

STEMkey
Module
IO4



**Human anatomy and
physiology with
smartphones**

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CONTENTS

Summary.....	2
Subject Introduction	3
Key Competence Approach	5
Learning Outcomes.....	9
HE Module plan	10
Materials and resources	10
Evaluation	Error! Bookmark not defined.
Transdisciplinarity.....	Error! Bookmark not defined.
References	Error! Bookmark not defined.
Further readings	Error! Bookmark not defined.



Summary

Human anatomy and physiology with smartphones

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Introduction: Human anatomy and physiology is part of almost all comprehensive primary and secondary school curricula in the world. However, teaching and learning about these topics is considered difficult. Majority of the students have smartphones and tablets with the power of supercomputers in the past. Therefore, it would be unwise not to use them as devices in schools and teach students how to use them outside school as part of lifelong learning.

Objectives:

- To develop model activities which can be used in classrooms or outside it with the application of smartphones.
- To develop model activities based on observation, counting, and measurements by application of tablets or smartphones.

Methods: Practical works were tested with students – prospective biology teachers as a part of regular curriculum in Biology didactics.

Results: In addition to introduction (Know your smartphone) three activities based on observation (Smartscope), counting (Smart hearth), and measurement (Coagulation of proteins) were tested, and protocols were prepared.

Conclusions: It was shown that introduction of such activities in prospective STEM teacher courses raise not only knowledge but enrich creativity, critical thinking, and problem solving strategies as well.



Subject Introduction

In biology there is a body of knowledge (topics) that can be considered traditional. One of these topics, taught in probably all schools in Europe, is human anatomy and physiology (hereafter HAP), enriched with health and environmental education, which necessitates the inclusion of these topics in the initial training of teachers.

At the school level, the content of HAP, especially in the anatomical part, is canonized and is not subject to major changes over time. The differences between primary and secondary education are mainly in the comprehensiveness provided for each age level and school type, as well as in the facts to be memorized. Šiling & Šorgo (2017) have shown that what students learn in biology classes is fragmented and not connected to the biological hierarchy levels. According to the finding that students prefer active methods, teachers should introduce such methods into their lessons to make them more challenging (Tranter, 2004). In biology, active methods are usually associated with laboratory and field work, although the latter are not suitable for HAP instruction. With regard to the development of key competences it has already been recognized that it is possible to improve a number of competencies through computer-based laboratory work (e.g., Šorgo et al., 2008), especially mathematical competencies, competencies in science, technology, and engineering, and digital competencies, as well as to enhance other competencies (Šorgo & Špernjak, 2009).

Since the invention of smart pocket devices with the power of supercomputers from the past, we can observe that young people organize their lives around these devices (Boyd, 2014). Therefore, it would be unwise not to use familiar technologies in the biology classroom. While smartphones are regularly used (unless banned) for computation, communication, and in terms of information literacy, they are rarely or never used in the biology lab as a data collection system for gathering environmental data as a tool for observation, counting, and measurement as key principles of school-based hands-on activities.

The basic idea of module IO4 is to introduce smartphones into the HAP classroom by creating new and adapting existing biology lab exercises for smartphones and tablets using the devices' internal sensors (e.g., light sensor, gravity sensor, camera, etc.). In this module HAP, work is done within the framework of the secondary school biology (science) curriculum. The development of new and the transformation of traditional laboratory work into smartphones can be considered a novelty in biology teaching, with the possibility of transferring it to a family of similar practical activities.

The module is divided into four sections following the basic principles of hands-on work. The planned labs are gender neutral and can spark interest in STEM /ICT regardless of gender. They can also be accessible to different groups of students through the use of built-in applications.

Activity 1: Know your smartphone

Students are asked to explore the capabilities of their own (or teacher-provided) smart devices and the sensors they contain. At the end of the activity, their tasks, which involve creativity, critical thinking, and inquiry-based strategies, provide ideas about the potential use of smartphones in the HAP classroom.

Activity 2: Construct Your Own Smartscope

Observation is a key process and skill in the life sciences. Knowing that objects can be visible or invisible to the naked eye provides insight into the level of cells and tissues. Students are encouraged to construct their own microscope using a combination of smartphone and home devices.

Activity 3: Heart Rate

Many processes in a body follow discrete patterns and can be the subject of frequency analysis. Counting is a process to obtain data, such as the number of cells in body fluids, heartbeats, etc. Students should use a smartphone to assess the factors that affect heart rate.

