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Teaching Mathematics and Computer Science

Mobile devices in Hungarian university statistical education

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Abstract. The methodological renewal of university statistics education has been continuous for the last 30 years. During this time, the involvement of technology tools in learning statistics played an important role. In the Introduction, we emphasize the importance of using technological tools in learning statistics, also referring to international research. After that, we firstly examine the methodological development of university statistical education over the past three decades. To do this, we analyze the writings of statistics teachers teaching at various universities in the country. To assess the use of innovative tools, in the second half of the study, we briefly present an online questionnaire survey of students in tertiary economics and an interview survey conducted with statistics teachers.

Key words and phrases: statistics education, mobile learning, statistics education in Hungary.

MSC Subject Classification: 97-01, 97U70, 87K80.

Introduction

Before the 2000s, there was no base for research in statistical education, and searching for relevant studies was difficult for those interested in this field of science. The reason for this is that studies related to this topic have been published in papers of various disciplines (e.g., psychology, natural science education, mathematics education or educational technology) and are often considered research on these topics. Reflecting on this realization, in 2002 the Statistics Education Research Journal (http://www.stat.auckland.ac.nz/~iase/serj) was founded, thus the research of statistical education has the first scientific online journal which focuses exclusively on high-quality research. The subject of the studies is the investigation of a statistical activity, or the research of the introduction of a technological tool and teaching method (Noll, 2007). Moreover, some statistics teachers have focused their attention on studying students' learning in the classroom (e.g., Chance, 2002; Lee et al., 2002). Most of these studies are conducted by the researchers in their own classes, sometimes they examine only one class, but sometimes they involve several ones within a given institution.

It was also the website of IASE (International Association of Statistical Education) where we came across the list containing more than 130 doctoral dissertations, written and uploaded by students of different departments from all over the world since 2000 (http://iase-web.org/Publications.php? p=Dissertations). Research on the teaching/learning of statistics in higher education is significant also because there is an extremely large number of students in the introductory statistics course of the training program of natural sciences. Among the above-mentioned dissertations, we studied those that are about the research of the technological device (e.g., J. H. Shamatha et al., 2004; T. T. Starling, 2011) or teaching method (e.g., Noll, 2007). We did not find a dissertation on the use of mobile devices in classrooms.

Due to the large number and variety of research related to statistics education in higher education, Garfield et al. (2008) made a list of the various topics:

(1) How can technology be used to support statistical reasoning?

(2) How effective online education is?

(3) What do students remember after completing the statistics course?

(4) How effective active learning is in teaching statistics?

(5) How can formal statistical ideas be developed from informal ideas?

(6) Can the training improve the statistical problem-solving ability of students?

(7) What is the role of student success in learning statistics?

(8) How does the students' reasoning develop during the statistics course?

Of these ones, we follow specifically the studies of the first topic. We see that one of the main areas of international research related to statistics education is the involvement of technological tools (in the 2000s, computers, graphing calculators, software and the Internet). Many studies have been dealing with this since the 2000s. In summary, it can be said that:

- Simulations performed with technological tools significantly influence the understanding of statistical concepts (Lane & Peres, 2006).

- DelMas et al. (1999) helped to learn the concept of distributions with a simulation program, as it was possible to perform several samplings from various populations.
- Lane and Tang (2000) compared the effectiveness of simulations for teaching statistical concepts to the effectiveness of a textbook (Garfield et al., 2008).

This list clearly shows that the role of simulations is significant, which leads us to conclude that the use of technology promotes specifically the representation in the learning process of mathematics. We know that visualization plays a significant role, as students need vivid images, often the first step in problem-solving is drawing, which helps to understand and record concepts. At the same time, it is also important for conjectures (intuitive work), problem solving and heuristics. In the following, we briefly describe the mathematical representational competence and the models of mathematical representation, in both cases referring to the possible involvement of mobile devices.

Mathematical representational competence is essential because different representations (presentation, drawing, expression) of mathematical objects, processes, relations, and situations are of fundamental importance in learning mathematics. This is also supported by the results of brain research, since in terms of working memory, we separate verbal and visual memory stores, i.e., we can represent the same information in two ways if one store is saturated and the other store is used (Ambrus, 2004). However, we must pay attention to maintaining the balance between the verbal and visual areas, so as not to overload either of them. Moreno and Mayer (1998) recommend following these principles:

- *Principle of multiple representations*: animation appropriate from a didactic point of view and teacher's explanation together are the best, so the student builds two types of representations (e.g., GeoGebra applet about the statistical task and the teacher's comment).
- *Principle of simultaneity*: visual presentation and verbal explanation must occur at the same time; they must be present in the working memory simultaneously so that the knowledge construction can be created.
- *Principle of divided attention*: in addition to visual presentation, we explain verbally, not in writing, thereby avoiding overloading the visual library (Papp-Danka, 2014).

Also, it is important to use Bruner's (2004) three basic forms of representation:

- *Material (enactive)*: learning takes place through specific material activity, manipulation; e.g., dice roll, a specific representation of rolling the dice.
- *Visual, pictorial (iconic)*: learning takes place with the help of illustrations and imagined situations; e.g., in a game, the number 6 or not the number 6 is interesting. We do several experiments and count the frequency of rolling 6s, then plot it on a bar chart, this is a visual representation.
- *Symbolic*: here the introduction of mathematical symbols is already in effect and the language has a prominent role (initially mother tongue, then this is replaced by the knowledge of the technical language and later the formalized language by using the computer); e.g., in the case of dice rolls, we perform several experiments and count the frequency of 6s, then calculate the probabilities. If we write down the method of the calculations based on the appropriate formula, the students will see a symbolic representation.

Thus, Bruner distinguishes between three types of representation and considers it effective if we follow the order and gradually move from object representation, through images, to symbolic representation. It is immediately noticeable that mobile use can play a role in the visual representation stage, so it is worth introducing it at that point. In summary, it can be said that for the effective development of representational competence, it is recommended to keep the representational planes in mind, paying attention to the order and the transition between them, too, and at the same time to balance the visual and verbal memories.

