The Connection of System SMPSL (System for measurement using a computer in the school laboratory) and CAA (Computer Aided Assessment) for Demonstration of Mathematical Modeling of Angle

RADEK NEMEC, ANDREA BERKOVA, PAVLA HANZALOVA
Faculty of Education, Department of Informatics, University of Hradec Kralove, Hradec Kralove, CZECH REPUBLIC
radek.nemec@uhk.cz, andrea.berkova@uhk.cz, pavla.hanzalova@uhk.cz
http://www.uhk.cz

Abstract: - The angles are very often used in practice and it is good to obtain knowledge of their approximate estimation. We can use angles not only in mathematics, but it is necessary for some professions – such as mechanical engineering, civil engineering or astronomy. During the practical lessons we can check the accuracy of estimation of different indicated angles with the SMPSL system and displacement sensor. It is shown using a graph of approximation drawing angle. Subsequently we can practice the ability to estimate different angles by using the CAA (e.g. Maple TA). The CAA system enters the angle graphically or by using angular (or radiant) rate. Students try to fit in the estimation to a certain (sufficiently narrow) interval containing a pictured angle in solving the task. CAA system is able to evaluate a solution and it is able to demonstrate the mistake graphically and numerically.

Key-Words: - DAQ, system SMPSL, measurement system, computer aided experiment, CAA, mathematical education

1 Introduction

System SMPSL is a measurement system using a computer in the school laboratory, which will be very cheap to assemble the hardware and software is available for free.

CAA means web-based system for testing mathematical knowledge. It is used for the production and distribution of learning materials, but mainly it is used for practicing, testing and evaluation of students.

We can demonstrate a different approach to practicing estimates of variously defined angles by combining these two systems.

2 System SMPSL

This system was designed as a cheap and flexible interface for recording the values of transmitting using via USB interface.

System SMPSL is based on eProDas platform, resulting in the University of Ljubljana, Slovenia. eProDas is very affordable system, easily attachable to a computer, offering many possibilities of measuring and processing of data [9,10]. It is suitable for science experiments. eProDas is seen as a platform for providing data acquisition and signal generation for performing different experiments in the natural sciences such as physics, chemistry, biology, medicine, mathematics and engineering.

SMPSL system consists of hardware delivery and control software available for free. Instructions for the preparation of the hardware and instructions for downloading software controls are on the website of this system: http://smpsl.radeknemec.cz.

The hardware part consists of a microcontroller PIC 18F4550 with programmed firmware (platform eProDas) and a few components [5].

The resulting product is composed of 4 analog inputs for connecting sensors, 4 digital outputs to trigger other devices and one analog output for regulating the output (Fig. 1).

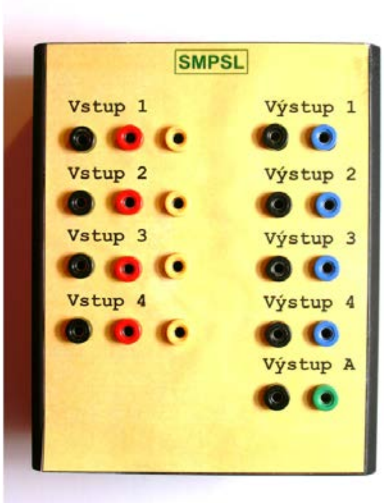

Fig. 1 – System SMPSL central unit

The connection with computer is ensured by standard USB interface, which is in charge of the power supply. Therefore it does not solve some complicated connecting to the computer and an external power supply.

The software part is a comprehensive utility program that is responsible for starting the measurement, its management and graphical output (Fig. 2). It consists of the main part (Fig. 2 a)) with the control of measurement and possibility of setting inputs including calibration and display graphical output (Fig. 2 b)). [6]

Fig. 2 a) – The main part of the management system

Fig. 2 b) – The graphical output

3 Systems CAA

CAA (Computer-aided assessment) is a web environment that integrates content, testing and communication tools for students and teachers. [1, 4,7]. Mathematical CAA system has special functions usable for testing of mathematical knowledge. It enables to work with graphs, number series and mathematical symbols. Students who work with this system can not only choose from the offered answers but also find their own solutions and the CAA is able to verify the accuracy of the answer. Some CAA systems offer Equation Editor (Fig. 3) similar to MS Word (it is simple to use for a user) for the input of symbols. Advantages of these learning systems are also tools for the administration of individual students and statistics of their results. Other advantages include the objectivity during the evaluation and saving time by teachers and students.