Activity 4: Coagulation of proteins

Direct or indirect measurements are basic methods to obtain data on continuous variables such as weight, length, etc. The light sensor in a smartphone is used to emulate a dynamic colorimeter.

All modules are about connecting digital devices and everyday experiences (HAP). Because of the near-universal availability of smart devices, there is an opportunity for students to conduct advanced and inexpensive experiments in HAP in nontraditional settings, such as at home, in their own privacy. Therefore, exploring one's own body in a noninvasive way through labs can help expand knowledge and understanding. The principles learned through smartphone data collection can be easily applied to measurements in their living environment and other biological topics.

NEEDS ANALYSIS

It is common knowledge that teachers at the beginning of their careers are not necessarily well prepared for a demanding profession. Since it is impossible to prepare them for all the situations and technologies they might encounter in their workplaces, it is important that they learn some generic skills and applications of the latest technologies. The Framework for Technological Pedagogical Knowledge (Mishra & Koehler, 2006) is an appropriate framework. The philosophy of the course will not be just to follow the manuals, but to adapt and improve them.

TARGET GROUPS

The primary target audience for the course is future biology (science) teachers teaching HAP. However, due to the common use of mobile devices as measurement tools, their use is also foreseen in the other biology chapters (e.g., plant physiology, ecology) or in any other STEM subject.

Recalling the original statement (Boyd, 2014), it would be unwise not to provide students with familiar technology in biology classes. However, there is little evidence of the use of smart devices in hands-on biology labs, so the envisioned work will pioneer at least some areas.

PROBLEM SOLVING

Problem solving is one of the key competencies, skills, or abilities that are tested daily by everyone. These activities provide a context for demonstrating how common technologies can be used for educational purposes.

CRITICAL THINKING

Critical thinking through the use of smartphones can be defined as: "The skills to use ICT to make informed judgements and choices about obtained information and communication using reflective reasoning and sufficient evidence to support the claims." (Van Laar et al., 2017). However, the definition can also be extended to the entire educational context. Since much of the work is delegated to students, critical thinking methods and principles can be introduced in this context in all phases of the development, application, and evaluation cycle .

ANTICIPATED IMPACT

Future biology teachers will be able to use smartphones as laboratory tools in the classroom HAP. They will also be able to transfer these skills and knowledge to other areas of biology and science.

TRANSFERABILITY

There are two possible roles of technology in laboratories. The first is to work on the same topic from the perspectives and using the methods of different disciplines. The second approach is to use the same technology and test it in different contexts. Basically, for example, measuring the strength of sound and a sonogram follow the same procedures in different living and non-living environments, combining physics and biology. HAP is a universal topic in probably all secondary schools in Europe, so the project manuals and ideas are universal. Consequently, they are suitable for any institution that trains biology (science) and elementary school teachers.



Key Competence Approach

To be innovative, productive and competitive in the global context, the European Union has recognised that the knowledge, skills and abilities of the European workforce are an important factor. Due to increasing internationalisation, rapid change, and the constant introduction of new technologies, it has been recognised that the goal of education should not only be to train citizens to keep their specific job-related skills up to date, but also to ensure that they have the generic competences that enable them to adapt to change, which can also contribute to their motivation and job satisfaction and thus influence the quality of their work (European Union, 2007).

Against this background, the Council and the European Parliament adopted a European Framework of Key Competences for Lifelong Learning at the end of 2006. This framework identifies, for the first time at European level, the key competences that citizens need for their personal fulfilment, social inclusion, active citizenship and employability in a knowledge-based society. Member States' initial education and training systems should support the development of these competences in all young people, and adult education and training provision should provide real opportunities for all adults to learn and maintain these skills and competences. The list was updated in 2018, but the basic message remains the same. These original eight key competences recognised by the European Parliament are: Communication in mother tongue; Communication in foreign languages; Mathematical competence and basic competences in science and technology; Digital competence; Learning how to learn; Social and civic competence; Initiative and entrepreneurship; Cultural awareness and expression.

All of the competences listed are considered interdependent and equally important. However, this does not mean that every school subject or teacher can contribute equally to the development of each competence. In science subjects, we can divide the listed competences into three groups (Špernjak, & Šorgo, 2009b). The first group includes the core competences: mathematical competence and basic competences in science and technology, as well as digital competence, in the development of which the science subjects play a dominant role. The second group includes the competences in which science subjects are on par with other subjects. Such competences are learning to learn, initiative and entrepreneurship. The third group includes competences in which science subjects play a minor role compared to other subjects: Communication in the mother tongue, communication in foreign languages, social and civic competences, and cultural awareness and expression.