Models of mathematical representation

Models of mathematical representation are based on the theory presented above by the American psychologist Jerome S. Bruner (1915-2016), and are developed further. First, we present the Lesh model, which completes Bruner's model with real situations, and then the Johnson model, completing the Lesh model by technological representation.

The Lesh Translation Model of multiple mathematical representations differs from Bruner's theory of representation in that regarding symbols it discusses written symbols and spoken ones separately. Also, it introduces real situations as a way of representation, for example, measuring ingredients when making a cake. Kovács (2018) mentions that the importance of situations was already emphasized by Tamás Varga (1987, pp. 28–31), drawing attention to the need for situations in which students recognize and formulate what needs to be done (the task).

We think that it is difficult in class (especially in higher education) to put students in a specific (objective) situation during a task, but it is recommended to use the imagined situation. Figure 1 below illustrates how students move between the five modes of mathematical representation to construct the mathematical concepts, this is called the Lesh Translation Model (Lesh et al., 1987):

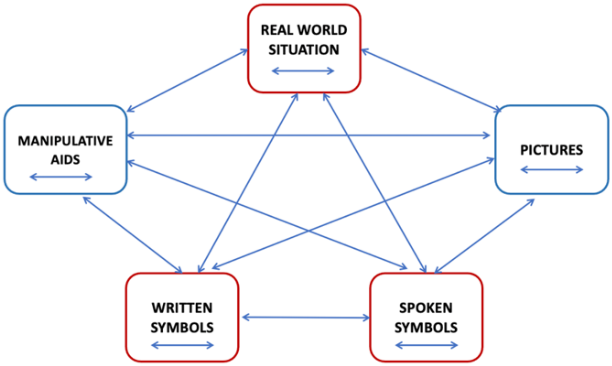

Figure 1. Lesh Translation Model of multiple mathematical representations (Lesh et al., 1987)

- *Manipulations* or *specific representations* (Bruner's object plane) allow difficult concepts to be mastered in a developmentally appropriate, practical, experiential way (see the example above in the case of Bruner's model).
- *Pictorial representations* can be manual or computer-generated drawings and represent specific objects (see the example above in the case of Bruner's model).
- *Real-life situations* refer to events and objects in the world that enable students to explore mathematical relationships. In the above example, in board games, we decide the number of steps in the next turn by rolling the dice. Other examples could be using money in a grocery store, measuring ingredients when making a recipe, or measuring wooden beams when building a garage, etc.
- *Symbolic representation* refers to the actual letters, digits, and/or symbols used to represent numbers, formulas, or any other numerical, algebraic, or geometric concept (Lesh et al., 1987). We classify them into two groups: *written* and *spoken* symbols. A spoken symbol is a tool used to express an idea,

concept, relationship, or mathematical generalization through speech, for example, spoken in a language understood by the student. Written symbols represent any means by which an idea, concept, relationship, or generalization of mathematics can be expressed in writing. Of course, these two are naturally connected to each other (Abed & Hassan, 2021).

With this addition, the model became more comprehensive than Bruner's one had been and reflects the student's understanding by being able to represent ideas, concepts, relationships and mathematical generalizations in a variety of ways.

Johnson (2018) suggests completing the Lesh model with a technological representation that is actually the same as a moving image display, so it is a new form of representation. To create technological representations, you need a tool which can be a tablet or phone application, a computer program, a website, etc. Johnson makes this suggestion based on a study he wrote. As described, three teachers videotaped the classroom work for five average days. By the analysis of the research based on the video recordings, the representations of the Lesh model appeared in the following proportion: manipulations were used in 12.4% of the teaching time, pictorial representations in 24.1%, written expression in 18.6%, and verbal communication in 45%. While analysing the data, it became necessary to create a separate code for the use of technology (computer, Prometium Board and iPad, among others), and as examined, 18% of the total learning time was spent using technology representation. This 18% includes parts of pictorial, written, and verbal representation, which affects the degree to which they are used, but does not affect manipulations or real situations. In addition to analysing the video recordings, he interviewed the teachers, too. Teachers reported that they often used technology instead of manipulatives due to lack of time or behavioural issues, but at the same time, technology is viewed as a bridge between manipulatives and static images. Technological representation can be seen in action when movable and/or manipulated images, diagrams and graphs, digital representations of real situations (e.g., rolling dice using an augmented reality (AR) application and not real dice), educational videos, etc., appear in the classroom. The National Library of Virtual Manipulatives (http://nlvm.usu.edu/en/nav/topic_t_3.html) has a variety of manipulatives covering primary and high school curriculums. GeoGebra (www.geogebra.org) is a well-deservedly popular educational software in Hungarian public education, which provides a dynamic way of representation, giving, for example, the opportunity to observe the curve of normal distribution in the case of changes in the data. Also, many applications support technological representation. According to Johnson (2018), technology has come to the fore, and concrete manipulations and paper-and-pencil-based representations have fallen into the background. As a result of the research, she extended the Lesh diagram by using technological representation, saying that in today's average classroom, we should see this in action (Figure 2).

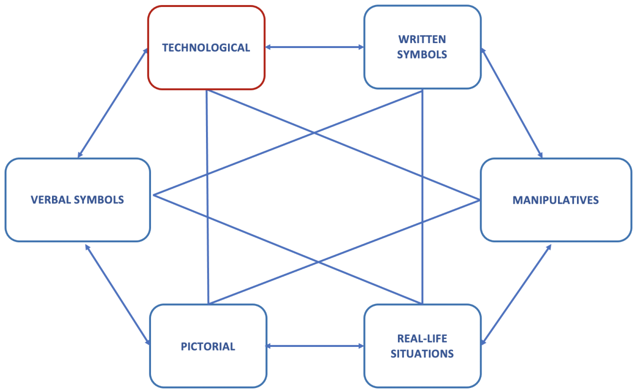

Figure 2. Johnson Mathematical Representation Model

Mobile learning (m-learning) in statistical education

Mobile learning is an educational method that creates a special educational environment and takes learning to individuals through mobile devices (Traxler, 2009). The connection range of mobile devices and applications can also be set within the application to enable local communication within the classroom, or more specifically, within the groups via Bluetooth or Wi-Fi. Alternatively, they can be configured to allow communication with others outside the classroom and access information on the Internet, as collaboration is an important aspect of m-learning. Likewise, students can only connect directly to the teacher (i.e., to a central device that the teacher has access to) and indirectly to other students through the teacher. Of course, students can connect with each other directly (Roschelle et al., 2003).

