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# WHAT DO PRE-SERVICE AND IN-SERVICE TEACHERS THINK OF EDUCATION IN COMPUTER BASED LAB?

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**Abstract**

*The research data taken from pre-service and in-service teachers during testing of newly designed real-time computer based experimental activities for education in Computer Based Science Laboratories are presented in the paper. The teachers' responses to selected items of a questionnaire evaluating the proposed activities for Chemistry and Biology were processed and interpreted. We considered several factors generating potential differences between investigated groups; (i) the significant differences between pre-service and in-service teachers, (ii) the differences inside the in-service teachers group generated by a particular school as an influencing factor and (iii) the different responses for Chemistry and Biology. All presented results relate to the partial study of the European project COMBLAB aimed to enhance the acquisition of science competencies in secondary school students by means of real-time computer-supported experiments in Physics, Chemistry and Biology.*

**Keywords**

*Pre-Service Teachers. In-Service Teachers. Computer Based Laboratory. Chemistry education. Biology education.*

## INTRODUCTION

A partial study of the European project COMBLAB (COmpetency Microcomputer-Based LABoratory) titled *The acquisition of science competencies using ICT real time experiments* is presented in the paper. The project is following the idea of enhancing the acquisition of science competencies in secondary school students using real-time experiments (Tinker, 1996) Researchers from six universities belonging to five EU countries are cooperating to achieve the main project goal - to design and implement new research-based learning materials for students and supporting materials for teachers useable in Computer-Based Laboratories in education of Physics, Chemistry and Biology. The prepared activities are student-centered, having a structure of inquiry guided performance proposed by Tortosa (2012) and following the Predict-Observe-Explain (POE) sequence (White & Gunstone 1992). The proposed versions of the activities were implemented and tested with secondary school students in parallel in all project-participating countries and the results are planned to be primarily used to revise and improve the activities to their final form.

## METHODS

In Slovakia the newly designed activities were evaluated by three groups of evaluators: (i) secondary school students, (ii) university students (pre-service teachers) and (iii) secondary school teachers (in-service teachers). Four research tools were administered to the participants during the testing in order to have a relevant feedback leading to revising and improving the proposed activities: two tests for student's motivation (Pintrich et al., 1991, McAuley et al., 1989) to reveal the student's self-perceived motivational orientation toward computer based laboratory and particular activities, and two different questionnaires (one for students and one for teachers) to evaluate the activities.

This study is focused on results arisen from the questionnaire for teachers. The data were obtained during the implementation of Chemistry and Biology activities and involve only the Slovak part of the project research. The study follows our recent works in the field considering students' motivational orientation and some of the interesting research aspects resulting from the questionnaire for students (Urban-Woldron et al., 2013, Tortosa Moreno et al., 2013, Skoršepa et al., 2013).

The Slovak part of the research on teachers included 8 *in-service teachers* (7 females) from four Slovak grammar schools. Only one of them had short previous experience with sensors and data loggers in the school science laboratory. Due to the serious lack of necessary equipment in the participating schools, all activities were implemented in the university laboratories (Matej Bel University) with invited secondary school students (N = 146). As the teachers involved in the research were not experienced in the field, they were not the tutors during the experimental sessions. Therefore, the activities were led by a researcher and his assistant. However, the teachers were present at the sessions as observers. Each teacher participated in evaluating more than one activity. Therefore, the total number of evaluations performed by 8 in-service teachers was 51.

Furthermore, 8 *pre-service teachers* (all females), the future teachers of Chemistry and Biology, participated in the research. None of them had previous experience with working in computer-based laboratory. In our research, the pre-service teachers were considered in two different ways: (i) as *students* and (ii) as *teachers*. Apart from the in-service teachers, the pre-service teachers performed the activities as students first and evaluated them using the research tools prepared for students (the tests for motivational orientation and a questionnaire for students). Afterwards, they were asked to evaluate the activities as teachers by filing in the questionnaire for teachers. However, it is important to note that this study considers them the teachers only and their student role is not taken into account in this paper (only data from the questionnaire for teachers were processed). Similarly to in-service teachers, each pre-service teacher participated in evaluating more than one activity, which led to 72 evaluations. The total number of evaluations realized by both groups of teachers is then 123.

