko, 2016].

In order for STEM-education to have the maximum effect it is necessary for the teachers to understand this concept correctly. There are a lot of methods and approaches to its implementation that just involves the process of 3-D modeling. However, they are not really characterized by all aspects of STEM-education, because to achieve it approaches must be characterized by methodology and didactic which provide. However, we clearly sure that, nowadays, STEM-education may be interpreted not the ways as it can give the best results. There are a lot of methods and approaches to its implementation that just involves the process of 3-D modelling and robotics. However, they are not really characterized by all aspects of STEM-education, because to achieve it approaches must be characterized by methodology and didactic which provide an absolutely new higher level of student's awareness. It means that not the topic of the lesson indicates the approach of education but the sum of methods involved to create it and its didactic which provide the multidisciplinary, creativity, mind freedom to solve the problem and possibility to use modern real-life approaches of the science and engineering.

This work is devoted to determining the research and engineering approach as methods to implement STEM/STEAM-education.

Previously, we were proposing to use a research method to implement STEM-education. In addition, it is declared a new educational direction "Specialized scientific education" in Ukrainian law. It means in-depth preparation of STEM-subjects, studying scientific methodology and engineering to increase the quantity and quality of scientists, engineers, and innovators [Ukrainian education Law].

STEM/STEAM-approaches and its modern challenges for education

We sure, that STEM/STEAM-education is devoted to achieving next aims:

1. Increase the motivation of the students.
2. To provide an implementation in the education of the new results of science and engineering.
3. To provide research and engineering way of thinking to further specialists due to the possibility of its implementation in differed labour market fields.
4. To increase the cooperation skills and soft-skills in further life.

The situation to solve is observed due to the increase of the specialties where it is necessarily making decision in the intellectual problems such as: to create the constructing or to create the program, to increase the attractiveness of the technologies - where classical approaches can't be used. However, to solve creative tasks the research and engineering approaches are used.

Another important factor is decreasing of the student's motivation due to increasing of the digital informational sources where students can get more information than a teacher can give to them. This factor means that students can discuss some aspects of the subject of education and if it is necessary can find the information by themselves,

Thus, it is one of the most challenges of education to transform old "Teacher-know-all" system to coaching system in education. Coaching system of education foresees that teacher doesn't know everything but he knows where to find it and how to study informational systems using to find the information. The coach can simulate quest (task; the science of engineering challenge) for students where they must solve this problem using the creativity, knowledge, experience, and skills. It can be simulated using scientific or engineering methods.

In addition, there was proposed to use the modulation of the scientific researches in educational process to increase quantity and quality of the further scientists [Michael, 2002]. In addition, STEM-approaches are included to school curriculum and it foresees the using of digital technologies [Budnyk, 2018].

Sure, STEM-education is not just the scientific or engineering methods. However, we determine the absence of them is the most important problem to implement the STEM-education in Ukraine.

The research and engineering approaches

Scientific and engineering methods are the basis of any research process, regardless of the field of knowledge. Both methods have been worked out for a considerable time and are now recognized by the international scientific community as the main means for carrying out scientific and educational research activities. The context content of the scientific method can be schematically presented. Scientific method of research presented in the form of the algorithm in Figure 1 and table 1. [Scientific Method].

