What Are the Initial Measurement Skills of Medical Students?

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Abstract. *The background of measurement theory is provided to medical students at the Faculty of Medicine Comenius University in Bratislava (FMCU) within the biophysics course. The paper presents results of the research focused on collection of information about student's former physics education and characteristics of selected student's measurement skills (74 respondents). The research was realised using written questionnaire administered to 616 first-year-students and observation of 74 students during their practical training. In accordance to students' responses, totally 60% of them realized laboratory measurements as a part of their former physics education and more than three quarters of those students proceeded also measurement protocols (47% of all students). Short test and observation of students' practical skills showed that 35% of students did not discern the value of the smallest division while reading the measured value from a scale, 69% of students did not know to read the measured value while using the instrument with a band switch and multiple analogue scales. Research results show that students' initial knowledge and skills are not sufficient for effective study of biophysics. To facilitate understanding of evidence-based-medicine the even very essentials of measurement theory should be an integral part of medical-physics education.*

Keywords: education, measurement, skills, medicine

1. Introduction

There is no doubt about the crucial role of measurement in medicine and clinical decision-making. A medical doctor has to know to select the appropriate measurement method, proceed the measurement correctly, read the measured value, evaluate the measurement and interpret the result. Students learn most of specific measurement methods during their clinical training and newest methods also later in their praxis.

The background of measurement theory is provided to medical students at the Faculty of Medicine Comenius University in Bratislava (FMCU) already at the beginning of their study - within the biophysics course. Certainly, the biophysics course is built on the assumption that students acquired some basic physics knowledge and skills during their former education. For example, it is expected that students are able to perform elementary measurements of length, liquid volume, temperature, electric current and/or voltage and understand the term accuracy of measurement. Hence the explanation of general rules of measurement is not included in the training.

Does the assumption about student's initial knowledge and skills correspond to real circumstances? Are the first-year medical students prepared to study probability and theoretical distributions, numerical and statistical evaluation of measurements [1] that are essential for understanding medical research and evidence-based-medicine?

2. Subject and Methods

Two types of information were collected within the research - subjective characteristics of student's former physics education and objective characteristics of selected student's measurement skills.

Characteristics of student's former physics education were collected using the written questionnaire with short open questions and questions with simple choice of an answer (yes/no). The questionnaire was administered at the very beginning of the biophysics practical training in academic year 2014/15. Totally 616 first-year-students were involved in the survey (see Table 1): 362 students who finished their upper secondary study in Slovak schools studying General Medicine in Slovak language (GM_S) or Dentistry in Slovak language (D_S), and 254 students studying General Medicine in English language (GM_{En}) or Dentistry in English language (D_{En}). Students in English programmes finished their upper secondary study mainly in Germany 39%, Greece 21%, Italy 8%, Austria 7%, Poland 6% and Slovakia 6%.

Two questionnaire items were focused directly on measurement - we asked the students whether they performed laboratory measurements as a part of their former physics education and whether they elaborated measurement protocols as a part of their former physics education.

Table 1. The sample characteristics – Number of students answered the questionnaire focused on former physics education and number of students answered the short test

Study program	Number of students answered the questionnaire	Number of students answered the short test on measurement skills
GM_S	324	42
D_S	38	-
GM_{En}	220	32
D_{En}	34	-

Selected characteristics of student's measurement skills were collected using short test and observation of student's performance of simple measurement. Totally 74 students were involved in this part of the research: 42 general medicine students studying in Slovak language in the academic year 2013/14 and 32 general medicine students studying in English language in the academic year 2014/15.

The short test was administered at the beginning of the first biophysics practical training in order to identify student's actual skills and knowledge. One question was focused on reading the measured value from a scale. Next week students were observed when they read the measured value from a simple linear scale of the wet spirometer. One more week later students were observed when they measured illuminance using analogue luxmeter with a band switch.

3. Results

Measurement in Previous Physics Education

Summary of student's responses related to their experience with measurement during their former physics education can be seen in Table 2. Totally 60% of respondents realized laboratory measurements during their former physics education and more than three quarters of those students proceeded also measurement protocols (47% of all students).