The research tool – a questionnaire for teachers mentioned above, was administered to both, in-service and pre-service teachers, after performing the activities. The questionnaire was divided into 2 separate parts: (i) a *general part* about the teacher and his/her general experience in using ICT in the lab (administered once) and (ii) an *activity evaluation part* (administered per each participated activity) in order to evaluate the particular activity. The second part of the questionnaire consisted of 39 items related the particular activities concerning several aspects of working in computer-based laboratory. Among open questions, the most items were set as declarative clauses and the answers were aligned on a 4-level scale: 1- I strongly agree, 2 – I agree, 3 – I disagree and 4 – I strongly disagree. The data involved in the study comprises 9 tested activities - 5 for Chemistry and 4 for Biology (Table 1).

Table 1: Tested activities.

| | **Chemistry activities** | **Biology activities** |
|---|---|---|
| 1. | Could oceans save us from climate change? *(gas dissolution)* | Life of yeast. *(alcohol fermentation)* |
| 2. | Antacids and the stomach acid. *(neutralisation, digestion process)* | Wake up, seed, wake up; it’s time to get up! *(seed germination)* |
| 3. | The most efficient home-made fire extinguisher. *(chemical kinetics)* | What makes your heart beat? *(electrocardiogram, ECG)* |
| 4. | Coal power and acid rain. *(process of acid rain formation)* | Nurse, the pressure! *(blood pressure)* |
| 5. | Anti-lime cleaning liquid and the hand skin. *(acid-base reaction, neutralisation, dilution)* | |

Various statistical methods were used to process the data: descriptive statistics, analysis of frequencies, comparative analysis (subject, teacher, activity) and cluster analysis. In comparative analysis, the Mann-Whitney U test and the Kruskal-Wallis H test were used to recognize the significant differences between considered groups.

**RESULTS**

Not all items of the questionnaire are discussed in this study. In Table 2 the outcomes from the analysis of frequencies for 20 selected items can be seen. In items requiring a direct contact of a teacher with the student's work, the responses from pre-service teachers were avoided and only the answers from in-service teachers were taken into account (items marked as *in-service teachers only*). The cumulative percent values of totally agreed answers per item are highlighted in grey.

The closed questionnaire items were formed as positive declarative clauses. As obvious from the analysis of frequencies (Table 2), the most of them were highly agreed by the respondents. Mainly, the items related to the quality of the activities were agreed at least by 90% of responses. Of course, there are differences between the particular activities as we also mention in conclusion. However, in this study we consider only the teachers' general view on activities as whole packages of materials for experimental work of students.

Items 4 a 5, answered by in-service teachers only, were responded with lower level of agreement and confirm that in some activities students needed their tutor's help. This confirms the same knowledge we gained from the students questionnaires (Skoršepa et al., 2013). However, the level of such help is different for particular activities (not considered in this study).

Lower frequencies of agreement were also achieved in item 10. We know from the teachers and also from the students' questionnaires (Skoršepa et al., 2013) that in some worksheets there were too many questions and empty boxes to be filled in by the students.

About half of the teachers (56.9 %) think that with these activities students learn the same scientific concepts as with traditional activities. It might mean that the other half of them either consider the proposed activities to teach concepts different from those in traditional lab or they do not recognize if students learn the same or different. It is to be pointed that in the last item, one fourth of respondents did not recognize the need of computer-based approach to perform such activities and thought that they can be performed without digital technique as well. We have to mention that all activities were research-based designed and took advantage of the computer-based equipment. This is why the experiments could not be performed easily without it. As teachers had no experience in the use of this technology in their classrooms, our results suggest that in teacher-training sessions, a Technological Pedagogical Content Knowledge (TPCK, Koehler and Mishra, 2006) approach is desired.

