Using Personal Smart Tools in STEM Education

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Abstract: Under STEM education, a lot of computer-based methods were used to improve motivation, personalization and enchaining of the quality educational process. However, the attention has not been devoted to using of the IoT and smart tools to measure parameters during educational research process. It stands even more relevant due to the growth of the amount of the smartwatch/band used by people. The methods of using personal smart tools under STEM classes and researches have been developed in the study. Colmi land 1, Xiaomi Mi Band, Samsung Smart Fitness Band, Xiaomi Mi Smart Scale were used to test the proposed methods. Firstly, As is – To be Business Process Model and Notation method was used to evaluate changes in educational processes for both, pedagogical and technical points of views. It is proven that proposed methods are characterizing by the higher efficiency compare to classical educational process. For the first time, the techniques of using personalized smart tools to measure during the experiments are described in the paper and ready to use.

1 INTRODUCTION

The acronym STEM has published by the US National Science Foundation in 2001. The acronym SMET was previously used, but has modified. As a separate area of didactics, STEM stood out in the USA in 2009 with its "Educate to Innovate" program. However, in Ukraine it only start to providing and its using is much less compare to traditional educational approach (Shapovalov et al., 2020; Kramarenko et al., 2020) even contrary its advantages.

A significant attention at STEM lessons is to increase the motivation of students. Also, such lessons are developing many skills such as communication, data processing and project management, which largely depend on information technology.

In general, STEM approach tools in education classified into tools, software and specific modern tools. The tool part can be divided into: digital laboratories, digital equipment, mobile phone, mobile phone with additional sensors, smart tools. The software like process calculators, modelling environment, VR video, VR applications (Joiner, 2018), AR applications (Martín-Gutiérrez et al., 2015; Dziabenko and Budnyk, 2019; Jong et al., 2014), educational environments (Joiner, 2018), 3D printing, 3D modelling tools (Sala, 2014), etc. However, in our opinion, the Internet of Things (IoT) has high untapped potential in education due to several advantages such as using cloud computing and calculation, and visualization of data measured or captured by devices. Due to those devices connected to the personal ecosystem, they provide personalized data.

Internet of Things (IoT) differs from cloud services because it can use cloud servers to provide its activity. Internet of Things includes M2M – machine-to-machine connection method (without human involvement) by measuring and interaction. The most perspective to use under STEM education classes is personalized smart tools.

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Smart tools are tools that can be part of the IoT and have automatic algorithms for processing information and can notify about a change in a specific user parameter IoT uses cloud services to provide a connection between instruments connected through internet. Smart tools can be compared with IoT. Smart tools as IoT are electronic devices connected through the Internet or Bluetooth, NFC and send measured (fixed) data into the cloud, where it saves. User can get information using cloud from any place using Android/iOS application or web-interface. The main advantages of its use are personalization (which is that personal connection of device in personal page of application/web-interface). Distinctive features of smart tools are:

- measures actual performance
- measures other calculated indicators
- analyzes the data
- states of necessary changes or displays a case that is important to the user

Smart tools include fitness bands (tracks), smartwatches, smart scales, smartphones. The most perspective to use under the education process are smartwatches/bands, scales, temperature sensors, humidity sensors, specific plant sensors. Relevance of the research proved by the increasing of the amount of using personal wearable device due to much higher affordability and simplicity of them (Gubbi et al., 2013). There was an expected jump from 100 million in 2016 to over 373 million in 2020 (Pal et al., 2020) and even up to 1.1 billion in 2022 due to transformation from 4G to 5G of mobile internet connection (Holst, 2020).

2 LITERATURE REVIEW AND PROBLEM STATEMENT

In general, as was noted before, the smart tools have been using widely in everyday life, sport, medicine and healthcare. For example, wearable devices use monitor state of the patients in clinics to alert the doctors (Stradolini et al., 2017).

IoT technologies and Cloud Services are becoming more and more popular for educational purposes (www.al-enterprise.com, 2018). IoT will significantly improve the quality of education. Implementation of IoT in education will create new ways to learn by supporting more personalized and dynamic learning experiences. IoT will give teachers new methods to explain the material for the lessons (www.al-enterprise.com, 2018; Bakla, 2019). Also, IoT will be an excellent opportunity to provide the unique lessons to people with some disabilities (Mcrae et al., 2018).

For example, Singapore has implemented the Intelligent Nation Master plan since 2006, in which technology-supported education is a significant part (Hua, 2012). South Korea had the smart education project, the main task of which are reforming the educational system and improving educational principles (Zhu et al., 2016). Australia collaborated with IBM and designed a smart, multi-disciplinary education system (Rudd et al., 2009). Ukraine has provided new school program concept, in which they underline the importance of smart tools and E-learning (Elkin et al., 2017).

Some authors create different education systems based on wearable devices and IoT technologies (Liang et al., 2019; Mavroudi et al., 2018). This education systems integrates with the IoT tools and special apps that can create more interactions between teachers and students in class while providing more innovative learning possibility. Also, IoT can inspire school students and increase their concentration in the classroom during the lessons (Pervez et al., 2018).

Also, have shown that the use of IoT technologies in the educational process will improve the quality of learning. Besides, the result of their scientific research showed that the using of IoT technologies significantly increase overall opportunities for the realization of creative abilities for both teachers and students.

Previously it was proposed to use such technologies like using of mobile Internet devices in the formation of the general scientific component of bachelor in electromechanics competency in the modelling of technical objects. In this work they have underlined that using of mobile Internet devices is a perspective way to improve the quality of education in general. Also, the authors have proposed different tools to work with, as an example: mobile augmented reality tools, mobile computer mathematical systems, cloud-oriented tabular processors as modelling tools, mobile communication tools for organizing joint modelling activities and more (Modlo et al., 2020).

Using the Internet of Things in education is an excellent function for connecting and educating students. Different researchers at their articles have tried to implement smart tools to provide various services in smart campus accessible in handheld devices by doing ideal connectivity among multiple things. Proposed system must do a collection of data from the classroom, just not only presenting information to students and collect from their interaction. Also, these data can be uploaded and can be opened by using smart e-learning application. At smart classrooms, tools are aimed at either real-time monitoring of teaching space or on smart tools that support students, in which multiple functions are brought together (Veeramanickam and Mohanapriya, 2014; Valks et al., 2019; Cebrián et al., 2020).

At the same time, the use of IoT is promising, but not widely used. Overall, there is no complete, systematic list of techniques that can be used in class. For today, the most popular smart tool is a smartphone, but in this work have been proposed methods which will use smart scales and bands/watches.

3 METHODS OF ANALYSIS

The study conducted using the methods of theoretical and empirical research: analysis and synthesis to determine the main trends in the use of IoT in the world and the educational process. Conceptual-comparative analysis has used to study the best pedagogical experience. Structural-system analysis and synthesis also have used to build a theoretical model of as is-to be process. The following devices were chosen for our experiment: Colmi land 1, Xiaomi Mi Band 4, Samsung Smart Fitness Band, Xiaomi Mi Smart Scale 2.