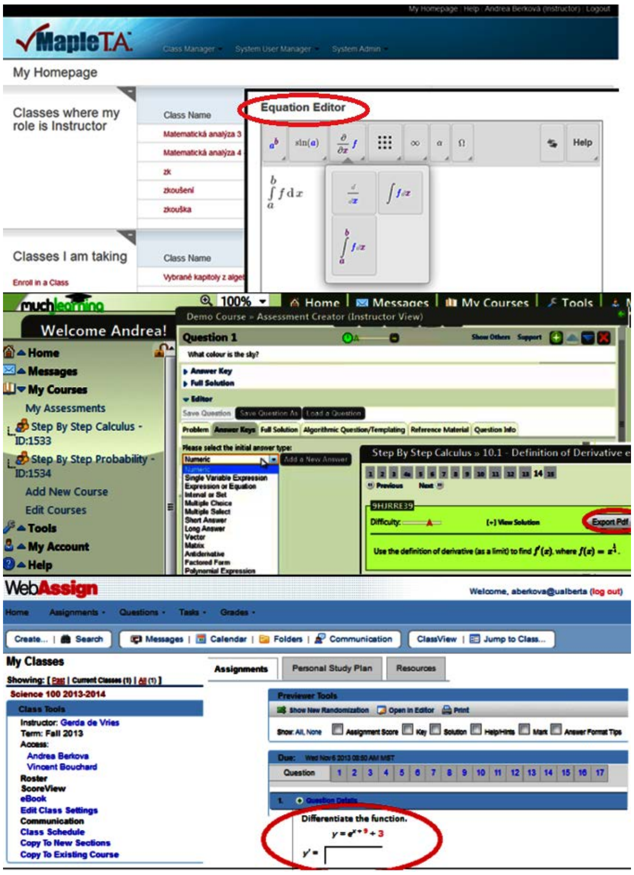

Fig 3 – Environments of CAA

It concerns among other the following systems: Online instructional system **WebAssign** which provides extensive content, instant assessment, and student's personal study plan [13]. **Maple T.A.** (built on the computer algebra system Maple) which is focused mainly on testing and assessment [11] or not so well-known platform **MuchLearning** [12].

These systems are the most common in Canada and the USA. Maple T.A. is already quite widespread in Europe. In the Czech Republic there is the use of these mathematical platforms still in its infancy [1,2].

4 Laboratory Activities

Laboratory activity is composed of worksheets whose range is four pages (Fig. 4). First, there is given a task, theory and space for the determination of angles which will be estimated. The angles are set according to the task and subsequently students draw it on the paper to verify by using system SMPSL with displacement sensor. Subsequently drawn estimates are compared to the measured angles.