Table 2: Frequencies of answers for selected questionnaire items. M – total mean score; S – score; T – total; F – frequency; V% - valid percent; C% - cumulative percent (No missing values were recorded; the Percent values are equal to the Valid Percent in all cases.)

| Item | | M | S | F | V% | C% |
|---|---|---|---|---|---|---|
| 1. | The objectives of the activity are well designed. | 1.42 | 1 | 73 | 59.3 | 59.3 |
| | | ± .53 | 2 | 48 | 39.0 | 98.4 |
| | | | 3 | 2 | 1.6 | 100.0 |
| | | | T | 123 | 100.0 | |
| 2. | Instructions for students are clear and have logical structure. | 1.50 | 1 | 69 | 56.1 | 56.1 |
| | | ± .61 | 2 | 47 | 38.2 | 94.3 |
| | | | 3 | 7 | 5.7 | 100.0 |
| | | | T | 123 | 100.0 | |
| 3. | The *difficulty* of the activity is adequate to students' knowledge. | 1.55 | 1 | 62 | 50.4 | 50.4 |
| | | ± .60 | 2 | 54 | 43.9 | 94.3 |
| | | | 3 | 7 | 5.7 | 100.0 |
| | | | T | 123 | 100.0 | |
| 4. | Students needed teacher's help to comprehend the principle and the objectives of the activity. *(In-service teachers only)* | 2.22 | 1 | 5 | 9.8 | 9.8 |
| | | ± .64 | 2 | 31 | 60.8 | 70.6 |
| | | | 3 | 14 | 27.5 | 98.0 |
| | | | 4 | 1 | 2.0 | 100.0 |
| | | | T | 51 | 100.0 | |
| 5. | Students needed teacher's help to design and perform the experiments in this activity. *(In-service teachers only)* | 2.04 | 1 | 11 | 21.6 | 21.6 |
| | | ± .72 | 2 | 28 | 54.9 | 76.5 |
| | | | 3 | 11 | 21.6 | 98.0 |
| | | | 4 | 1 | 2.0 | 100.0 |
| | | | T | 51 | 100.0 | |
| 6. | It was easy for students to work with the computer system. *(In-service teachers only)* | 1.86 | 1 | 7 | 13.7 | 13.7 |
| | | ± .35 | 2 | 44 | 86.3 | 100.0 |
| | | | | 51 | 100.0 | |
| 7. | The duration of the activity is optimal. | 1.65 | 1 | 54 | 43.9 | 43.9 |
| | | ± .65 | 2 | 59 | 48.0 | 91.9 |
| | | | 3 | 9 | 7.3 | 99.2 |
| | | | 4 | 1 | .8 | 100.2 |
| | | | T | 123 | 100.0 | |
| 8. | The activity fits to our state educational curriculum. | 1.67 | 1 | 54 | 43.9 | 43.9 |
| | | ± .61 | 2 | 59 | 48.0 | 91.9 |
| | | | 3 | 9 | 7.3 | 99.2 |
| | | | 4 | 1 | .8 | 100.2 |
| | | | T | 123 | 100.0 | |
| 9. | Students learn science with this activity. | 1.40 | 1 | 79 | 64.2 | 64.2 |
| | | ± .75 | 2 | 40 | 32.5 | 96.7 |
| | | | 3 | 4 | 3.3 | 100.0 |
| | | | T | 123 | 100.0 | |
| 10. | The number of "gaps" in the worksheet to be filled in by the students is optimal. | 1.87 | 1 | 34 | 35.0 | 35.0 |
| | | ± .60 | 2 | 54 | 43.9 | 78.9 |
| | | | 3 | 25 | 20.3 | 99.2 |
| | | | 4 | 1 | .8 | 100.0 |
| | | | T | 123 | 100 | |