To provide analysis of proposed teaching process modification, firstly, "As is-to be" method (Visual Paradigm, 2016; Fossland and Krogstie, 2015) has been used. The method based on using of Business Process Model and Notation (BPMN) (BPMN, 2013) to note the current process and for proposed approach for both, technological and pedagogical process business analysis. BPMN provides a decomposition of the complex processes to simple elements and connection of them by arrows to interpret the total process. Also, BPMN uses "lines" to decompose elements of the process by the executor, for example, teacher and student.

In general, BPMN is using in business analysis, but taking into account its specifics, it will be suitable to use in scientific work to justification of expediency of using proposed approaches. Besides, there very few researches have been used BPMN to describe processes in education (Morais et al., 2020; Wiechetek et al., 2017).

To evaluate the content of devices that can measure the concrete parameters, hotline service and its filters were used. The following formula $N/N_a \times 100$ was used for this purpose, where N – specific gadgets with needed parameters, N_a – all gadgets of the selected brand.

4 RESULTS AND DISCUSSION

4.1 Existing IoT Ecosystems

The most popular devices are those that are part of a smart home and are connected using either Wi-Fi or Bluetooth protocols. The most common types of devices are: scales, watches, fitness trackers. The leading manufacturers of these types of products are: Samsung, Xiaomi with Amazfit/Huami sub-brands, Apple, Google Nest and others.

Samsung smartphones can become a central link in the entire ecosystem. From a phone, you can control your watches, devices, headphones, write some notes and then continue working on them on the other device. At the same time, all synchronisation is seamless. The main thing here is the availability of the Internet. But even without the Internet, you can exchange data between your tablet and smartphone using Samsung Flow. The heart and brain of their developments are Bixby 2.0, an intelligent assistant who will easily connect to Samsung devices. Bixby 2.0 is the central hub of the IoT ecosystem, learning from daily interaction with users' devices to better understand and anticipate all your needs (Mesquita et al., 2019; Këpuska and Bohouta, 2018).

Today more than two hundred companies and start-ups are located under the Xiaomi, each of which is responsible for its type of product. The Amazfit brand is developing fitness trackers and smart clocks. Ninebot is adding to the company's range of personal electric vehicles, and SmartMi develop smart home appliances. Wearing electronics has long since ceased to be a curiosity, and today it helps monitor physical activity, sleep quality and overall health for millions of users around the world. Xiaomi could not remain indifferent and, together with Amazfit, has taken its niche in the ranks of smart wearable gadget manufacturers. It is no secret that Xiaomi Mi Band is one of the best and most popular fitness trackers on the market. With each new generation, the fitness bracelet is pumping its capabilities and becoming more functional. Furthermore, it is maintaining a reasonably loyal price tag that provides the gadget with such popularity.

But the company is not in charge of wearable gadgets. Household medical devices such as electronic thermometers, inhalers and tonometers have also found their place in the range of Chinese technology giants. And recently, Xiaomi has begun mastering another area – home simulators. At the moment, among Xiaomi's simulators, one can find the WalkingPad A1 folding treadmill. There is no doubt that in the nearest future the company will also cover other sports equipment for home sports.

Apple HomeKit and Health app are the platforms, the central purpose of which is to unite all the smart technologies in the home. The HomeKit platform was released by Apple back in 2014 as part of the WWDC conference, and already a year later full-fledged devices based on it began to be available for sale. Starting with iOS 8, Apple mobile devices will be able to manage compatible home appliances and home life support systems. One of the advantages of HomeKit is close integration with the Siri virtual assistant. HomeKit can be controlled by voice commands, which opens up truly enormous opportunities for home appliance developers and software developers (Mesquita et al., 2019; Këpuska and Bohouta, 2018). Today, third party software has used to control home smart appliances, but a native application has appeared in iOS 10. The programme will be able to take over the management of all Smart Home appliances equipped with the appropriate software. Apple's Health app allows you to monitor your health, daily activity, and provide important information to your family or friends when needed. It is especially critical in the event of an accident or sudden illness, as well as when tracking fitness stress. Health app excellently works with Apple Watch. Apple Watch can measure the level of O_2 in blood and can take electrocardiograms.

Google began taking its first steps towards a smart home back in 2016 when it introduced the first Google Home speaker. It was supposed to be a kind of analogue of Amazon Echo, i.e. it could control home appliances and be used as a multimedia device. The Google Cast application, which used to configure and manage Chromecast devices, has since been renamed Google Home and its functionality has extended to the new column. One of the latest innovations from Google in this field was the Google Home Hub, shown last year. Google Home Hub is a tablet with a display that can combine information about your smart devices in the Google Home ecosystem and display it on a built-in display. In May 2019, Google presented its product Nest Hub Max at a presentation. Unlike Google's Home Hub, it has a camera and added multiplayer functions. Central operating tool of "Google Nest" is "Google Assistant" (Mesquita et al., 2019; Këpuska and Bohouta, 2018). In addition to the devices produced and presented by Google itself, there are a large number of companies that manufacture devices compatible with this ecosystem. Their number has already surpassed 500. And every day, there are more and more manufacturers producing products marked "work with Google Assistant".

However, it seems relevant to analyse the ecosystems of those companies based on the parameters can be measured by concrete equipment. The main parameters used during educational researches are heart rate, blood pressure, ECG, oxygen content, weight, muscle, fat, bone, and water content in the human body. Examples of devices of different companies, that can measure concrete parameters are presented in the table 1.

4.2 Advantages of using Smart Tools in the Educational Process

The main functions of IoT devices in the educational process are defined:

- The *training functions*. The training involves the use of IoT devices in the study of individual subjects, especially STEM subjects directly. Most often, certain types of devices are used as a tool to perform a learning task. They can also be used in the design of research activities and the performance of research tasks.
- The *health-preserving function* involves the use of IoT devices as a tool for monitoring the prime indicators of the body. First of all, to form a healthy lifestyle with the subsequent formation of skills to control physical shape. It can also be used to monitor vital signs in people who need it.
- The *control function* involves the use of devices as a tool for self-control and control by others (parents, managers). Allows control over certain types of activities and the children GPS, especially primary school and preschool children by parents or persons who replace them, if necessary, such control may be carried out by a teacher. It helps to increase the level of self-control, which is supported by the formation of habits.
- The *ergonomic function* involves the use of devices to improve productivity, namely planning, coordinating the use of their own time, and the effectiveness of the actual use of tools that help increase the productivity of each child and the educational process as a whole. Rational use of IoT devices and time allows to control admissible physical, nervous and mental loadings of the child and allows to increase its working capacity.

The use of smartwatches/bands in the learning process contributes to the development of principal competencies:

- *mathematical competence* expressed in the formulation of navigation, calculation of the necessary parameters using indicators created from reasonable years;

Table 1: Examples of devices of different companies, that can measure concrete parameters.