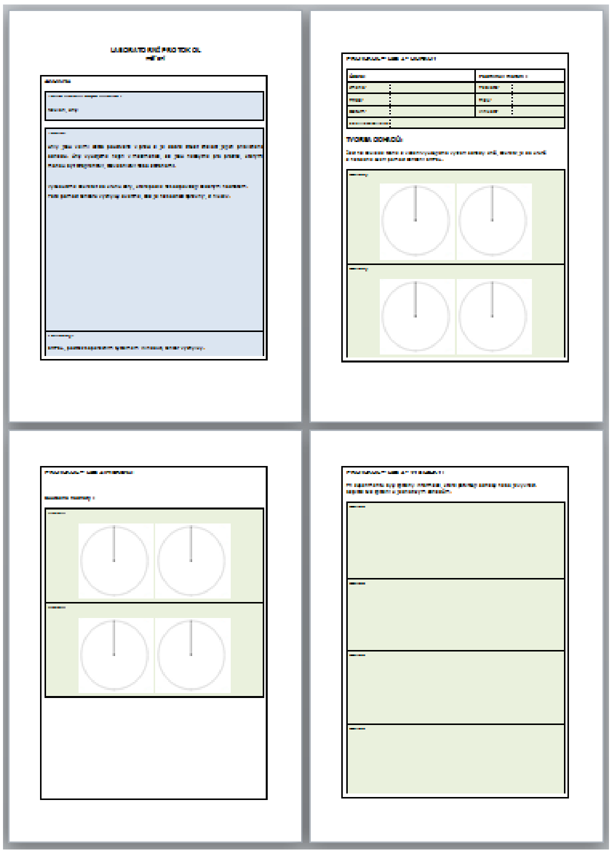

Fig. 4 – Laboratory protocol

Laboratory exercises focused on estimates different angles find their application in almost all fields of natural science. It could be connected with the teaching of radiant rate, trigonometric functions or deflection of different objects in Euclidean space. Using mathematical programs such as CAA system, student may be tested whether they mastered the issue or not. In addition, the CAA is also suitable means for continuous practice because there is a possibility to work on assignments repeatedly (CAA always chooses a new assignment randomly). Therefore students try different angle each time during the practicing.

4.1 Demonstration by Using System SMPSL

We connect the sensor for measuring angles to estimate the several entered angles by using SMPSL system (Fig. 5). We can see that it is built using a construction set "Merkur".

Fig. 5 – Angle sensor

The task for estimation of measurement by using the SMPSL system is to draw several angles of deflection on paper. These are the angles: + - 20 ° - + 40 ° - + 60 ° - + 80 - + 100 ° and back to 0 ° deflection. The SMPSL system displays the entered angle graphically and at the same time it displays the process how the student came to the specified angle. In Figure 6, we can see how the angles are changed depending on time (x-axis is a determination of time; y-axis is a record of angle). Next to the graph, there is a frame with the current value. A complete record of setting angle is generated during the graph plotting. You can see it at the bottom of the picture [3, 8].

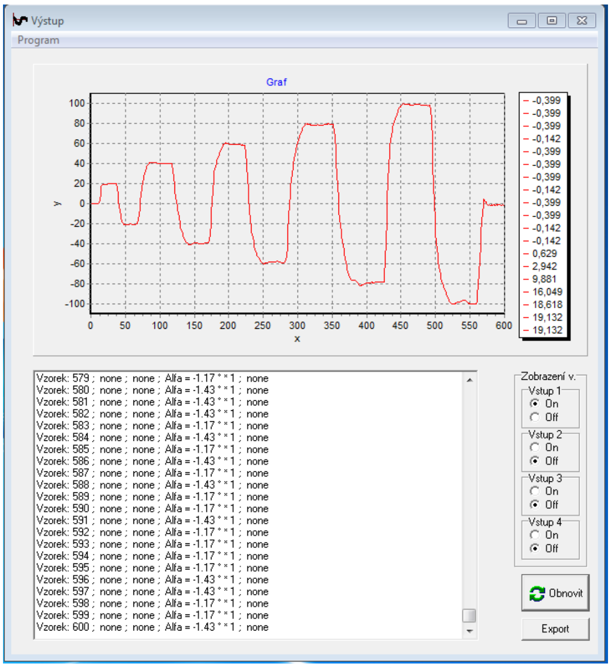

Fig. 6 – Graphical representation of the specified angle

4.2 Demonstration by Using System CAA

Using mathematical software seems very useful for the demonstration of angular (radiant) rate. For example, we get nice graphical outputs using the Dynamic Interactive Geometry programs or Computer Algebra Systems. First, there was the need to use any software for demonstration the angle. Secondly, we were looking for an apparatus which is able to verify the student's ability to estimate the angle and which is also suitable for practicing. Systems CAA fulfill all of these requirements. Tasks creating were motivated by the following three task types:

a) TASK1: We have the specified size of the angle (e.g. by using the radian measure) and our task is to mark the angle within a circle. Figure 7 shows an example of the specified angle, α=60°. We can see into what range (determined by a teacher) the student must fit in order to count the correct result.