Several theoretical models have been developed to describe mobile learning (Koole, 2009; Peng et al., 2009; Kearney et al., 2012), in our paper, we briefly describe the TPACK model (Figure 3) developed by Koehler and Mishra (2008). According to this model, effective teaching in a digital environment can be realized if technological, pedagogical, and content knowledge is available and takes equal weight in the framework of the technological knowledge of teachers. Considering the frequent use of the TPACK model in previous research, which includes those related to assessment (Schmidt et al., 2009), measurement of student achievement (Lyublinskaya & Tournaki, 2011), and teacher education (Lee & Hollebrands, 2008), we think that this model is the best tool to use as a basis for planning our own research. Also, another pro of TPACK is that Handal et al. (2014) developed an application evaluating system using TPACK to select the appropriate application.

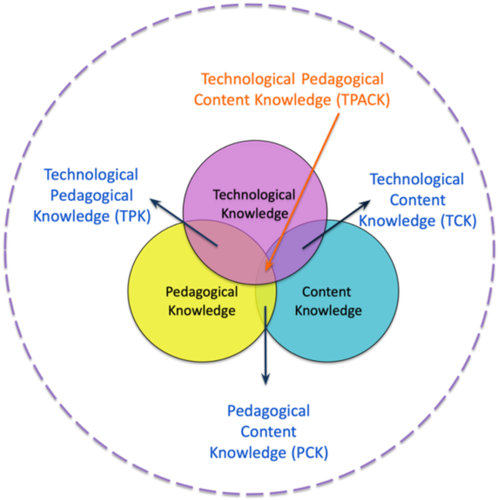

Figure 3. TPACK model

The structure of TPACK is not set in stone being obligatory to be accepted but during work (creating an educational video, redesigning an educational website, designing an online course) it becomes clear how dependent the three components are on each other (mutually dependent).

Koehler and Mishra (2008) state that (prospective) teachers should be given the opportunity to participate in designing technological education. During the conducted research, the participating teachers forever understood the complex interaction between content, pedagogical and technological knowledge, i.e., their TPACK developed.

Advantages and problems of using mobile devices in learning

Of course, as with all methodological innovations, we must keep in mind the pros and cons, and always consider the use of tools. Interactivity, motivation, creativity, and innovation are often mentioned among the arguments in favour of the use of mobile devices in classrooms. Sometimes the advantage provided in differentiation is emphasized, and it is also said to be useful in the practice of knowledge verification, evaluation, and attendance records. Their use can also help with group work, collecting opinions and practising the course material. With online software or mobile applications, the course material can be processed faster, thus leaving more time for analysis and discussion. In our opinion, in university statistics education, it helps students to activate and immediately visualize a task during lectures. We would consider their use particularly effective where practical statistics lessons are not held in a computer room. We think it is important to check the calculations on paper or use them instead of more complicated calculations, and to make accurate representations.

Of course, we need also to talk about the pitfalls of including mobile devices in learning, we have collected the problems we consider important.

For example, on the part of the teachers, there may be a lack of methodological justification, or incorrectly applied methodology, or excessive attachment to a tool or method. Technical development is far ahead of didactic development, which is why we can expect a lack of teacher competencies, so unification, organized counselling, and regular exchange of experiences are necessary (Kovács, 2008). Lesson preparation requires increased foresight. Teacher responsibility can be a problem when choosing a tool.

On the side of students, the lack of critical thinking can also be a problem, as it often happens that they accept the results without thinking them through. At the same time, students' proficiency in using the software may differ, which can hinder efficiency and cause negative emotions. In the following, we present the document analysis first, followed by the online questionnaire completed with the students and the interview research conducted with the teachers. The contents of this article are summarized in Figure 4.

Document analysis

To present the methodological renewal of statistical education from the 1990s to the present day, we performed a document analysis. To this end, we studied the writings related to the topic and highlighted the section on the use of tools, so we got an idea of the appearance of different technologies in Hungarian statistical education.

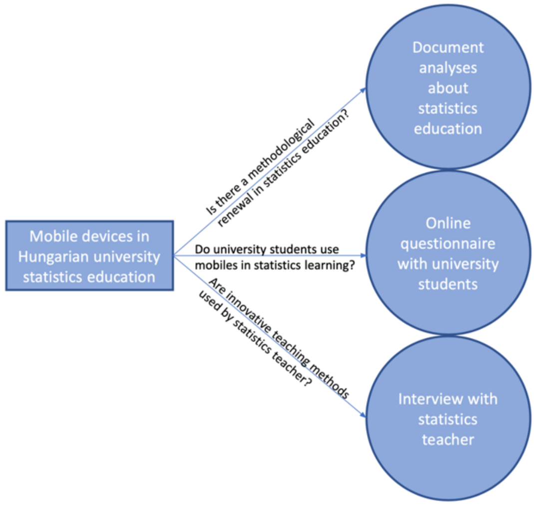

Figure 4. A summary of the studies presented in the article

Reading the literature relative to the topic, we found that in recent decades the Statistical Review has focused most on the methodology of the statistical education in higher education institutions, during which computer support has arisen every time.