	Samsung	**Xiaomi**	**Apple**	**Google**	**Other brands**
Smart watches/bands					
Heart rate	100% of devices: Samsung Galaxy Watch 1, Samsung Galaxy Watch 2, Samsung Galaxy Watch 3	100% of devices: Amazfit T-Rex, Amazfit Bip S, Amazfit Stratos	100% of devices: Apple Watch Series 1, Apple Watch Series 2, Apple Watch Series 3	N/A	100% Aspolo Smart-Watch U8, UWatch U8, SmartYou DZ09
Blood pressure	-(3,9%)Samsung Galaxy Watch 3	- (0%)	- (0%)	N/A	5.5% Havit HV-H1100, UWatch DT88 Pro, Aspolo DT88 Pro
ECG	(0 %)	+ (4.4 %) Xiaomi Mi Watch Color, Xiaomi Haylou Smart Watch	+ (52.5 %) Apple Watch Series 5, Apple Watch Series 6, Apple Watch SE	N/A	7 % No.1 DT28, Lige Smart, Gelius GP-L3
Oxygen content	- (3,9 %) Samsung Galaxy Watch 3	- (0 %)	10,2 % of devices: Apple Watch Series 6	N/A	11.7% Aspolo M1Plus, Aspolo DT35, UWatch E66
Sleep quality (stages of the sleep)	100% of devices: Samsung Smart Charm, Samsung Galaxy Fit E, Samsung Galaxy Watch Active	100% of devices: Xiaomi Mi Band 4, Xiaomi Mi Band 5, Amazfit GTS,	100% of devices: Apple Watch Series 5, Apple Watch Series 6, Apple Watch SE	N/A	100% Aspolo Smart-Watch U8, UWatch U8, SmartYou DZ09
Smart scales					
Weight measuring	N/A	+ (100%) Xiaomi Mi Smart Scale 1, Xiaomi Mi Smart Scale 2	N/A	N/A	100% Laretti LR BS0015, HUAWEI Body Fat Scale, AEG PW 5653 BT Black
Muscle, fat, bone, and water content in the human body	N/A	+ (100%) Xiaomi Mi Smart Scale 1, Xiaomi Mi Smart Scale 2	N/A	N/A	100 % Yunmai Mini Smart Scale, Garmin Index Smart Scale, Acme Smart Scale

- *competences in the field of natural sciences, engineering and technology*, which is formed based on acquiring skills in working with physical parameters, vital signs, geolocation data, ability to work with different models of certain devices and their analogues, etc.;
- *innovation* is defined in the formation of skills in the use of leading technologies for personal and public health;
- during the connection process of smartwatches/bands with a smartphone, the students get acquainted with the concepts of “cloud technology”, “synchronization”, “remote access” – the mastery of this knowledge will facilitate the formation of *information and digital competence*;
- *social competencies* manifested in the configuration of the ability to be aware of personal feelings and the ability to listen to internal needs, which is shown in the perceived need to maintain a healthy lifestyle;
- smartwatches/bands encourage students to take accurate measurements of their heart rate, blood oxygen concentration and stress levels – this knowledge allows them to produce *health-preserving competences*.

For example, a pupil can see on his smart clock that negative emotions (anger, aggression) accelerate heart rate. These devices can be used to create motivation for a healthy lifestyle. For example, you can offer students a cup of coffee, an ’energy drink’ and then measure their heart rate. Such experiment will demonstrate the effect of certain substances on the functioning of individual organs and systems.

Smartwatches/bands also have considerable potential for developing useful skills and habits. Most of these devices have a reminder mode. At first, you can set up a notifier that after 40 minutes in a sitting position (while doing your homework), you need to do some exercises. But after 40 repetitions of this sequence, a useful skill becomes a habit that can be reproducing without a smart device.

But smartwatches/bands have the most pedagogical potential in shaping research competencies.

Document "The European Qualifications Framework for Lifelong Learning" (Guest, 2007) determines that a high-level specialist should have research competence in his or her field of knowledge. Research competence is the ability of the acquired education to perform research educational tasks, to carry out research activities aimed at obtaining new knowledge and / or finding ways to apply them, in accordance with the profile of study (Cabinet of Ministries of Ukraine, 2020; Nechypurenko and Soloviev, 2018).

With the help of smartwatches/bands, a student can obtain a large amount of data – this is the stage of acquiring new knowledge. Also, a student can analyse this data with mathematical tables – this is the stage of creating a knowledge system.

It is also possible to use smartwatches/bands to create motivation for learning activities within the STEM approach. For example, students observe the phenomenon of heartbeat acceleration after physical activity, after they will ask a problematic question: Why does it happen? How is the heart activity regulated? And the whole lesson lays out around this doubtful question.

There are also perspectives for using smartwatches/bands for students with special needs. For example, it is challenging to teach a child with hearing disabilities how to measure his pulse, and smartwatches/bands can help to solve this problem.

In this article, we present several methods of using smartwatches/bands during the learning process. These methods can be divided by the time they will use:

a) methods that can be directly used in the learning process at school;

b) methods that ensure long-term experiments, for example, within 24 hours, the application of the latter is relevant to the performance of research work or projects by students.

Thus, the use of the smartwatch/band allows:

- to create motivation for learning activities;
- to create impulse for a healthy lifestyle;
- to develop an information-digital, health care and research competencies.

4.3 Analysis of Proposed Teaching Process Modification

Smart tools are the perspective way to provide transcendent educational experience. For example, students can interact with objects directly, they investigate it necessary by themselves. By using smart tools, students can make different type of activities such as asses level of O_2 in blood, heart rate and more. To create a smart-lesson, it is necessary to achieve connectivity between smart tool and smartphone via specific application, for example, Xiaomi Mi Fit.

During the "As is" for the researching STEM lesson process anticipates that the teacher explains the theory, which is always hard to understand by students, with further explanation of parameters which will affect on the object or process. In all cases teacher will explain an experiment using class board without any research, less often by providing demonstrations, and very rare, will provide group experiment. In those cases, a student doesn't understand the material clearly. Also, skills and competencies delivered using this process will be limited only by specific, laid down in the topic of the lesson, which may be not enough according to the latest international and Ukrainian documents.

Besides, the technical part for all demonstration and group experiment, will be mostly provided manually by students or teacher, and results of it will be calculated, processed and interpreted manually. This time can be used for more beneficial for students teaching process. Thus, measuring starts from choosing the measurer and providing measuring. Obtained data must be notes and written by using of class board or worksheets. Then calculation is provided manually, which, sure may be very useful, comparing to automatic computation. The best effect may be obtained by the combination of both manual and automatic calculation. Obtained data interpreted in graph, board or worksheet. Finally, the graphics and data are analysed. As is process (including technical interaction) is presented in figure 1.