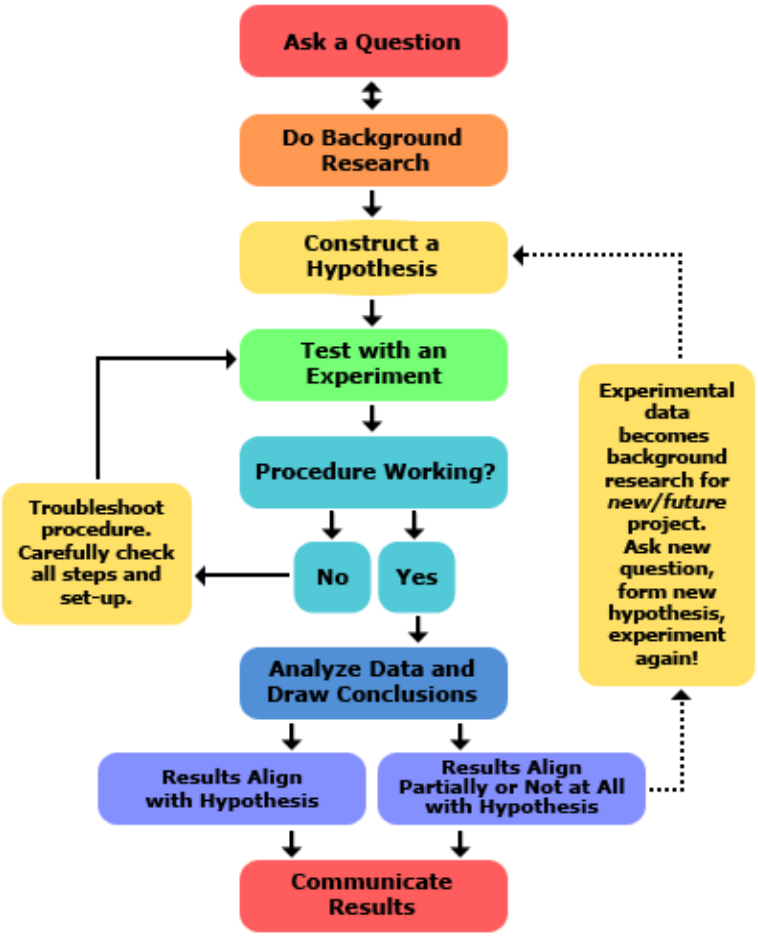


Fig. 1. *Scientific method of research presented in the form of the algorithm [Scientific Method]*

Table 1. *Scientific method's steps [Scientific Method]*

Ask a Question: The scientific method starts when you ask a question about something that you observe: How, What, When, Who, Which, Why, or Where? For a science fair project, some teachers require that the question be something you can measure, preferably with a number.	Your Question
Do Background Research: Rather than starting from scratch in putting together a plan for answering your question, you want to be a savvy scientist using library and Internet research to help you find the best way to do things and ensure that you don't repeat mistakes from the past.	Background Research Plan Finding Information Bibliography Research Paper

Construct a Hypothesis: A hypothesis is an educated guess about how things work. It is an attempt to answer your question with an explanation that can be tested. A good hypothesis allows you to then make a prediction: "If _____[I do this] _____, then _____[this]_____ will happen." State both your hypothesis and the resulting prediction you will be testing. Predictions must be easy to measure.	Variables for Beginners Hypothesis
Test Your Hypothesis by Doing an Experiment: Your experiment tests whether your prediction is accurate and thus your hypothesis is supported or not. It is important for your experiment to be a fair test. You conduct a fair test by making sure that you change only one factor at a time while keeping all other conditions the same. You should also repeat your experiments several times to make sure that the first results weren't just an accident.	Experimental Procedure Materials List Conducting an Experiment
Analyze Your Data and Draw a Conclusion: Once your experiment is complete, you collect your measurements and analyze them to see if they support your hypothesis or not. Scientists often find that their predictions were not accurate and their hypothesis was not supported, and in such cases, they will communicate the results of their experiment and then go back and construct a new hypothesis and prediction based on the information they learned during their experiment. This starts much of the process of the scientific method over again. Even if they find that their hypothesis was supported, they may want to test it again in a new way.	Data Analysis & Graphs Conclusions
Communicate Your Results: To complete your science fair project you will communicate your results to others in a final report and/or a display board. Professional scientists do almost exactly the same thing by publishing their final report in a scientific journal or by presenting their results on a poster or during a talk at a scientific meeting. In a science fair, judges are interested in your findings regardless of whether or not they support your original hypothesis.	Final Report Abstract Display Board Science Fair Judging

However, it cannot be used for all tasks. Sometimes in real-life quests, it is necessary to use well-known approaches. In these cases, solving this problem will go by engineering scenario.

One of the important stages of conducting scientific work is conducting a preliminary study (literary review). The literary review represents the current known information in a particular industry and indicates the information that needs to be explored [Baker, 2000]. The research process requires a literary review that shows the structure of the known information. Information of interest to the researcher can be presented in various forms, for example, even in the form of extracts from military protocols, however, as a rule, these are scientific literary sources. A literary review intended for industrial purposes requires the adoption of well-founded decisions,

and therefore should include a comprehensive, comprehensive review of all possible documents [Boote, 2005].