The Education Subcommittee of the Statistical Committee of the Hungarian Academy of Sciences prepared a detailed report in 1999 describing their surveys of statistics education. A total of 41 institutions of higher education were interviewed in a questionnaire survey, giving a relatively complete picture of the state of the statistics education. The study mainly sought to answer the question regarding which statistical topics are taught in the various institutions, in what form and in what depth. The article reveals that the compulsory form of education in statistics is more in-depth than its alternative and optional education. It should also be emphasized that statistics are taught as a compulsory subject in colleges of economics (Hunyadi et al., 1999).

Balogh and Vita (2005), who discuss computer education in statistics, consider preferring the use of Excel over various professional but less accessible and less user-friendly packages. In their opinion, in the case of introductory courses, statistics education supported by Excel is a good option, as it has many advantages:

- individual steps of data analysis and the entire process can be easily followed;
- graphical presentation of the data, the most important feature;
- the behavior of individual indicators can be easily followed by purposefully changing one or more basic data;
- makes accessible to students' statistical concepts that are often elusive, such as sampling variance and sampling distribution;
- it multiplies the amount of analysis that can be carried out in a practical session of a given duration, and thus frees up time for practising the correct interpretation of results.

The authors of the article foreshadow their plan to try Excel-supported education for the first time in the second term of the 2004/2005 school year within the framework of the Statistics II subject. In mass education, in this case with more than 1,000 students, there is no possibility to hold practical classes in a computer room, therefore, they decided to use Excel passively or semi-actively. Passive use means that the way you use Excel and the figures and analysis results produced with it are organized into Power Point slides, and these slides are presented. Semi-active use means that the teacher executes and projects Excel runs on the teacher's computer (Balogh & Vita, 2005).

In 2008, Rappai, an associate professor at the University of Pécs, wrote that the subject of statistics (subject group) in the field of economics training in the Hungarian higher education was in crisis. He explains this with the transition to the Bologna Process, the mass training being typical in Hungarian higher education, the lack of strict admission requirements (in his opinion, those admitted to economics education should be required to have Math baccalaureate included in the mathematics entrance score, currently it is optional), and the resulting inhomogeneous knowledge groups of students.

According to Rappai, the modernization of statistics education is impossible if the following three suggestions are not taken into account:

(1) educational thematic based on unique data: fortunately, most IT tools (software) also support primary calculations from individual data as opposed to the primary and comprehensive basic population;

(2) the role of informatics: data collection, re-presentation and further analysis of the data should come to the fore, and we should not only use informatics to show algorithmic procedures for emerging problems;

(3) assessment of IT support: nowadays the question is not whether we use IT tools or not, but to teach statistics or data analysis (Rappai, 2008).

Kovács's article entitled "Modernizing the methodology of statistics" was also published in 2008. In this, the author sees that the subjects themselves taught in statistics in bachelor's degrees in economics are the same in all Hungarian higher education institutions, but there are significant differences in the methodology. At the University of Szeged, they try to combine the traditional methodology with computer support. It is also necessary to process the topic paper-based before computer-processing it, he says (Kovács, 2008).

According to Sándorné Kriszt (2018), students have the opportunity to learn about various types of statistical software, but their actual use and interpretation of the results are realized in most cases later during their work. The author of the study believes that this should be changed, and more time needs to be devoted to practical education. As an opportunity, she mentions the teaching of complex subjects that already exist in the business program, which consists of pooling economic mathematics, probability, statistics, and informatics knowledge.

The author accurately describes the purpose of statistical education in higher vocational education:

- the student is informed about the methodology;
- be able to manage and organize individual data according to the changing needs of the company;
- know the main function of graphic representation, the significance of illustration;
- be aware of and understand the most important descriptive statistical methods;
- can calculate and interpret ratios;
- have knowledge of indices and their uses;
- and be able to solve smaller project tasks.

She suggests what should be changed at the undergraduate level. To begin with, the first half and the final part of the analysis process should be given more weight. She thinks that it is necessary to teach students how to get data, but at the same time, they need to know what they can tell from the available data sets and what statistical correlations they can show. It is important to address the issues of data collection and data cleansing, but also more emphasis should be placed on teaching data visualization. In her opinion, students need to be able to ask their questions correctly, explain their problems accurately, and give methodologically correct answers to them. It is necessary to fully introduce the use of Excel.

In “Modern teaching methods in action in statistical classes”, Kovács et al. (2021) discuss the use of different innovative methods and modern technology in action in the field of Statistics. We can read about their experiments in some modern teaching methods, such as problem-based learning, project-based learning, thinking-based learning, flipped classroom, gamification, new technological devices, and the combination of these methods, as well.

After they present some active teaching techniques (problem-based learning, project-based learning, thinking-based learning, flipped classroom, gamification), several concrete classroom examples were introduced. Student experiences and opinions are mostly positive, they report those descriptive statistics topics are more likeable in that way. Educators tried to balance the statistical methods, the use of digital tools, and the social aspects.

Considering the above, we conclude that everyone urges the inclusion of technology, pointing out its advantages in learning statistics. After that, we would think that today at least Excel is used everywhere in the practical classes of statistics courses. It will be revealed hereinafter whether this is the case. It is important it would be to use the mobile phones in students' pockets, thereby facilitating understanding, speeding up the process of representation and making students more motivated and activated.

A pilot survey about the usage of mobile devices in the students' mathematics learning

When we started to take an interest in students' conscious use of mobile phones, we conducted comprehensive research in the 2017/2018 academic year, using an online questionnaire entitled 'Use of mobile devices in university students' mathematics learning'.

The purpose of this survey is to compare the mobile learning in higher education in three countries. These are Slovakia, Hungary, and Romania. Our main scope of this study was to survey the utilization of mobile devices in students' math learning (Koreňová & Veress-Bágyi, 2018). The questionnaire was originally prepared in both Hungarian and Slovak, but in this case we are only dealing with the processing of the Hungarian-language questionnaire. At the same time, it is important to emphasize that we asked the Hungarians, who are a significant minority in Romania and Slovakia too, with the Hungarian-language questionnaire.