As in "As is" process, the teacher starts classes from the theory and further transferring to more practical oriented part, which is explaining the factors that will affect on some object or process. Also, based on the amount of available smart tools, pupils will have the demonstration, group experiments or personal experiments. Understanding of the materials will be better due to the higher speed of the research. Calculation and graph creation will be provided automatically. Students will work with personal data and graphs. They will understand how to work with graphics and data, and how to use individual wearable smart tool to provide researches which will motivate students to research and will present better usage to health care. During personal experiment, students will have more questions comparing to the as-is process due to higher motivation. And, same as in “As is” process, classes will finish by investigation and discussion of the results.

The main features of the “To be” approach is time-saving and motivation increasing. From a technical point of view “To be” process is significantly more automatic. Only methods of measuring and analysing in this case provides by teacher and students. All analysing process which includes sending measured data to smartphone, saving data, processing data and creation of the graph must be conducted by the teacher or student. The data that is using additional soft can be imported to Excel for further processing.To be process (including technical interaction) is presented in figure 2.

So, in general, “To be” process is more interactive, engaging and beneficial for students, and motivate them to provide personal researches, and learn how to use individual smart gadgets to healthcare, it may save a lot of time to use it more effective. Sure, worth to note, that during “As is” process student teaches how to process the data. And it seems relevant to combine those methods.

4.4 Advantages of using Smart Tools in the Educational Process

4.4.1 Methods Can Be Used during Lessons

Topic: Measure of the heart rate before and after physical activity with smartwatches/bands (figure 3).

Aim: Demonstrate to students that a smartwatch/bands can measure heart rate and effect of physical activity to heart activity.

Equipment: IoT or smartwatch/bands or fitness tracks with heart rate monitoring functions; blood pressure, oxygen concentration (optional).

Experimental procedure: The technique involves the selection of 10 participants of each sex for the study. Each of the participants takes heart rate, blood pressure (optional), oxygen concentration (optional) measurements at rest. Then student must make 20 squats, after he needs to take the estimations one more time. The analysed data, can be both personalised as a graph on their smartphone and in a table drawn on a blackboard, where the teacher finds regularities related to all students (including, sex, weight, age, etc.) and explains them to the audience.

Analyse of data: To analyse the data, we need to find regularities before and after physical activity. Compare actual and relative changes in indicators after physical activity in boys and girls, and we need to find dependencies of other indicators, such as height, weight.

Topic: The effect of sleep duration on heart rate (figure 4).

Aim: Demonstrate to students that sleep duration affects the functioning of the circulatory system. Use personal example to prove to students the importance of sleep and adherence to the daily habit.

Equipment: Smartwatches/bands with heart rate, blood pressure (optional), oxygen concentration (optional), ECG (optional).

Experimental procedure: The research is personalised, so each student carries it out separately. The method foresees changing time regime in two steps. Firstly, students during the experiment must get sleep daily for seven days at 22:00 and get up at 7:00. As soon as you wake up, students provide a measure of the heart rate, blood pressure (optional), oxygen concentration (optional), ECG (optional), as well as the quality of your sleep. After the first seven days of the test, students must get sleep at 23:00 and get up at 6:00 and students provide record the findings, same, as soon as wake up.

Analyse of data: Analyse of date is performing by comparing the heart rate and oxygen concentration in the blood on the first stage (go to bed at 22:00 and get up at 7:00) and executed on the second stage (go to bed at 23:00 and get up at 6:00) with the normal condition. Changes in data must be attached to stress or adaptation state using theoretical knowledge.

The experiment is safe and can conduct regardless of the health conditions. But we recommend that the research supervised by the teacher or adults. Based on the results, it is possible to study adaptation, human comfort areas and stress conditions.

Topic: Determination of differences in muscle, fat and bone composition in men and women (figure 5).

Aim: Demonstrate to students some differences in the muscle, fat and bone composition of men and women. Explain the reasons for such differences.

Experimental procedure: The technique involves the selection of 10 participants of each sex for the study. Each of the student must measure muscle, fat and bone tissue. The analysed data, can be both personalised as a graph on their smartphone and in a table drawn on a blackboard, where the teacher finds regularities and explains them to the audience.

Analyse of data: To analyse the data, it is necessary to find regularities in the amount of muscle,