Hart in the study noted the importance of any literature review to further disseminate the knowledge gained to the new audience [Hart, 2003]. Garrard defines a review of literature as "the analysis of scientific materials on a specific topic, which requires the researcher to carefully study each source to assess the purpose of the study, determining the expediency and quality of scientific methods, the analysis of questions and answers raised by the authors, the synthesis of the results of various studies, development of objective synthesis of the results of various studies" [Gerrad, 2014].

In addition to this, there is an Engineering Design Process. It devoted to study pupils to use their creativity and to provide creation of the mechanisms (or technics) which will be most fitting to solve some tasks. Its steps are presented in Figure 2 and table 2 [Engineering Design Process].

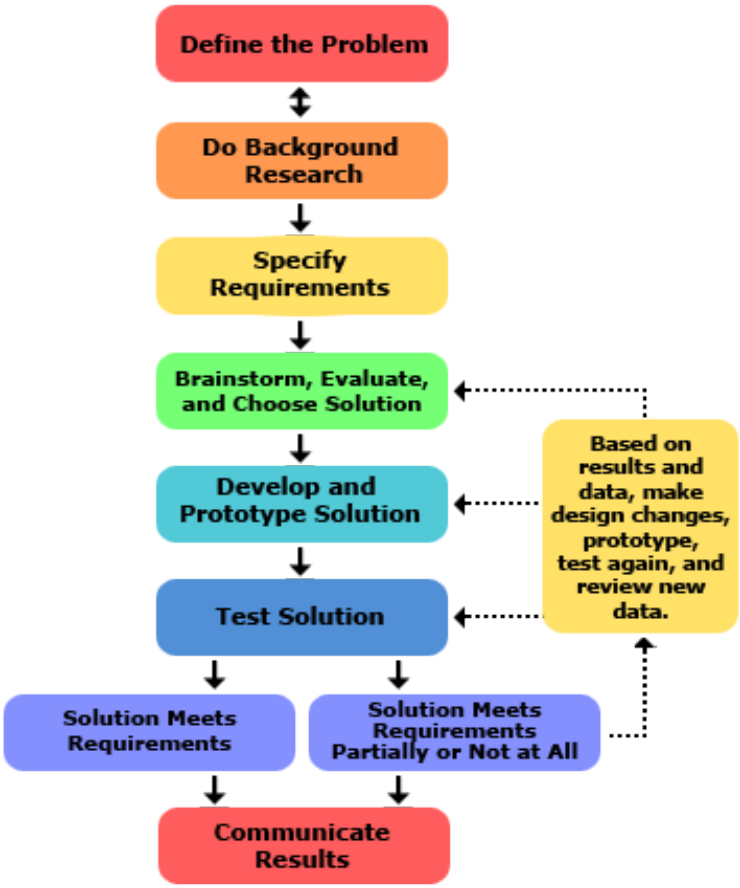


Fig. 2. *Steps of the Engineering Design Process [Engineering Design Process].*

Table 2. *Description of the steps of the Engineering Design Process [Engineering Design Process].*

Define the Problem. The engineering design process starts when you ask the following questions about problems that you observe: What is the problem or need? Who has the problem or need? Why is it important to solve? [Who] need(s) [what] because [why].	Define the Problem Design Notebook Mind Mapping Engineering Project Proposal Form
Do Background Research: Learn from the experiences of others — this can help you find out about existing solutions to similar problems, and avoid mistakes that were made in the past. So, for an engineering design project, do background research in two major areas: Users or customers Existing solutions	Background Research Plan for an Engineering Design Project Finding Information Bibliography Research Paper Background Research Plan Worksheet
Specify Requirements: Design requirements state the important characteristics that your solution must meet to succeed. One of the best ways to identify the design requirements for your solution is to analyze the concrete example of a similar, existing product, noting each of its key features.	Specify Requirements Design Brief Worksheet Design Requirement Examples How to Analyze a Physical Product How to Analyze a Software Product or Website How to Analyze an Environment How to Analyze an Experience How Many Design Requirements?
Brainstorm Solutions: There are always many good possibilities for solving design problems. If you focus on just one before looking at the alternatives, it is almost certain that you are overlooking a better solution. Good designers try to generate as many possible solutions as they can.	Brainstorm Multiple Solutions
Choose the Best Solution: Look at whether each possible solution meets your design requirements. Some solutions probably meet more requirements than others. Reject solutions that do not meet the requirements.	Choose the Best Solution Decision Matrix Worksheet
Develop the Solution: Development involves the refinement and improvement of a solution, and it continues throughout the design process, often even after a product ships to customers.	Development Work Drawing Storyboards