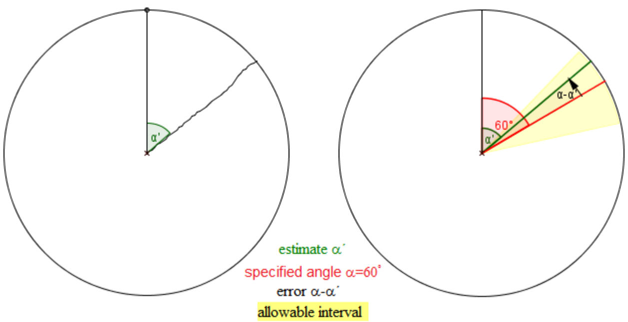

Fig. 7 – Graphical representation of TASK 1

As you can see, this is a similar task to the one solved in the laboratory exercises. The angle can be also specified in radian measure. In the CAA setting, a different angle is entered for each student. Then students mark the angle on the circle. The ways of marking angles may be variable in the different systems CAA.

b) TASK2: The angle is entered graphically. Out task is to estimate its size. In Figure 8, there is an actual example again. The first diagram is a specified angle. A student estimated its size as 92°. The second chart shows that student's estimation (plotted in green) does not fit in the allowed interval.

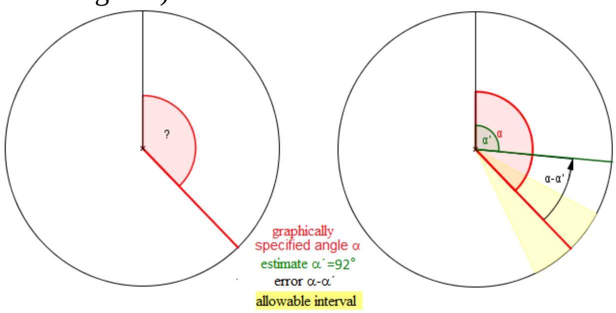

Fig. 8 – Graphical representation of TASK2

We can solve the TASK2 in the angular or radian measure. CAA systems are able to recalculate it. We created many other challenges (addition to these two basic tasks - TASK1 and TASK2), which arise by their aggravation or their combinations (e.g. TASK3).

c) TASK3: The angle is specified graphically (e.g. α). Our task is to draw a new picture with angle, whose sum with originally specified angle α is given the specific size (e.g. 60°). In this case we have to find the angle: 60°- α. Of course, the task may be not only graphical estimate, but also size estimate of this angle. This task may be varied in different ways. It turns out that accomplish a TASK3 is much more demanding for students than TASK1 or TASK2.

According to our experiences, the CAA has distinct advantages for teachers and students of mathematics, including support for independent students' creative thinking. It turns out that a good notion of the size of angles is important primarily for students of engineering studies because of their future studies and practice.

Therefore, we decided to perform pedagogical experiment with secondary school students focused on engineering and computers. Teaching the control group was led by the traditional way and in the experimental class was used SMPSL system and then system CAA Maple T.A. to practice. Test was focused on the axis of angle, transferring angle, radian measure, oriented angles and simple physical application. Results of this final test fell as follows (see Fig. 9).