Some of the most essential questions in the questionnaire

- Are students using smartphones, tablets, e-book readers and other technologies in their studies?
- Is there a difference between Slovakian, Hungarian and Romanian students regarding the usage of these technologies?
- What technologies do Slovakian, Hungarian and Romanian students prefer for study purposes?
- Are students using mobile devices for math learning? Which math applications do they know, and which ones do they use?
- Are their teachers encouraging the use of smart tools in the classroom?

Results

Although questions about statistics education are not listed separately, in this paper, we present the part of the research that is relevant to our later narrowed focus, namely statistical education. 263 (45,11%) men and 320 (54,88%) women participated in the study, men's age $M = 22.91$ years ($SD = 4.057$), women's age $M = 22.59$ years ($SD = 3.904$). Men and women do not differ significantly in age $t\,(581) = 0.964\,p = .335$.

In the sample, 374 people (64.2%) filled out the questionnaire from Hungary, 209 (35.8%) from Romania and 7 (0.01%) from Slovakia. Since the number of items in the Slovak sample does not allow inclusion in the analysis, the Slovak sample was excluded from the study. In the Hungarian sample, the proportion of men is 43% and the proportion of women is 57%; in the Romanian sample, men are 48.8% and women are 51.2%. The samples from the two countries do not differ significantly regarding gender proportions.

In the questionnaire, we listed 6 majors and gave the opportunity to enter other majors, however, during the analysis, we combined and classified the majors into four groups, namely economics 253 people (46%), sciences 217 (40%), humanities 68 (11.7%), and mathematics teachers (7%). The number of men studying economics in the sample is 85 (33.3%), while the number of women is 168 (57.7%); in sciences, the gender distribution is 145 (56.9%) men and 72 (24.7%) women. There are 19 (27.3%) men and 49 (72.1%) women in humanities; 12 (29.3%) men and 29 women (70.7%) in mathematics education. There is a significant difference in the gender distribution between the majors, $X^2(df = 3; N = 579) = 67.110\,p < .001\,\varphi = .340$, the difference is due to the fact that there are more men in sciences proportionally, and in the other types of training the proportion of women is higher.

We found a significant difference between Hungary and Romania in the proportion of answers received from the specialization of economics and from sciences. In the Hungarian sample, the proportion of students studying economics is higher, while in the Romanian sample, the proportion of sciences is higher. We found no significant difference in the proportion of humanities. However, in the case of mathematics teachers, we see that practically the entire sample came from Hungarian courses. The explanation for this is that there is no separate teacher education major in the Romanian teacher training, but the students who prepare also for the teaching career take a so-called Peda module in the given specialization, the subjects of which module are integrated into the semester subjects of the basic education. During further analyses, we take these differences into account, and in the case of a significant effect, we try to clarify whether the possible difference comes from the differences between the countries or from the specifics of the specialization.

In the first part of the questionnaire, we asked about the use of smart devices, listing several of them: smartphones, tablets, e-book readers, and others. Practically everyone has a smart device (Table 1). Those who do not have it are dropped from the sample.

	No		**Yes**	
	N	**%**	**N**	**%**
Male	7	2,6%	263	97,4%
Female	4	1,2%	328	98,8%
Total	**11**	**1,8%**	**591**	**98,2%**

$X^2(df = 1; N = 602) = 1{,}599\ p = {,}206\ \varphi = {,}052$

Table 1. The use of smart devices

Furthermore, you can see the distribution of smartphone function usage below, we have given more options (14 in total plus Other), and the diagram below (see Figure 5) shows the first eight most frequently marked smartphone usage habits.

The highest proportion of students use their phones to manage their emails (91%) and to take photos (90%), there is no significant difference between these two $p = .510$. This is followed by visiting social networking sites (87% use them), which is significantly lower than emails ($p = .007$), but does not differ significantly

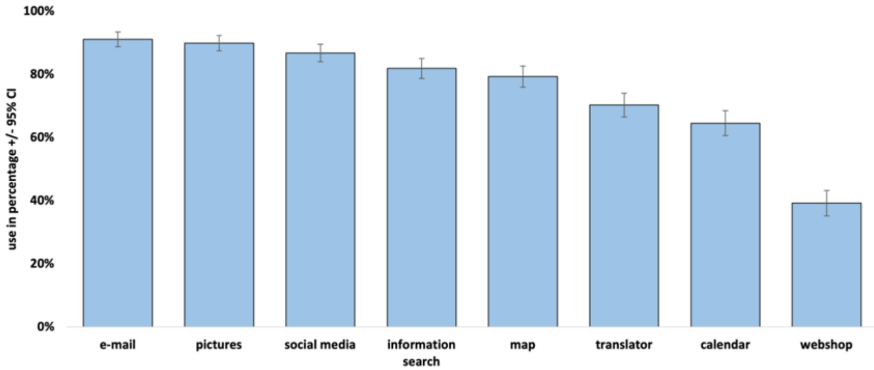

Figure 5. General usage of smart devices

from photos ($p = .070$). This is followed by the function of searching for information (82%), and the function of the map (79%), which is a function used to a significantly lower extent than social networking sites ($p = .015$ and $p < .001$), then dictionary (70%), calendar (65%), and finally, significantly ($p < .001$) less often than all the previous ones, the function of the online store (39%).

Then we asked students about the habitual usage of mobile devices during their learning process (Figure 6). One of the possible answers was: "for solving a math problem". We can see that more than 30% of the respondents marked that they also use it to solve math problems.

During the analysis, this question was also examined by major. We were interested in what proportion the various majors use their mobile phones also to solve math problems (Table 2).