Before their implementation in the classroom, all of these competences need to be operationalized. For operationalizing competences in science education, a different list proposed by the Mayer Committee (1992) is used. This report identifies seven key competencies that people should acquire before entering the workforce: (a) Collecting, analysing, and organising information; (b) communicating ideas and information; (c) planning and organising activities; (d) working with others and in teams; (e) applying mathematical ideas and techniques; (f) solving problems; and (g) using technology. There is much overlap between the two lists, but Mayer's list of general competences is more appropriate for science classrooms. In addition, Mayer's list fits better with the idea of

cross-cutting competencies embedded in the European framework and lists fashionably named 21st century skills.

The problem with the recommendation to include all competencies for teachers of a regular subject (e.g., science) is that competency-based didactics is still at a very early stage and lacks models that can be directly applied to actual teaching. While it is assumed that all competences are equally important, it is very unlikely that every teacher contributes equally to the development of all eight competences when teaching their subject. Therefore, interdisciplinary and transdisciplinary collaboration among multiple teachers is a plausible solution. This strategy is most often used in the context of project days or specially designed events that constitute only a small part of the curriculum. While such an approach can lead to some plausible results, it cannot be easily transferred to the prevailing traditional schools. Due to organisational problems, it is almost impossible to organise such a strategy on a daily basis in traditional schools with fixed daily schedules.

Consequently, activities need to be developed that are embedded in the science curriculum and in regular classes that follow the traditional schedule and enable the teacher to teach the multicompetency approach. The problem is that teachers of a particular science subject may have extensive pedagogical content knowledge in the subject they teach, but not in the core disciplines needed to develop other competences. For science teachers, the core competences are "Mathematical competence and competence in science, technology and engineering" and "Digital competence" while they need to support the development of the other competences. Therefore, helping students develop creativity, problem solving, and critical thinking as transversal and cross-cutting skills not only brings digital literacy and science and scientific literacy (competences) to a higher level, but also the other competences as well. The best part is that such strategies can be combined in the regular classroom by a teacher without having to rearrange the lesson plan.

With the ubiquitous use of computers, and more recently with the advent of smart portable devices (smartphones and tablets), it has become possible to incorporate many experiments into science lessons that were unthinkable in traditional school labs. As shown in previous analyses of hands-on work, it is possible to teach students how to collect, organize, analyse, and report data and results while developing problem-solving skills and critical thinking using computer-based laboratories. While experiments with computers and data loggers are limited to the classroom, the use of cameras and sensors in smartphones allows students to experiment on their own and apply what they learn in new contexts. A new window is opened to make school science a lifelong skill.

In Module IO4 Human Anatomy and Physiology with Smartphones, knowledge, skills, and attitudes can be achieved through four hands-on activities that follow the basic principles of laboratory and field work, as follows. The first activity is designed to introduce learners to the instruments (smartphones) and the principles of data collection, organization, analysis, and interpretation. It serves as an entry activity for the other activities. The basic approach of the second activity (Smartscope) is to observe objects that cannot be seen

with the naked eye. The third activity (heart rate) is about counting, and the fourth activity (protein coagulation) is about measurements. All activities are open-ended and allow for extension to other biological topics and to other STEM disciplines, opening a window for innovation and creativity.





Learning Outcomes

For open-ended assignments, such as those proposed in module IO4, the learning outcomes can be formulated as follows:

At the end of the module, students should, through active participation in all activities, completion of all assigned tasks, homework, and reflective feedback:

- gain insight into the capabilities of their smartphones;
- be able to complete activities according to guidelines and suggestions;
- adapt model activities that can be done in the classroom or outside of the classroom using smartphones
- adapt model activities based on observation, counting, and measurement using tablets or smartphones.

Materials and resources



IO4 Module plan

The module IO4 can be divided in sections and four activities. Only the first activity (Know your smartphone) has fixed position at the beginning of the course. The Order of the other three activities is only optional. Additionally, each activity can be replaced by an activity with similar objectives. The course and each activity is further divided in four main domains:

- pre-lab activities
- work in the laboratory
- homework and assignments
- Summative evaluation

Summative the length of the module should not be fixed but students' suggestions should be explored. However, the suggested lengths is at least 8-10 lesson hours. The time can be shortened in a way, that only the first activity (Know your smartphone) is obligate to all, and the other activities are divided among students as a group work. In such case, the proposed time can be condensed to two 90-minute sessions and an extra hour for discussion about their homeworks, if any.

Individual activities are presented separately.

References

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