| Item | | M | S | F | V% | C% |
|---|---|---|---|---|---|---|
| 11. | The activity increases students' *motivation* and *curiosity*. | 1.36 ± .51 | 1 | 81 | 65.9 | 65.9 |
| | | | 2 | 40 | 32.5 | 98.4 |
| | | | 3 | 2 | 1.6 | 100.0 |
| | | | T | 123 | 100.0 | |
| 12. | The activity supports the developing of students' *creative thinking and working*. | 1.39 ± .52 | 1 | 77 | 62.6 | 62.6 |
| | | | 2 | 44 | 35.8 | 98.4 |
| | | | 3 | 2 | 1.6 | 100.0 |
| | | | T | 123 | 100.0 | |
| 13. | The activity supports developing of students' ability to *formulate hypothesis*. | 1.59 ± .54 | 1 | 53 | 43.1 | 43.1 |
| | | | 2 | 67 | 54.5 | 97.6 |
| | | | 3 | 3 | 2.4 | 100.0 |
| | | | T | 123 | 100.0 | |
| 14. | The activity is *enjoyable* for students. | 1.40 ± .64 | 1 | 82 | 66.7 | 66.7 |
| | | | 2 | 35 | 28.5 | 95.1 |
| | | | 3 | 4 | 3.3 | 98.4 |
| | | | 4 | 2 | 1.6 | 100.0 |
| | | | T | 123 | 100.0 | |
| 15. | The activity encourages students in *working in groups*. | 1.34 ± .56 | 1 | 85 | 69.1 | 69.1 |
| | | | 2 | 35 | 28.5 | 97.6 |
| | | | 3 | 2 | 1.6 | 99.2 |
| | | | 4 | 1 | .8 | 100.0 |
| | | | T | 123 | 100.0 | |
| 16. | The activity enables students to *apply their knowledge*. | 1.41 ± .54 | 1 | 75 | 61.0 | 61.0 |
| | | | 2 | 45 | 36.6 | 97.6 |
| | | | 3 | 3 | 2.4 | 100.0 |
| | | | T | 123 | 100.0 | |
| 17. | The activity supports the developing of students' *autonomy in learning*. | 1.74 ± .63 | 1 | 44 | 35.8 | 35.8 |
| | | | 2 | 67 | 54.5 | 90.2 |
| | | | 3 | 12 | 9.8 | 100.0 |
| | | | T | 123 | 100.0 | |
| 18. | The activity supports the developing of students' *inquiry skills* and *exploratory work*. | 1.56 ± .57 | 1 | 45 | 36.6 | 36.6 |
| | | | 2 | 71 | 57.7 | 94.3 |
| | | | 3 | 7 | 5.7 | 100.0 |
| | | | T | 123 | 100.0 | |
| 19. | With this activity, students learn the same scientific concepts as with traditional activities. | 2.30 ± .74 | 1 | 19 | 15.4 | 15.4 |
| | | | 2 | 51 | 41.5 | 56.9 |
| | | | 3 | 51 | 41.5 | 98.4 |
| | | | 4 | 2 | 1.6 | 100.0 |
| | | | T | 123 | 100.0 | |
| 20. | The activity could be performed without ICT approach maintaining the same educational effect. | 2.77 ± .67 | 1 | 8 | 6.5 | 6.5 |
| | | | 2 | 22 | 17.9 | 24.4 |
| | | | 3 | 83 | 67.5 | 91.9 |
| | | | 4 | 10 | 8.1 | 100.0 |
| | | | T | 123 | 100.0 | |

Interestingly, running the Mann-Whitney U test, it was found that 10 of the items were perceived differently by the pre-service compared to the in-service teachers. In all of these items the distributions of the scores for both groups were not similar. Therefore, we are not able to compare the median values between the groups. However, significances for these items confirming the statistically significant differences between the groups are listed in Table 3. The differences in mean values can be seen in Figure 1.