Build a Prototype: A prototype is an operating version of a solution. Often it is made with different materials than the final version, and generally it is not as polished. Prototypes are a key step in the development of a final solution, allowing the designer to test how the solution will work.	Prototyping
Test and Redesign: The design process involves multiple iterations and redesigns of your final solution. You will likely test your solution, find new problems, make changes, and test new solutions before settling on a final design.	Test and Redesign
Communicate Results: To complete your project, communicate your results to others in a final report and/or a display board. Professional engineers always do the same, thoroughly documenting their solutions so that they can be manufactured and supported.	Final Report Abstract Display Board Science Fair Judging

Clearly that those methods differ. Comparing of them is presented on the table 3.

Table 3. *Comparing of Engineering and Scientific processes [Engineering Design Process; Scientific Method]*

Integral step number	**Scientific method**	**Engineering**
1	State your question	Define the problem
2	Do background research	Do background research
3	Formulate your hypothesis, identify variables	Specify requirements
4	Design experiment, establish the procedure	Create alternative solutions, choose the best one and develop it
5	Test your hypothesis by doing an experiment	Build a prototype
6	Analyse your results and draw conclusions	Test and redesign as necessary
7	Communicate results	Communicate results

Sure, real-life tasks simulating and using of the scientific or research methods will increase the motivation of the students to study. In addition, it possible to add some elements of virtual or augment reality as part of those processes to increase the motivation of students even more [Shapovalov, 2018b: 73].

Implementation of engineering and scientific methods in education to provide STEM-education

To summarise the difference between "real" STEM-training lesson based on research or engineering approaches and emulation of it, a comparing of the examples was provided. To be sure that the independence of the possibility of introducing STEM education from the topic, we will analyse the best practices on the topic which do not related to robotics and 3-d modelling, namely yogurt production.

The comparison of lessons steps is presented on the table 4.

Table 4. *The comparison of lessons steps of STEM-leasson (The yogurt production) and not-STEM-leasson (Typical robotics work)*

Step of the engineering approach	**Step of the work**	**The yogurt production**	**Typical robotics work**
Ask a question	Step 1	The familiarization with topic	To achieve concrete task to create the algorithm
	Step 2	Yogurt production	-
	Step 3	Describing and understanding of the process	-
	Step 4	Asking the questions about the process	-
Do background research	Step 5	Understanding of the basics of microbiology, biochemistry of the process	-
	Step 6	Understanding well-known technologies	-
	Step 7	Understanding of the modern scientific and engineering approaches in the field	-
Specify requirements	Step 8	Achieve the task of the coach to create the technology with requirements ***(or without it, depends of available time)***	-

Brainstorm Multiple Solutions	Step 9	To discuss the solutions of the task and choose the way of it solving	-
Developed the prototype and solution	Step 10	Create the technological scheme of the production	Solving the task using the method which coach gives
Testing the solution	Step 11	Share your results with coach and students; discuss it; achieve feedbacks from the coach, colleagues and other teams	-
Based on the feedbacks making solution better	Step 12	Modernize the solution; and repeat achieving the feedbacks - if there some more ideas - modernize it again	-
	Step 13	Create 3-d model of the production in paint 3-d or in other soft ***(or without it, depends of available time)***	-
Communicate results	Step 14	Prepare your materials to presentation	Share the result and get coach feedback
	Step 15	Present your solution	-
	Step 16	Best 3-d solutions can be printed ***(to motivate student and involve modern technics)***	-

Sure, it is pretty clear that method on robotics can be modernized to achieve the increasing of research and engineering in this work. But, it necessary to do to name "STEM-education". To do this, robotics must include not just instructional part but additional creative and searching parts; brainstorm and teamwork part; and modernizing of solution part. This is important due to modern challenges in sociality, especially in developing countries, where no already created sociality based on the principles of teamwork, problem solving, and finding best approaches to solve it (include the international experience).

Therefore, we propose our decisions on this. To describe them, technical cards will be presented below.