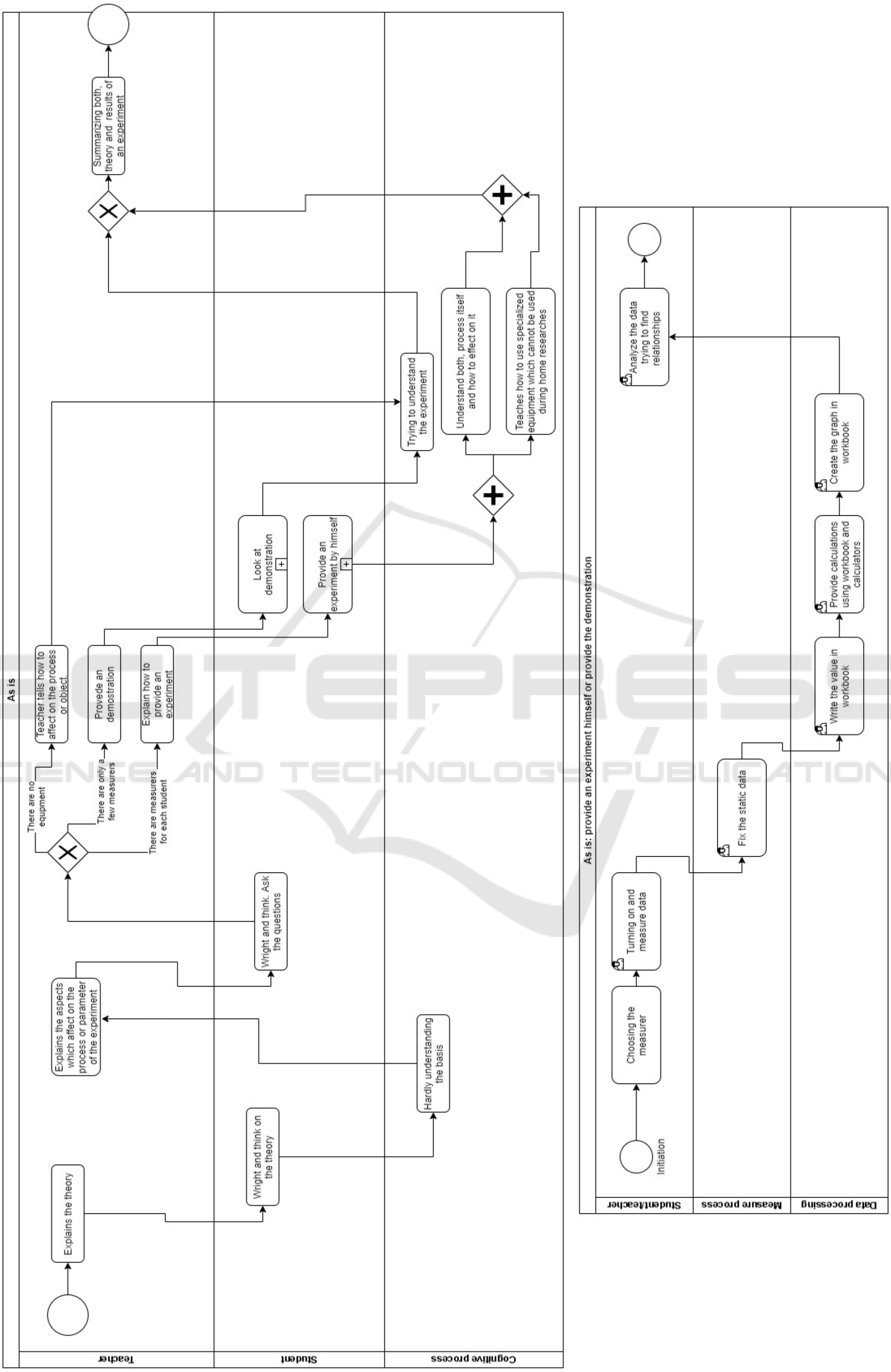


Figure 1: “As is” process (including technical interaction).

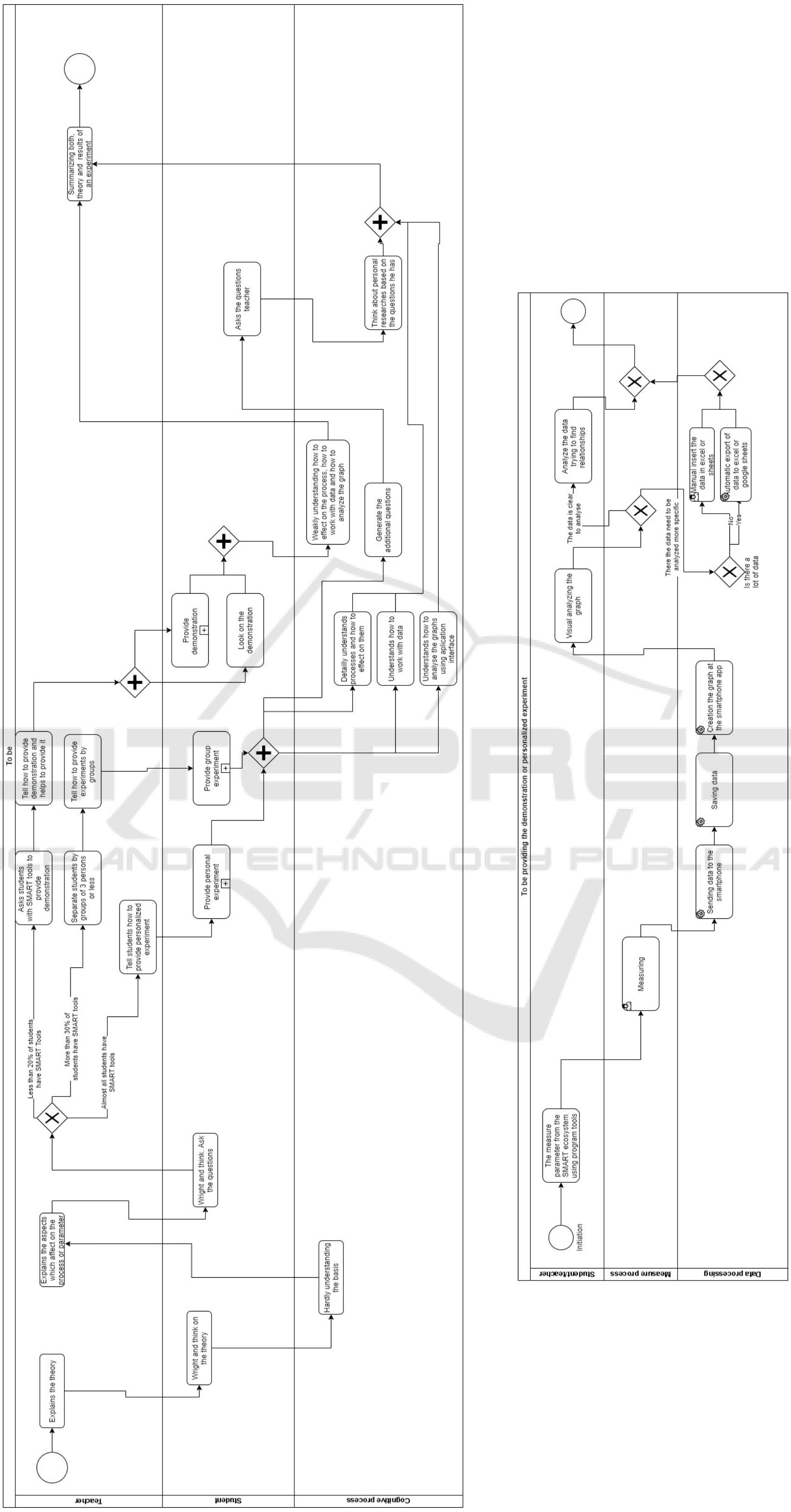
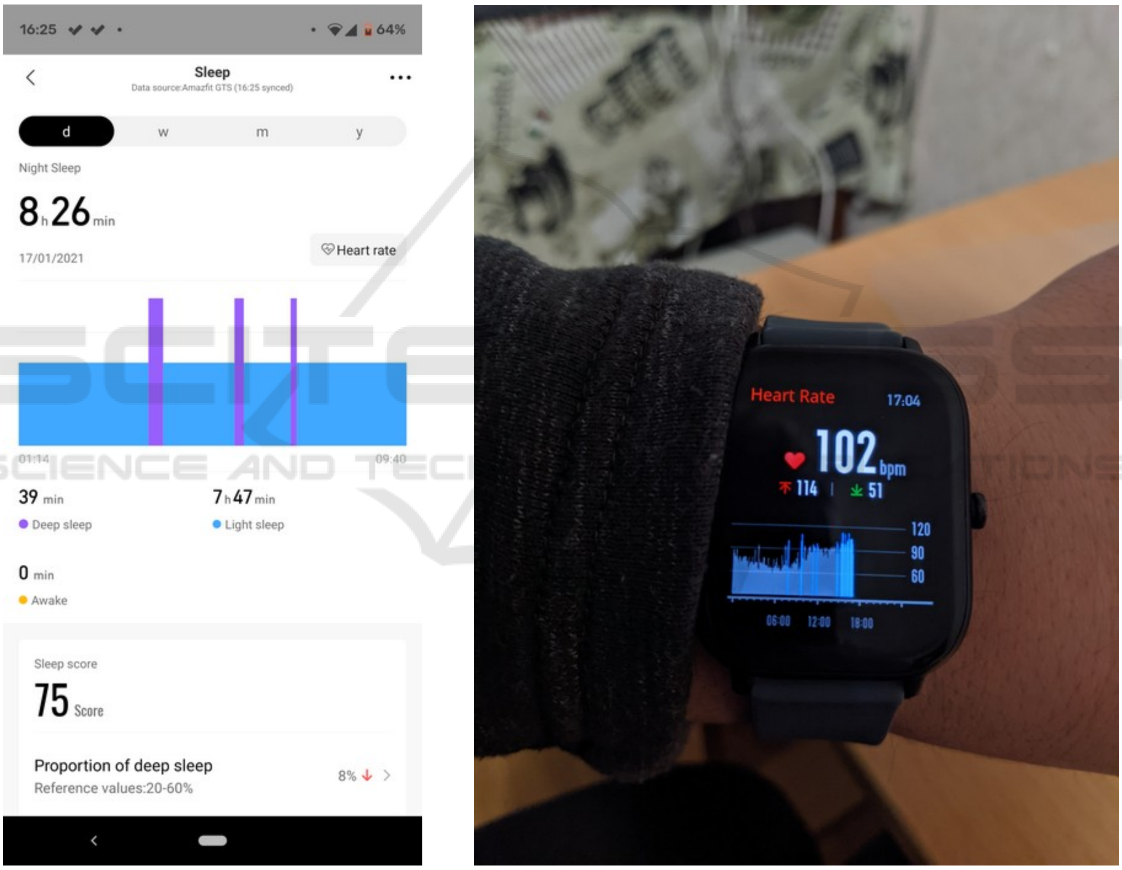