Table 3: Differences between in-service and pre-service teachers. (Items with statistically significant differences only) $MR_{In}$ – Mean Rank for in-service teachers, $MR_{Pre}$ – Mean Rank for pre-service teachers

| Item | | Mann-Whitney U test significance* |
|---|---|---|
| 3. | The *difficulty* of the activity is adequate to students' knowledge. | $U$ = 1 458.0, $z$ = –2.352, $p$ = .009<br>$MR_{In}$ = 70.88; $MR_{Pre}$ = 55.71 |
| 7. | The duration of the activity is optimal. | $U$ = 1 160.0, $z$ = –3.869, $p$ = .000<br>$MR_{In}$ = 75.25; $MR_{Pre}$ = 52.61 |
| 10. | The number of "gaps" in the worksheet to be filled in by the students is optimal. | $U$ = 1 339.5, $z$ = –2.742, $p$ = .006<br>$MR_{In}$ = 71.74; $MR_{Pre}$ = 55.10 |
| 11. | The activity increases students' *motivation* and *curiosity*. | $U$ = 1 515.5, $z$ = –1.995, $p$ = .046<br>$MR_{In}$ = 68.28; $MR_{Pre}$ = 57.55 |
| 12. | The activity supports the developing of students' *creative thinking and working*. | $U$ = 1 375.5, $z$ = –2.808, $p$ = .005<br>$MR_{In}$ = 71.03; $MR_{Pre}$ = 55.60 |
| 13. | The activity supports developing of students' ability to *formulate hypothesis*. | $U$ = 1 281.0, $z$ = –3.272, $p$ = .001<br>$MR_{In}$ = 72.88; $MR_{Pre}$ = 54.29 |
| 14. | The activity is *enjoyable* for students. | $U$ = 1 458.0, $z$ = –2.352, $p$ = .019<br>$MR_{In}$ = 69.41; $MR_{Pre}$ = 56.75 |
| 15. | The activity encourages students in *working in groups*. | $U$ = 1 466.0, $z$ = –2.358, $p$ = .018<br>$MR_{In}$ = 69.25; $MR_{Pre}$ = 56.87 |
| 16. | The activity enables students to *apply their knowledge*. | $U$ = 1 440.0, $z$ = –2.389, $p$ = .017<br>$MR_{In}$ = 69.76; $MR_{Pre}$ = 56.50 |
| 18. | The activity supports the developing of students' *inquiry skills* and *exploratory work*. | $U$ = 1 273.5, $z$ = –3.297, $p$ = .001<br>$MR_{In}$ = 73.03; $MR_{Pre}$ = 54.19 |

* Asymptotic significances are displayed.

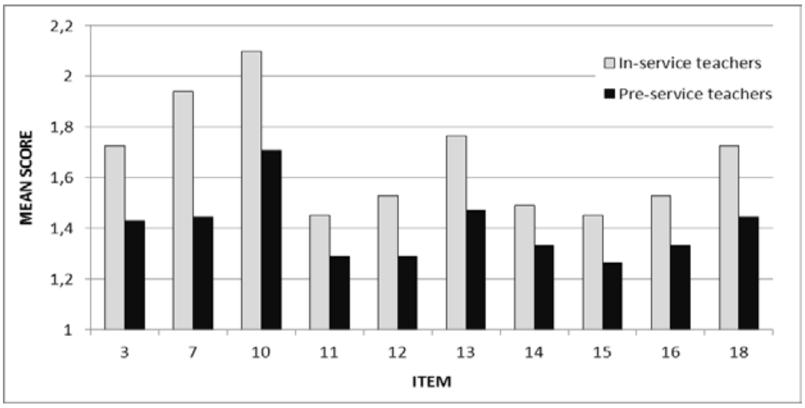


Figure 1: Mean scores for in-service and pre-service teachers.
(See Table 2 for specific item numbers.)