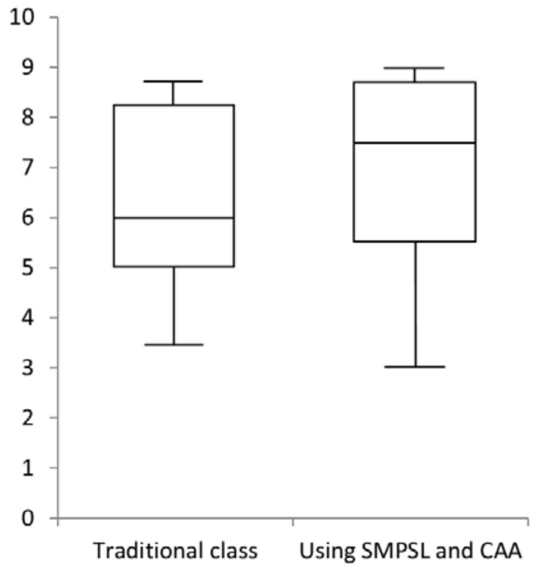

Fig. 9 – Results of the research

As we can see in the Figure 9, the median of students in the control group is 6 points and it is shifted to the lower quartile. Median of the experimental group is 7.5 points and it is shifted toward the upper quartile. The maximum score was 10 points. It is necessary to mention that the exercises were scored one point maximally. A proportional part of the point was assigned to a student for partially correct answer. There were not any outliers or extreme values. It is interesting that the worst result was in the experimental group and the best results in both groups were not much different (we can see from the graph that the best results were in the experimental group – 9 points, but in the control group these were by only 0.25 points lower). This does not affect the overall assessment. In the experimental group, there were more students with better results. It can be seen on the median and upper quartile as already mentioned. The box plot shows that students who have gone through the experimental teaching (SMPSL + CAA) have better outcomes than the control group students (traditional class).

4.3 Other Measurements

In addition to the above mentioned estimating and measuring angles, many similar phenomena may be presented and practiced on the basis of interconnection of system for measurement using a computer (system SMPSL) and CAA different platforms.

Damped oscillations can be one of possible example for other application of connection of real measurement and mathematical modeling. The result of the real measurement is shown in Figure 10. The y-axis shows an angle, which decreases gradually to be zero depending on time (x-axis) – it is the principle of the damped oscillation.

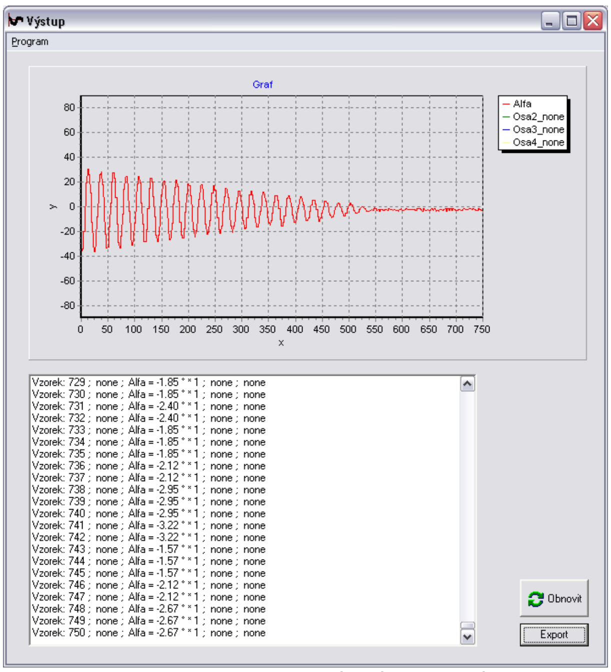

Fig. 10 – Measurement of deflection of roller

5 Conclusion

Implementation of different systems to representation of estimate the angle provides a better instilling the accuracy of angles. Science experiment for the use of ICT is for students learning about the innovation processes. They will gain practical skills and better understand the phenomena themselves. It is also beneficial to gain interest in the natural sciences and the actual motivation of students.

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Andrea Berkova is a Ph.D. student in the field of Information and Communication Technologies in Education. She is also a lecturer in the Department of Mathematics at the University of Hradec Kralove. Her research interests include Mathematical Analysis, Mathematical Education, Technological Innovations in Education, etc.

Pavla Hanzalova obtained master degree in Mathematics and Music in Education in 2013 at University of Hradec Kralove. She is a student of doctoral degree in Information and Communication Technologies in Education at the University of Hradec Kralove. Her scientific activities are modelling, simulation and ciphers.

Radek Nemec is a student of Ph.D. in the field of Information and Communication Technologies in Education at the University of Hradec Kralove. His research focuses on systems for Measurement Used in the School Laboratory.