Figure 2: “To be” process (including technical interaction).

(a) (b) (c)

Figure 3: Experimental part of the work (a), heart rate before (b) and after exercise (c).

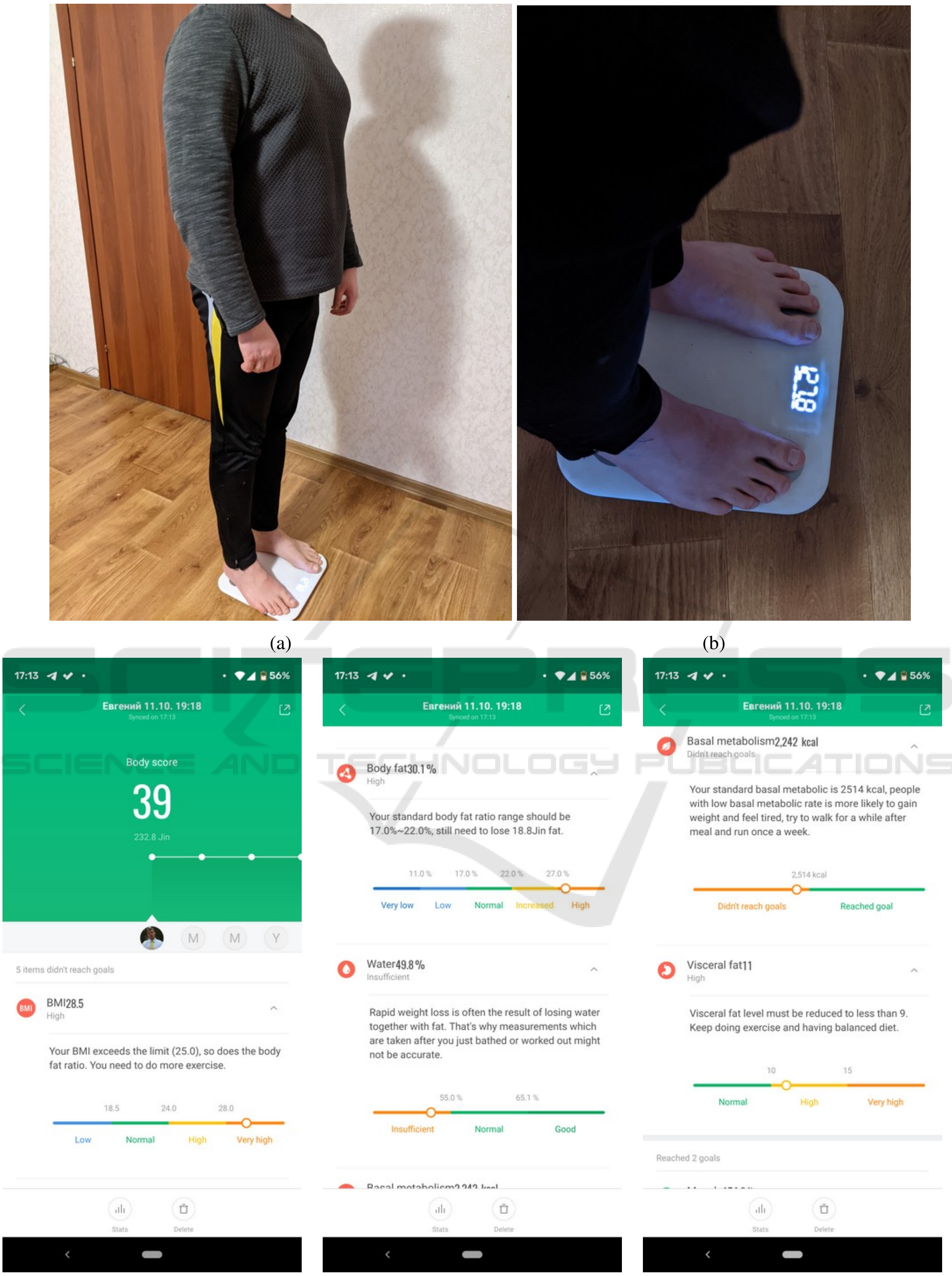


(a) (b)

Figure 4: Interface of smart watch's application sleep tab (Amazfit Zepp) (a) and the result of the analysis (b).

fat and bone tissue and compare the actual and relative speed of change in the amount in boys' and girls' bodies.

It is necessary to mention that the method is simple and promising to use in every school, especially since it does not require sophisticated, expensive smart equipment. At the same time, it is useful because students measure the real indicator, compared to the traditional process, and they also learn to analyse data and graphs on their smartphone. Also, students are more motivated to research after the class. To analyse the data, we need to find regularities in the amount of muscle, fat and bone tissue and compare the actual and relative speed of change in the amount



(a) (b)

(c) (d) (e)

Figure 5: The procedure of weight measuring (a), example of weight displaying (b), interface of integral automatic weight state assessment (c), details of body state (d, e).

of muscular, fat and bone tissue in boys' and girls' bodies.

Topic: Determination of the level of saturation in suspected COVID-19 (figure 6).

Figure 6: The result of oxygen content in blood determination.

Aim: to teach students to measure the level of blood saturation (oxygen concentration) in the blood, which became especially relevant during the COVID-19 pandemic.

Equipment: IoT or smartwatch or fitness tracks with monitoring of oxygen concentration – saturation.

Experimental procedure: Measure your oxygen concentration in blood by smartwatch/band. If the value is less than 95%, consult a doctor immediately.

Analyse of data: This experiment can be performed once, and can be exported to Excel for a long time every day. In a healthy person, the level of saturation is the same and does not depend on any factor.