	Yes		**No**	
	N	**%**	**N**	**%**
Economics	67	26,9%	182	73,1%
Real	82	38,3%	132	61,7%
Human	13	19,1%	55	80,1%
Math teacher	16	39,0%	25	61,0%
Total	**178**	**31,1%**	**394**	**68,9%**

$X^2(df = 3; N = 572) = 12{,}999\ p = {,}005\ \varphi = {,}151$

Table 2. Usage of mobiles to solve math tasks by major

The four specializations differ significantly in the extent to which students of the specialization use their smart devices to solve mathematical problems:

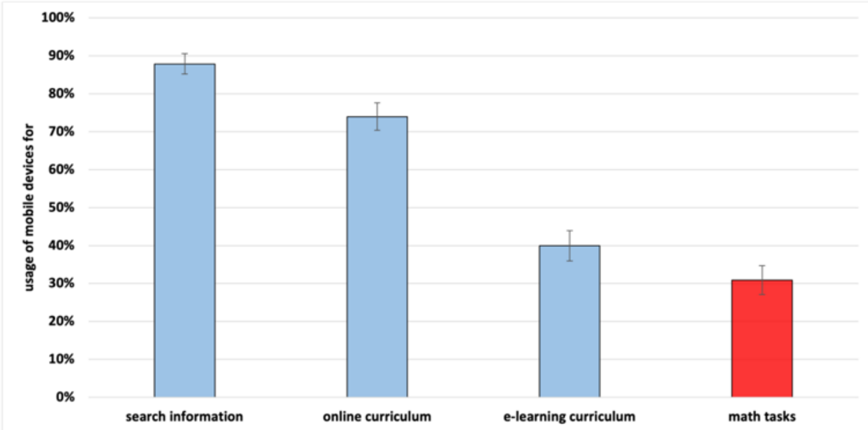

Figure 6. The habitual usage of mobile devices during their learning process

in economics this proportion is 26.9%, in sciences 38.3%, in humanities 19.1%, in mathematics education 39%.

Going further, we also analyzed whether there is a gender difference in the extent to which the tool is used to solve math problems (Table 3).

	Yes		No	
	N	**%**	**N**	**%**
Male	97	37,6%	161	62,4%
Female	81	25,5%	237	74,5%
Total	**178**	**30,9%**	**398**	**69,1%**

X^2(df = 1; N = 576) = 9,807 p = ,002 φ =- ,130

Table 3. Gender differences in the use of mobiles to solve a math problem

A significant gender effect can also be observed in the function of math tasks: 37.6% of men and 25.5% of women use their smart devices to solve math tasks. There is a significant, weak difference in usage between the sexes ($X^2(df = 1; N = 576) = 9.807\, p = .002\, \varphi = -.130$).

Later, we asked to what extent apps supporting math are used. We asked about several apps. Based on the results, the popularity and use of most apps are shown below (Figure 7). We mark that GeoGebra and Wolfram Alpha are two such apps that can be used well in statistics education.

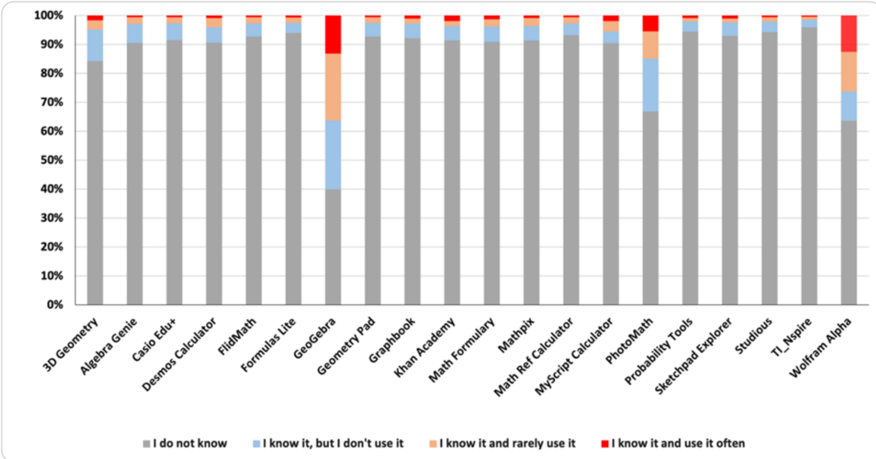

Figure 7. About knowledge and use of different math apps

Using a two-way ANOVA, we checked to what extent the use of mathematical applications is influenced by the specialization, and whether the applicant came from a Hungarian or Romanian university. Since the size of the sample of mathematics teachers in the Romanian sample ($N = 2$) does not allow their analysis, the group of mathematics teachers was excluded from the following analysis. The descriptive statistics of the sample are included in table below (Table 4).

	Hungary			**Romania**			**Total**		
	M	**SD**	**N**	**M**	**SD**	**N**	**M**	**SD**	**N**
Economics	-0,226	0,667	136	-0,493	0,805	45	-0,292	0,711	181
Real	0,753	1,102	75	-0,119	1,014	77	0,312	1,142	152
Human	-0,485	0,554	33	-0,747	0,425	18	-0,577	0,523	51
Total	**0,040**	**0,944**	**244**	**-0,320**	**0,919**	**140**	**-0,091**	**0,950**	**384**

Table 4. Use of mathematics apps by major and country

In the study, the homogeneity of standard deviation is not met $F(5.378) = 7.792\, p < 0.001$, which is because standard deviations are lower in the sample of humanities. Since the number of elements in this sample is also low, the harm of homogeneity of variance does not affect the first-type error, but only the probability of the second-type error. The test becomes stricter by that, but the results stay explainable. The effect of the specialization is significant: $F(2.378) = 33.612\, p < 0.001$ Part. $\eta^2 = 0.151$. The effect of the place of the course is also significant:

$F(1.378) = 19.421\, p < 0.001$ Part. $\eta^2 = 0.049$, and the interaction of these two is significant as well: $F(2.378) = 5.333\, p = 0.005$ Part. $\eta^2 = 0.027$. The nature of the interaction is illustrated in the graph below (Figure 8).