Example 1. Yogurt production

Table 5. *Steps of STEAM-lesson*

Practical aspect	Students familiarize with yogurt production and they conduct it. Students are locating the milk and microorganisms in a yoghurt, thermostat or just leave in a heated room throughout the day. If available, equipment for the manufacture of yogurt is equipped with digital pH and conductivity sensors
What happens? The process microbiology	*The biological part of the STEM-lesson can be provided in the biology classes.* Students prepare samples of ready-made yoghurts to examine find types of microorganisms who are conduct the process. Coach (teacher) can give advices to find them or give students full freedom in searching. The species of microorganisms can be determined using ontology-based instrument of microorganism's definition.
What changes are going on?	*The part of lesson which is conducted on the chemistry classes.* The reaction which are going during lactic fermentation on are described in a simplified form.
What needed to provide the process? The technology	*The lesson can be provided at the engineering classes* and it suggests to create the technological scheme of yogurt production
Can you image pro production? 3-d modelling	*This part can be provided on the in informatic classes.* Students build 3d models of the production complex for the development of imagination and creativity. To construct 3d models, it is suggested to use the paint 3d software (preferably using a stylus and a touch screen).
What is the coast of production process? The economics	*Fundamentals of economic analysis of technology can be provided at the lessons of geographic and economic orientation.* A detailed review of the technology can be offered for further refinement at home
Is it possible to use modern approaches in the production?	*Homework,* the results of which will be included in the presentation stage. It suggests to provide the searching on the best modern approaches to use them in proposed technology. The teamwork is encouraged
Was it possible to reach to yogurt? Turner's chemical method to acidity measuring	It is suggested to demonstrate by a teacher or teach students to do titrimetric analysis (deepens on available time)

The presentation	Students compile the results obtained during the study process into a single project and present it. At this stage, the student gets the competence of information analysis, computer literacy, analysis, synthesis, use of search engines, critical thinking and presentation.

Therefore, the proposed lesson is comprehensive and fully compliant with the STEAM approach.

It is advisable to consider in greater detail the features of the biology part, since it is a key to this lesson.

TECHNOLOGICAL CARD ON THE BIOLOGY PART (General characteristics of the training session)

Table 6. *General characteristics of the training yogurt session*

Topic	**Study of microorganisms that cause the formation of yogurt**	
The question	What types of microorganisms cause the formation of yogurts? How can they be classified?	
Aim	Familiarize students with the morphology of microorganisms that cause the formation of yogurt and their systematic situation using.	
Content	Methods of classification of microorganisms on the example of microorganisms of yogurt cultures.	
Terms	Systematics of microorganisms, microorganisms that are part of yogurt cultures.	
Outputs	A student distinguishes microorganisms that cause the formation of yogurt; can use a method of microorganisms defining in the ontology system ontology4.	
The equipment	Samples of yoghurts of various brands, chemical glasses, toothpicks, crystallizers, slides, nail polish remover (based on acetone), pharmacy fuchor solution, bandage, immersion oil, microscopes with immersion system, computers with open access to the Internet.	
The plan and the script of the lesson		Duration, minutes
1.Introduction	Motivational coach's speech, safety training	2-3

2. Telling part	The story of the main stages of yoghurts industrial production and microorganisms that take part in the production of yogurts, and how to classify them.	5
3.Awareness of knowledge	Individual and group work with the material of worksheets (students, with the teacher, identify microorganisms, describe their specifics and paint microorganism's schematic specifications in workbooks), and determine microorganisms using the ontology4 system.	20
4. Summarizing	Questions to students	5
Ways and forms of verification of educational results and products received by students at the lesson		
Student activity is recorded (answers to questions, expressed ideas, questions put). Students fill out the worksheets.		
List of materials necessary for the occupation		
1. Worksheet for students 2. Samples of various brands of yoghurts, chemical cups, toothpicks, crystallizers, slides, nail polish remover (based on acetone), fucorcinum solution, bandage, immersion oil, imperium-based microscopes, computers with open access to the Internet.		