Measurement Skills

Approximately one third of students did not discern the value of the smallest division (Fig. 1, Table 3). They assumed that it is 1/10 of centimetre. Nobody mentioned spontaneously the uncertainty of a single measurement. The item was discussed with students and explained.

Table 2: Summary of student's responses relating to measurement in their previous physics education.

	GM_S (N = 324)	D_S (N = 38)	GM_{En} (N = 220)	D_{En} (N = 34)	Totally (N = 616)
I performed laboratory measurements as a part of my former physics education	70%	75%	46%	27%	60%
I wrote/prepared measurement protocols as a part of my former physics education	55%	42%	41%	10%	47%

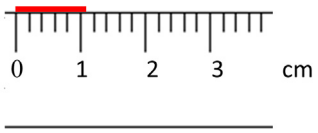

Fig. 1. Test question focused on measurement skills: What is the length of the line ?

One week later students measured vital capacity of their lungs using a mechanical spirometer, where the smallest division of the scale was "quite large" (note: the distance of two lines representing 0.5 litre was 1 cm). After the single intervention a week ago, still 27% of students were not able to understand that it is not allowed to divide the scale into smaller divisions (neither in their minds) to make the measurement more precise. One more intervention was given to these students about the uncertainty of single measurement and information given by the scale division.

Students faced a new challenge up when they used the analogue luxmeter with a band switch. Almost 69% of students were not able to choose the appropriate scale and read the correct value of illuminance. The item was explained to these students. Some of them needed repeated explanation with several different measurement instruments.

Table 3. Summary of student's measurement skills observation.

	GM_S (N = 42)	GM_{En} (N = 32)	Totally
Correct reading from a simple scale focused on smallest division of the scale. (1^{st} training)	66.7%	62.5%	64.9%
Correct reading from a simple scale focused on uncertainty of simple measurement. (2^{nd} training)	76.2%	68.8%	73.0%
Correct reading of the measured value with band switch and multiple analogue scales (3^{rd} training)	35.7%	25.0%	31.1%

4. Discussion

Though students in general accept the importance of measurement in clinical decision making, the non-formal discussion with students showed that they do not feel the necessity to improve their knowledge and skills. Most students believe in their competency to realise simple measurements, but this believe arise form daily-life experience not from the scientific and/or technological expertise.

Our research showed that the initial measurement skills of medical students at FMCU are not sufficient for effective study of the biophysics course. However the upper secondary physics curricula declare measurement as inevitable part of physics education and basic principles of measurement are taught usually already in primary schools, a lot of students expressed that they did not provide measurement as a part of their former physics education. The situation was significantly better among students studying in Slovak language than among students studying in English language (chi-square test $p < 0.001$). Similar findings came also from the research of FMCU student's initial factual knowledge in physics [2]: the average score among students studying in Slovak language was significantly better than the average score of students studying in English language ($p < 0.005$). These findings do not necessarily mean that the upper secondary education is more effective in Slovakia (note: The OECD findings in research on scientific literacy [3] showed that Slovak students are below the average). The above mentioned difference can be a consequence of the admission criteria that does not require any level of knowledge in physics.

Though new tools are developed to assess children's experimental skills (including measurement), to our knowledge no such attempt was realized to assess university students.

If students are not able to read the measured value correctly, how can they evaluate and interpret it? Our goal is to teach students to understand different measurement methods, to be able to select the best one in specific situation and use it correctly. But: if our students do not understand the very essentials in measurement theory, can we assume "this is not our job"?

5. Conclusions

It is a nowadays inevitability to consider students' initial knowledge and skills in teaching biophysics at the university level. Otherwise students will achieve neither real understanding nor operational knowledge nor expert competencies necessary in their future praxis.

Research results show that even very essentials of measurement theory should be an integral part of medical-physics education. It is a great challenge to do this in limited time, with growing content and decreasing readiness and motivation of students to study biophysics. New teaching technologies like e-learning, can help only partially. A practical training and personal involvement of teachers are irreplaceable.

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