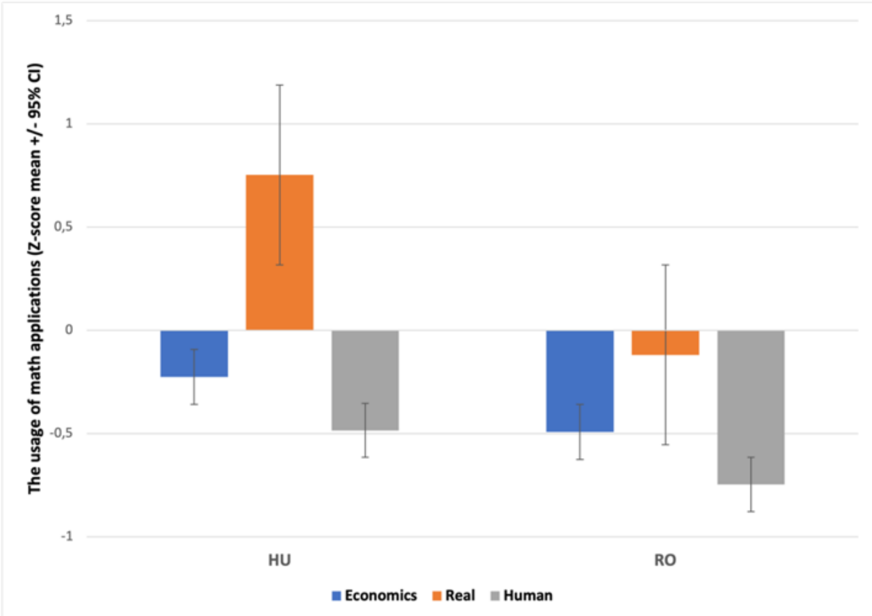

Figure 8. Use of mathematics apps by major and country

In summary, it can be said that in both countries, the students of the science education program use the apps to a greater extent, but in the Hungarian sample this difference is greater by orders of magnitude.

The above analysis of the data took place a few years after the end of the data collection, when the author of the paper made a data analysis with the help of a questionnaire for the author's dissertation. We extracted a part of these analyses and presented it above, highlighting the fact that it played a role in determining the focus group of our research, since we concluded that we were able to reach the participants in the economics course the most, which is mainly due to the mass educational nature of the mentioned major. Also, the economics course is a suitable target group for our planned research in statistics education, since this is where most people encounter the subject of statistics. We also took two statistics courses at Corvinus University for self-education, thereby gaining insight into the methodologies of both mass education and curriculum delivery. It was then that the decision was made to conduct a series of interviews with statistics teachers, the purpose of the research was to assess the practice of statistics education in Hungary. We will present this pilot survey hereinafter.

Interview research with statistics teachers

Studying the literature and considering the author's experiences during the attendance of two statistics courses in mass education, we think it is especially timely to deal with the methodological renewal of statistics education. Above all, we want to explore teachers' attitudes towards innovative methods. In this section, we examine the methodological renewal of educators through a series of interviews as a frame of an inductive, descriptive research strategy (Szabó-Thalmeiner, 2018). Due to the low number of interviewees (only five), we do not consider our research to be representative.

The research question is:
Are innovative teaching methods used by a selected group of statistics teachers?

The associated hypothesis:
It is not typical for Hungarian teachers of statistics in economics to use innovative methods to understand the curriculum better.

To accept or reject the statement formulated in the hypothesis, we conduct a structured interview with statistics teachers and evaluate it by qualitative analysis.

Preparation for the survey

The antecedent of the interview research was browsing the literature on the methodology of Hungarian statistics. During this, we saw there were relatively many articles and studies about the methodology of statistical education in the 2000s, when the involvement of computers began in many places. On the other hand, it is difficult to find articles from recent years, especially about the activation of students, group work, exploratory learning, and the involvement of mobile devices, in addition to the introduction of the use of Excel spreadsheets.

The interview research was conducted in the first term of the 2019/2020 academic year, with teachers teaching university statistics. The sampling type was convenience sampling, we searched the university for colleagues teaching college statistics. Ten teachers were contacted, but as we approached the end of the year, we were no longer able to meet three of them due to their busy schedules, and two teachers did not respond, resulting in an interview with five teachers. The five interviewees are not many, but we talked informally (e.g., in conferences) with more statistics teachers and the exchange of ideas with them is consistent with what is described here.

The questions asked in the interviews were compiled by us, considering the rules of the structured interview, which means that the questions raised to the interviewees were pre-recorded. In all cases, the interviewer was the author of the article, and in all cases we personally met at the location of the interview (workplace of the interviewee). The appointment was made via e-mail exchange. Another characteristic of a structured interview is that we must try to formulate the questions clearly, simply, and unambiguously, and to avoid suggestion. We tried to adhere to this rule, too.

Considering the order of the questions, ones raising initial interest were followed by questions important from the content point of view. Demographic questions were not included in the interview, as these were already known during the invitation.

The interviews per individual did not last longer than half an hour as we had announced. The location, with one exception, was the instructor's workplace. We informed everyone that we wanted to record what was being said so that the answers were not distorted during the notetaking. Everyone was cooperative and allowed the recording to be made.

Regarding the selected interviewees, it is important to note that they were chosen because the author read about them in the Statistical Review and in conferences publications as striving for innovation in statistics education. All of them have been teaching statistics for at least 15 years, all of them in economic education, two of them in mass education. It is also important to note that they do not only give a lecture, but also give a practice class, this is important, since most of our questions in the questionnaire require experience in this field. All but one of the responding instructors teach in the capital, and one instructor teaches both in Budapest and the countryside. One of them is the owner of https://www.stathelp.hu, the other is the co-author of GameSTAT, two gave a presentation at the "Statistics that Weaves Through Life" conference, and the fifth was my colleague at my former workplace. One of them asked not to be named, so we decided not to reveal the identity of the interviewees (in more detail).

Presentation of the survey experience

Considering the small number of respondents, we conducted fully qualitative research. For the analysis, we chose keyword analysis, where the keywords were highlighted from the text.

Question 1

What do you want to achieve by teaching the subject of statistics?

The student as a result of the course
a) understands the aims, the methods and the most important results of statistical science; b) is familiar with the uses of statistics (for research, etc.) and is able to interpret the results calculated with the software.
Please prioritize goals a) and b), as well as your other goals, if any.