To step 2: Telling part

The production of yogurt includes the following steps: milk's fat and dry matter content normalization, pasteurization, inoculation, fermentation, addition of fruit and berry filler, cooling, heat treatment, packaging of the product. The inoculate composition is very important to achieve the successful results, the presence of certain types of microorganisms and their relationships determine the taste properties of yogurt. The main microorganisms that cause the formation of yogurt include next ones:

- Streptococcus thermophilus
- Lactobacillus delbrueckii ssp. Bulgarian
- Lactobacillus acidophilus
- Bifidobacterium lactis

These microorganisms differ in morphological structure, metabolic processes,

they belong to different systematic groups.

Systematics of microorganisms is poorly highlighted in the school curriculum, but is an important issue in biology. The systematics of microorganisms can be demonstrated on the example of lactic acid bacteria. For example, according Bergy's classification, Streptococcus thermophilus has the following systematic position:

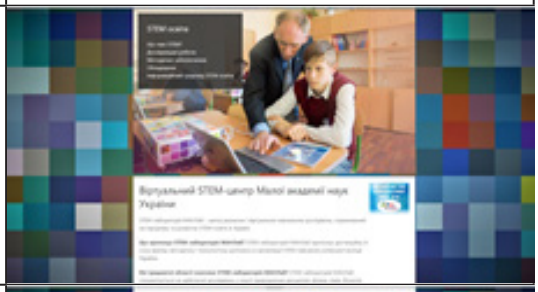
Domain: Bacteria
Phylum: Firmicutes
Class: Bacilli
Order: Lactobacillales
Family: Streptococcaceae
Genus: Streptococcus
Species: S. thermophilus

To step 3: Teacher's card

Stages of manufacturing a smear of yogurt culture are following:

1. мAdd 3-5 skimmed milk drops on the microscopes slide and then distribute the yogurt over the glass surface.
2. Fill the crystalliser with nail polish. Lay the microscopes slide in this solution for 10 minutes.
3. Add fucorcinum solution to the microscopes slide and hold it for 10 minutes.
4. Wash the dye with water, dry the smear.
5. Use the emissive system of the microscope to analyse the sample, find the microorganisms and determine their affiliation.

Table 7. *Instruction for working with the determining microorganism system*

№	Step	Screenshot
1.	Find: https://stemua.science/	
2.	Open the "Determinant of microorganisms" on the colonum «Knowledge systems»	

№	Step	Screenshot
3.	Put the name of Streptococcus thermophilus; the affiliation will be shown on the left side of the system	
4.	Analyse the morphology by the microorganism's photo	

To step 3: Student Sheet

Study of microorganisms that cause the formation of yogurt

Tasks:

1. Make a smear of yogurt culture.

2. Consider the smear using an immiscible microscope system and establish the generic (type) affiliation of the microorganisms.

3. Fill the table (table 8).

Table 8. *Instruction for working with the determining microorganism system*

№	Step	Describing
1	Add 3-5 skimmed milk drops on the slide and then distribute the yogurt over the glass surface.	
2	Fill the cristalyser with nail polish. Lay the glass in this solution for 10 minutes.	
3	Place the glass on the slides, add fucorcinum solution and hold it for 10 minutes.	
4	Wash the dye with water, dry the smear.	

5. Use the emissive system of the microscope to analyse the sample, find the microorganisms and determine their affiliation (table 9).

Table 9. Clean sheet to analyse the observed microorganisms

Species	Genus	Family	Order	Class	Phylum

In the conclusion, indicate which microorganisms you observed and to which systematic groups they belong.

TECHNICAL CARD OF STEM LESSON [Mechanism of muscle contraction]

The offered lesson can be applied by selecting a school day for a holistic STEM-class.

Subject: Mechanism of muscle contraction. Production and functioning of pneumomusicule.

Table 9. Steps of STEAM-lessons

Practical aspect	At first, students are introduced to the biochemical and physiological processes that ensure the functioning of the muscular tissues
What happened?	Biological component of the study. Performed in a biology lesson. Students find out the mechanism of reducing the masonry fiber, based on the function of understanding its structure. Make your own micropropagation
How's it going?	Using 3D models, biochemical mechanisms of masonry reduction are studied. https://youtu.be/NV_X1_jfHRM
What do you need to make? Technology	The lesson can take place in the lesson of work and consists in the manufacture of own pneumomusicule
How does pneumomusiculum function?	An ingredient that should be considered in the physics class. Students, using physical methods, investigate the functioning of the pneumomusicule

Is it possible to use pneumomusicu-lum?	Homework, the results of which will be included in the presentation stage
Presentation stage	Students compile the results obtained during the study process into a single project and present it. At this stage, the student receives the competence of information analysis, computer literacy, analysis, synthesis, use of search engines, critical thinking and presentation.