4.4.2 Methods Performed for a Long Time

Topic: Diet effect on body parameters, especially on the amount of muscle, fat and bone tissue (figure 7).

Aim: Demonstrate to students the relationship between diet and the amount of body fat, to form an understanding of healthy nutrition.

Equipment: smart scale.

Experimental procedure: Firstly, student measure the amount of muscle tissue, fat tissue, bone tissue using a smart scale. Based on the results of measuring the amount of fat, muscle, bone tissue in your body, students define a goal for themselves (for example, to get rid of fat tissue) consulting with a teacher and, based on it, chooses the diet. Students provide daily measuring of the amount of fat, muscle and bone tissue for sixth months, preferably in the morning before meals. The data can be analysed using a smartphone or using an Excel table.

Analyse of data: Students must define the efficiency of the diet and make conclusions about personal fitting of the diet. Students must analyse the tendencies by determining the specific periods (stressed state of the organism and adaptation).

The method can be used in every school, but it is a lengthy experiment. It would be better if the research would conduct under the supervision of a teacher or adults. It can be used as a source for data for research works for students researching contests.

Topic: The physical activity effect on sleep duration and heart rate (figure 8).

Aim: Demonstrate to students the physical activity effect on heart rate and sleep duration.

Equipment: Smartwatch or fitness tracks with heart rate monitoring functions; blood pressure, oxygen concentration (optional).

Experimental procedure: Measure the duration of sleep and heart rate, blood pressure, oxygen concentration (optional) without physical effort before going to bed for a week. After that, 3 hours before sleep, do one of two things:

1. Perform three times thirty squats and three times ten push-ups; repeat the exercise cycle four times a week; leave three days to rest.
2. Perform a 2-4 km run each day for six days per week (1 day left to rest).

Each day students must provide measuring the duration of sleep and heart rate, pressure, blood oxygen level. Enter your blood pressure, heart rate, long and short sleeping phases into the Excel table, and analyse the results.

Analyse of data: Compare the measured parameters before the activities and during "active" week. Define are the quality of long phase of sleep is increased, define the changes of heart rate before sleep. Compare the obtained data to well-being.

The method is simple and can be used in almost every school, especially considering that only smartwatch/band are required. It can be used as a source for data for research works for students researching contests.

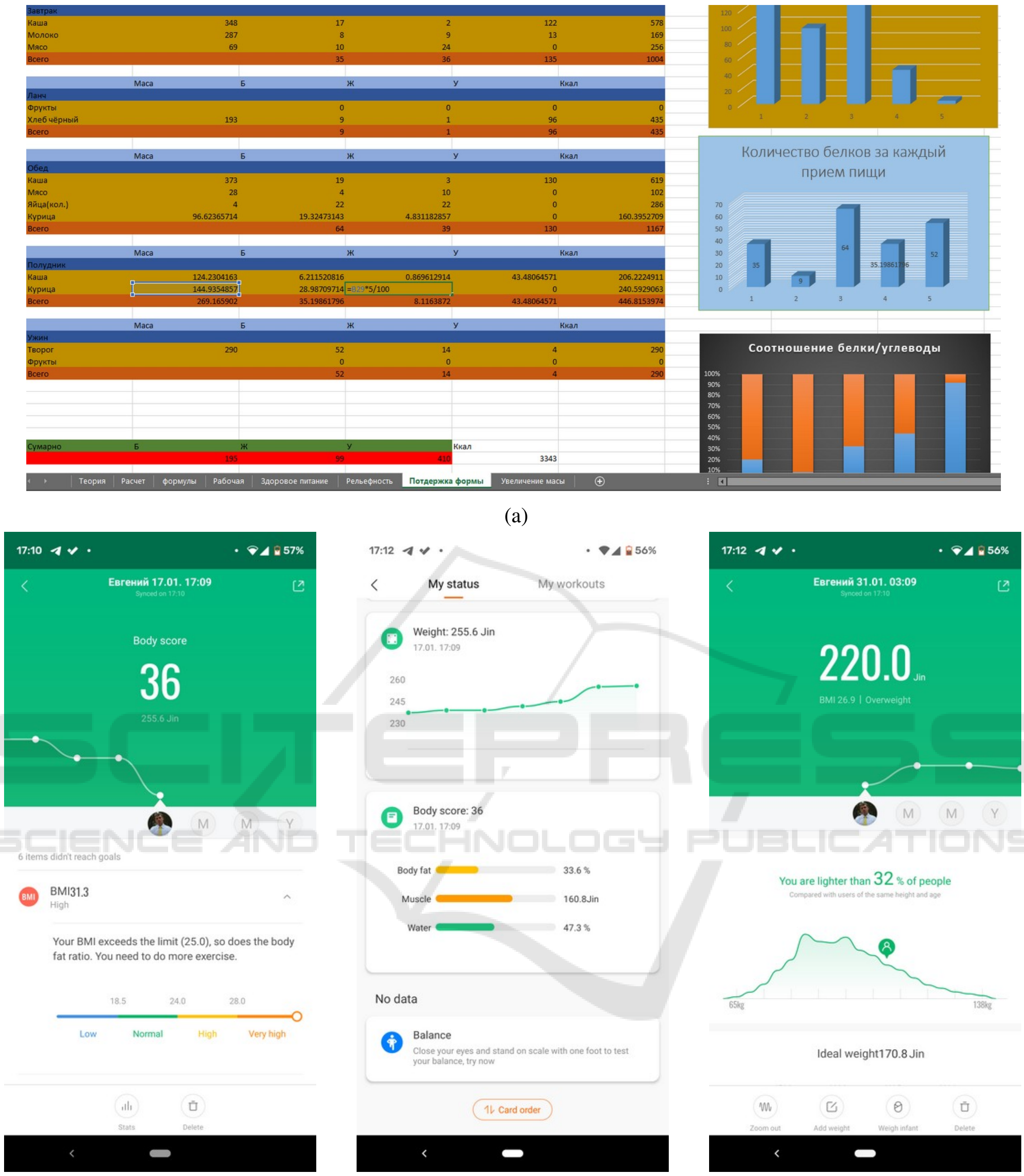
Topic: Physical activity effect of human muscle and fat tissue amount.

Aim: Demonstrate to students that regular exercise increases the amount of muscle tissue.

Equipment: smart scale.

Experimental procedure: Measure the amount of your muscle tissue using a smart scale. Starting the next day, perform one of the two options:

1. Perform three approaches for 30 squats and three times for ten push-ups. Repeat the exercise cycle four times a week. Leave three days to rest.