To analyse the answers to the first question, we defined the codes *importance 'A'* and *importance 'B'*. The responses revealed higher importance of practice and less one of theory. Three respondents repeatedly mentioned the importance of practice during statistics education, among them one respondent clearly highlighted practice and one of them considers both to be equally important. Summarizing the answers, we can say that answer b), namely practice is considered more important by the instructors. This statement is in line with what Sándorné Kriszt (2018) says, who emphasizes that more time should be devoted to practice, and mentions the introduction of complex subjects as a suggestion.

Question 2

How do you teach statistics?

a) on paper; b) using a spreadsheet; c) another method

In analyzing the question, we divided the codes into two groups, one examining the use of tools, and the other the teaching methods. We asked the question in this way because we already saw (experienced) that these two options for teaching the subject of statistics are the most typical (paper-based practical lessons or Excel exercises).

Regarding the use of the tool, we have learnt that there is one respondent who does not use a spreadsheet or other statistical software at all, and one of them does not teach on paper at all, the others use a mixture of paper-based and software-based education. We have found out that four respondents' digital curricula are also made available to students. While reading the answers, we decided to define new codes, because, in addition to the choice of tools, the choice of the teaching method appears in several places. Two of the respondents carry on a mixture of frontal and practical education. Two interviewees do not do practice at all, they mentioned the high number of students or the lack of a computer room as a reason. Another instructor also mentioned technical difficulties. Two instructors emphasize the role of self-preparation.

Question 3

In what forms of work do students work in class?

a) individual work; b) working in pairs; c) small group work

The third question concerned the form of work expected of the students. In addition to individual, pair, small group codes, it became important to define another code when reading the answers, namely group learning outside of classes. Confirming the answers to the previous question, neither the pair nor the group work applies to the two teachers who do not teach in practice. Of the other three respondents, one expects pair and small group activities, and there is individual work in the classes of two teachers. Learning together outside of class is mentioned by two respondents.

Question 4

What do you personally think about group work or pair work?

From the answers to the fourth question, we find out what the respondent him/herself thinks about pair and group work. Three out of five think it is a positive phenomenon, yet two of them do not apply it. The attitudes of the two instructors are mixed. Several mention limitations such as difficult assessment, lack of time.

Question 5

In your opinion, are there areas of statistics education where we can leave discovery to students?

Three respondents were completely positive, one mixed, and one negative. Two of those who thought positively gave ideas, too, indicating a specific part of the curriculum (problem statement, ratios in descriptive statistics). It is important to note, related to this question, that three teachers think that a certain degree of guidance and support for the students is needed during the discovery.

Question 6

In your experience, do students think about interpreting the result? (*Do they practice critical thinking?*)

Four of the five interviewees perceive student activity as mixed; they claim that a small group of students think about the results, but the majority of them do not. A teacher is completely negative about the issue, he feels that despite repeated calls, students tend to accept the results without criticism.

Question 7

Have you ever considered using the students' mobile devices (*smartphones, tablets*) *in the practical statistics class?*

One respondent regularly uses end-of-class instant feedback in the form of online quiz questions, he is completely positive about the topic. Another respondent allows students to use it but does not ask them to have it, he has a mixed attitude to the topic. The other three respondents do not use it, but only one instructor rejects it completely, the two have a mixed view of it despite not using it.

Teachers listed both counterarguments and ideas. They say there are facts that are against mobiles: they are not available to everyone, thus creating inequality (mentioned by three of them); technical limitations such as small screen, lack of proper application and lack of time (mentioned by four); the possibility of fraud (mentioned by two); the controllability of the course (again mentioned by two); and social difficulties as disrupting communication between students and the experience of learning together, and having too much unorganized information available to the student on the mobile (mentioned by three).

Our hypothesis was fulfilled, because the results of this interview research suggest that new methods – small group work, exploratory learning, critical thinking, and the free usage of mobile devices – are rarely or not at all present in university statistics classes.

As we examined a small group of teachers, we do not aim to generalize the results. However, the experience confirms that we need to try to apply the methods raised in the questions in the statistical lessons as part of a new research area. We plan to experiment with the use of mobile devices in the context of small group exploratory learning as regards action research in the case of first-year students studying statistics.

Conclusion

Summarizing the experiences of the three experiments, firstly, we see that more than 30% of the students use their mobiles to learn math, we also see that statistics education reached the point to introduce mobile devices as a new technological tool, thirdly, we think that teachers are open, but mostly methodologically unprepared to start the implementation of mobiles in the curriculum (see Figure 9). They have doubts, they do not see the practical implementation feasible.

Here are some thoughts they raised about the usage of mobile devices: they are not available to everyone, thus creating inequality; technical limitations such as small screen, lack of proper application and lack of time; the possibility of fraud; the controllability of the course; social difficulties as disrupting communication between students and the experience of learning together, and having too much unorganized information available to the student on the mobile.

Figure 9. The results and conclusions of the experiments presented in the article

We believe that a methodological solution already exists for most of these issues (e.g., the possibility of fraud; the controllability of the course). However, there are some of them (e.g., the small screen, although large screen phones are manufactured nowadays) that can be a realistic barrier to certain parts of the curriculum. For the rest of the suggestions (e.g., lack of proper application and lack of time) the solution is to develop a new methodology.

Some additional remarks

In summary, we think we have thoroughly explored the current state of statistics education. In our experiments, we are most interested in the use of mobile devices, as can be seen from the results, in the statistics education it rarely appears. It is not included in the methodology of the curriculum, and we have not encountered any specific future efforts to do so. We think that it would be very timely, as a first step, to develop a methodological recommendation for some parts of the Statistics topic that would allow colleagues who teach statistics to start using mobile devices during class work. During both the lecture and the practical lesson arise situations where it is the most obvious solution to involve and consciously use the tools available to students. In the following, we would like to address the development of the above-mentioned methodological recommendation.

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