Therefore, the proposed lesson is comprehensive and fully compliant with the STEAM approach.

It is advisable to consider in greater detail the features of the lesson on biology, since it is a key to this lesson.

TECHNOLOGICAL CARD ON THE BIOLOGY PART (General characteristics of the training session)

Table 10. Steps of STEAM-lessons

Topic	Muscle contraction mechanism	
The question	What are the peculiarities of the structure of the muscle contraction	
Aim	Introduce students with the biochemical and physiological processes occurring during the muscle contraction. Link the structure of the muscle to the functions that it performs.	
Content	Mechanism of muscle contraction	
Basic scientific concepts	Myosin, actin	
Result planning	The student understands the mechanism of the muscle contraction, possesses a method of manufacturing of a temporary preparation of muscle fiber.	
Equipment	Sample of muscle tissue (preferably pork, anterior part - shoulder blade), microscope slides, scalpels, tweezers, lancets, flasks, water, crystallizers, pharmacy solution of fucorcinum, microscope.	
The plan and the script of the lesson		Duration
Introduction	Motivation leader's speech, safety instruction	2-3 min
Telling part	The story of the head about the main stages of reduction of muscle fibber	5 min

Awareness of knowledge	Individual and group work with the material of the worksheets (students, along with the teacher, make a temporary micropropagation of muscle fibber, scribble it in a workbook).	20 min
Summarizing	Questions to students	5 min
Ways and forms of verification of educational results and products received by students at the lesson		
Student activity is recorded (answers to questions, expressed ideas, questions put). Students fill out worksheets.		
List of materials necessary for the occupation		
1. Worksheet for students 2. Sample of muscle tissue (preferably pork, anterior part - shoulder blade), microscope slides, scalpels, tweezers, lancets, flasks, water, crystallizers, pharmacy solution of fucorcinum, microscope		
Information sources 1.Aghajanyan NA and others. Human physiology. - M.: Medical book. N. Novgorod: Publishing house of the National Academy of Music of the Russian Academy of Music, 2003. - 520. 2.Plachty P. D. Human Physiology. Metabolism and energy supply of muscle activity: A manual. - Kyiv: VD "Professional", 2006. - 464. 3. Human physiology / ed. V. Pokrovsky, G. F. Korotko. - Moscow: Medicine, 2003. - 656.		

To step 2: Telling part

The reduction of muscle fibber occurs due to electrical impulses (nerve impulses) that nerve fibres transfer to muscle fibres. The formation of the nerve impulse is due to the regeneration of the action potential at the cell level.

In a calm state, the number of positive sodium ions in the extracellular space is greater than in the cell, and the number of positive potassium ions, on the contrary, is greater in the cell. That is, on the surface of the membrane more accumulated positive charge. Under the influence of any factor (high or low temperature, light, mechanical touch, chemicals), the cell membrane becomes more permeable to sodium ions, and they begin to enter the cell, because everything in nature is trying to reach the balance.

Why during arousal, first, the permeability of the membrane for sodium ions increases, and then for potassium ions? This is due to the peculiarity of functioning in the cell membrane of sodium and potassium channels. Channels are special holes in the membrane; Sodium channels pass only sodium-ion, potassium channels - only potassium ion. The opening of these channels depends on the charge on the cell membrane, which varies under the action of the external factor. If positive sodium

ions begin to move inside the cell, then a positive charge begins to accumulate on the inside of the membrane, and ions that carry a negative charge remain outside the cell. This stage is called depolarization. After the depolarization stage, the stage of repolarization comes in: now, potassium ions are beginning to come out of the cell. And again, on the surface of the cell begins to accumulate a positive charge. Such changes in charge on the surface of the cell membrane provide the emergence and movement of the nerve impulse through the nerves. However, the animal cell returns to rest and it needs to restore the lost balance of ions. This work is carried out by a special potassium-sodium pump. This pump, due to energy that a person or animal receives with food, for every three sodium-ions that are transported from the cell, into the cell only launches two potassium ions. Thus, in the environment, the content of sodium ions again becomes larger than the content of potassium ions inside the cell. he passages of the nerve impulse through the nerve fibber is associated with a constant change in the charge of the membrane. It is in this form that the nerve impulse extends to muscle fibber.