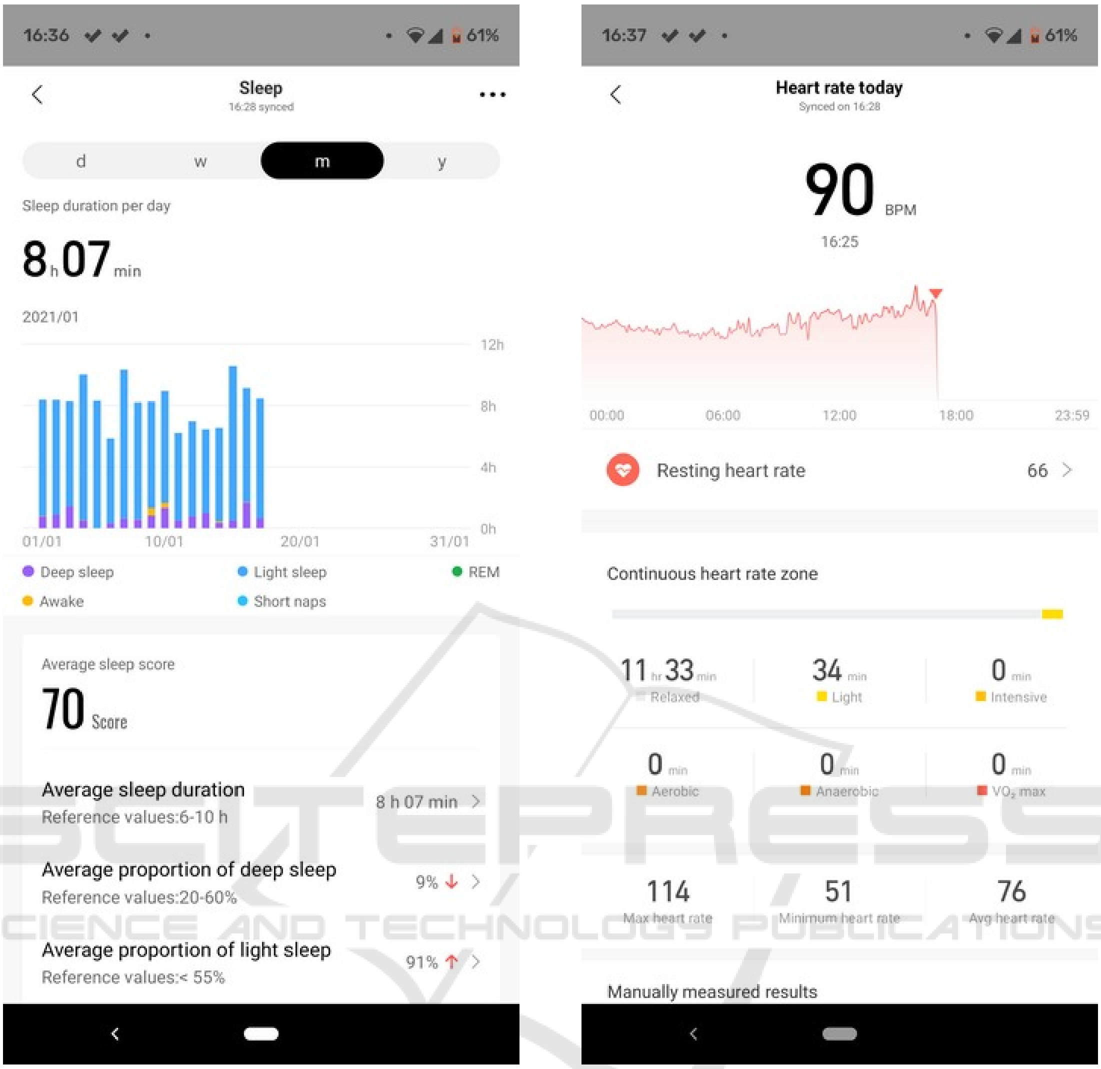
(a)

(b) (c) (d)

Figure 7: Screenshot of the method of mathematical modelling of student's nutrition ration (a), dynamic of the automatically body state estimation (b), current state of the body (fats, muscles, water content) (c) and weight dynamic and comparing with other users (d).

2. Make a 2–4 km run every day. Measure your muscle tissue using a smart scale over sixth months. Measure the amount of your muscular tissue using a smart scale every day for sixth months. Capture data with smartwatch/band interface as data or import it into Excel, and at the end of the year analyse the data on your muscle tissue development.

Analyse of data: Analyse the dynamic of the weight changes and its content. Define, the tendencies in changes of fat and muscles tissue amount. Define, changes in time stages (stress and adaptation). Calculate the weight of fats and muscles lost during the research. Try to define as the process of decreasing fats linear, or it has steps. Describe the steps if



(a) (b)

Figure 8: Dynamic of the long and short stages of sleep (a) and dynamic of the heart rate (b).

they were. The method involves performing exercises close to sports, which is why a preliminary medical examination and teacher's supervision are required.

Topic: Influence of fitness zone training on resting heart rate.

Aim: To teach students to individually calculate the maximum heart rate and the number of contractions that correspond to the fitness zone of physical activity, to select a set of exercises, the implementation of which will determine the required heart rate.

Equipment: IoT or smartwatch/band or fitness tracks with heart rate monitoring functions.

Experimental procedure: Students measure heart rate with a smartwatch/band. Then calculate your maximum heart rate according to the formula:

- For the girl $209 - (0.9 \times age)$
- For the boy $214 - (0.8 \times age)$

Then count 70–80% of maximum heart rate. This will be the optimal amount of heart rate during exercise. Students need to choose their own set of exercises, which will require the number of heartbeats controlled by a smartwatch/band. After three months of regular exercise, students measure their resting heart rate again.

Analyse of data: Define the optimal physical activity provides a student's heart rate in the fitness zone. Define the mean physical activity in the group and compare the individual results. Define dependencies of optimal physical activity to sex, weight and age.

When doing work, students learn to use smartwatches/bands and process their data.

5 CONCLUSIONS

The amount of the smart tools increased due to its usability and transcendent performance. In 2022 may be represented up to 1.1 billion of individual smart instruments due to shift from 4G to 5G. That means every seventh person on the Earth will use smart tools. So, firstly the concrete methods, which can be used during educational researches of STEM based process has been introduced.

At the first time, “As is – To be” BPMN method was proposed to evaluate the effect of the proposed method. By using of these methods were proved that using of personal smart tools during STEM education characterizing by enhanced automatization and provide developing of student’s thinking, using of graphs, calculation and involving students to conduct of the individual researches.

Training, health-preserving control, ergonomic, mathematical competences, competences in the field of natural sciences, engineering and technology and social competence can be achieved using personal smart tools to provide educational researches.

“Measure of the heart rate before and after physical activity with smartwatches/bands”, “Effect of sleep duration on heart rate”, “Determination of differences in muscle, fat and bone composition in men and women”, “Determination of the level of saturation in suspected COVID-19”, “Diet effect on body parameters, especially on the amount of muscle, fat and bone tissue”, “The physical activity effect on sleep duration and heart rate”, “Physical activity effect of human muscle and fat tissue amount”, “Influence of fitness zone training on resting heart rate” methods has been developed and ready to use.

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