The muscle fibber consists of threads of myosin and actin. The threads of myosin are thicker, with heads. Actin threads, in addition to this protein, also contain troponin and tropomyosin proteins, the latter being involved in the closure of active actin protein centres. There are areas where myosin and actin fibres overlap, but there are areas where overlapping does not occur, so skeletal muscles are called strained. Also, the fibres are divided into Z-plates on sarcommer.

The abbreviation is as follows:

1. The nerve impulse on the nerve fibres falls on the Z-plate.
2. Under the action of the nerve impulse, an acetylcholine mediator is released which binds to the corresponding receptor and causes the activation of the inositol triphosphatase enzyme.
3. Under the influence of inositol triphosphatase, Ca^{2+} is released from the tanks of the endoplasmic (sarcoplasmic) reticulum (mesh) into the cytoplasm.
4. Ca^{2+} is coupled with tropomyosin, and this complex causes spontaneous reorganization of troponin, as a result of which troponin releases active centres of protein actin.
5. The myosin stems attach to the active centres of the actin protein and carry out the comb-like movement. Then the head is disconnected from this active centre and goes to the next. To disconnect the myosin head from the active actin centre, you need energy that is in the macroenergic bonds of ATP. For example, the phenomenon of scrounging corpses is due to the fact that the concentration of ATP in dead tissues is low and the head of myosin cannot be disconnected from the active centres of actin.
6. Due to comb-like movements, the strands of actin are tightened between the threads of myosin. At the same time, the thickness of the muscle increases, which is visible visually when performing muscle work, but the length of the muscle does not change, because there are areas of myosin fibres, which

do not overlap with actinides.

7. Relaxation of the muscle is due to the pumping of Ca^{2+} enzymes by Ca^{2+} -ATPase from the cytoplasm into the endoplasmic reticulum tanks.

To step 2: Teacher's card

1. From the sample of muscle tissue using a tweezers, select the muscle fibber.
2. Place the fibber on the slide in a drop of water.
3. Consider the preparation under a microscope, using an eyepiece 15X and lenses 4X, 10X, 40X.
4. Place the muscle fibber on the substrate and apply a drop of fucorcinum for 10-15 minutes.
5. Fucorcin wash off with plain water, holding the muscle fibber with a tweezers. 6. Dry the dish in the air.
6. Consider the preparation under a microscope, using an eyepiece 15X and lenses 4X, 10X, 40X.

To step 3: Student Sheet

Subject: Mechanism of muscle contraction.
Task:

1. Get acquainted with the theoretical part of the work.
2. Make and consider muscle fibber.
3. Understand the muscle contraction mechanism.

Fill the table (table 11).

Table 11. Steps of STEAM-lessons

№	Stage of manufacturing	Process description
1	From the specimen of the muscle tissue, using a tweezers, select the muscle fibber.	
2	Place the fibber on the microscope slide with a drop of water	
3	Consider the preparation under a microscope using an eyepiece 15X and lenses 4X, 10X, 40X	
4	Place the muscle fibber on the substrate and apply a drop of fucorcinum for 10-15 minutes.	
5	Fucorcin is washed with plain water, holding the muscle fibber with a tweezers.	

Take a look at the smear with a microscope, analyse and paint the peculiarities

In the conclusion, specify which features of the structure of muscle tissue provide its reduction.

Conclusions

To provide STEM/STEAM-education it's important to understand what it means. Due to the fact that some approaches just include STEM-name, it is hard to implement real-STEM/STEAM approaches. Therefore, it is determined that not name (or topic) of the class is define the type of them but it determines by methodological and didactical approaches which are used. To clearly this, practical approaches to conduct the STEM-education are added. The main instruments of STEM-education (research and engineering methods) are described.

Firstly, it is shown difference between STEM-approach method and "just-named STEM-approach" method. The STEM-based methods are described on examples of pneumomusiculum research and yogurt production research. To simplify it implementations in educational institutions technical cards are added.

Thus, firstly the theoretical information on STEM-education is linked and totally corresponds to prosed practical approaches of STEM-education.

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