Comparing the groups using their Mann-Whitney U test mean ranks (Table 3) and the mean scores (Figure 1), it seems the pre-service teachers reported more optimistic (lower) scores than the in-service teachers in all items with statistical difference. Perhaps, less educational practice and still not sufficient experience of pre-service teachers is the reason. On the other hand, in-service teachers are more experienced, more familiar with the educational conditions and more grounded in students' working and thinking. Knowing the specific students' needs, they can also be more accurate in predicting the students' reasoning during the experimental exercise. Therefore, their responses are more careful but still not critical. The most differently perceived items considered (i) the difficulty of the activity, (ii) its duration, (iii) its potential ability to support students' motivation and curiosity, (iv) its contribution to the development of students' creative thinking and working, (v) its support of hypothesizing and (vi) its tendency to develop the inquiry skills of students.

Moreover, statistically significantly different answers were found not only between pre-service and in-service teachers but also within the in-service teachers group. A specific school was an effecting factor generating the difference. The Kruskal-Wallis H test revealed 5 items with such statistically significant difference. In all of these items, the score distributions were not similar for all groups, as assessed by visual inspection of a boxplot, so the median values between the groups were not compared. The statistical significances for the mentioned items confirming the differences between the in-service teachers teaching in different schools are listed in Table 4. Figure 2 provides the mean scores for the differently reported items.

Table 4: Differences inside the in-service teachers group generated by different schools. (Items with statistically significant differences only)

| **Item** | | **Kruskal-Wallis H test significance*** |
|---|---|---|
| 4. | Students needed teacher's help to comprehend the principle and the objectives of the activity. | $\chi^2(3) = 7.920$, $p = .048$ |
| 5. | Students needed teacher's help to design and perform the experiments in this activity. | $\chi^2(3) = 12.190$, $p = .007$ |
| 12. | The activity supports the developing of students' *creative thinking and working*. | $\chi^2(3) = 9.961$, $p = .019$ |
| 13. | The activity supports developing of students' ability to *formulate hypothesis*. | $\chi^2(3) = 8.054$, $p = .045$ |
| 20. | The activity could be also performed without ICT approach with the same educational effect. | $\chi^2(3) = 8.016$, $p = .046$ |

* Asymptotic significances are displayed.

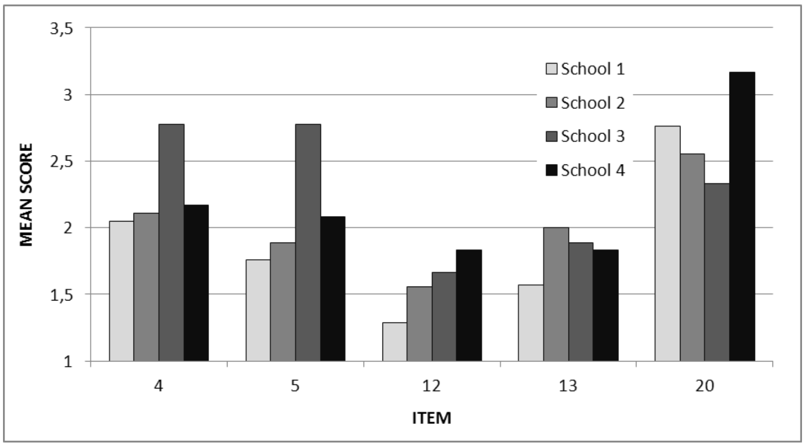


Figure 2: Mean scores inside the in-service teachers group generated by different schools.
(See Table 2 for specific item numbers.)

It is worth noting that teachers from different schools perceived differently their students' need of the tutor's help (items 4 and 5). School 3 reporting less need of tutor's help is an outlier lying over the other three schools. It can testify the teacher's knowledge that students from School 3 are more trained and experienced in laboratory work that tends them to cope with the experimental tasks without a cardinal help of a tutor. Of course, we know the situation in the schools and the differences between them, especially those related to their technical background and laboratory equipment, which has a direct impact on the students' experimental experience.

We were also interested in whether the teachers perceived differently the activities of different subjects. In our study, the data comprised 65 evaluations of chemistry activities and 58 evaluations of biology activities.

Table 5: Differences between subjects - Chemistry activities / Biology activities.
(Items with statistically significant differences only)
$MR_{Ch}$ – Mean Rank for Chemistry, $MR_{Bio}$ – Mean Rank for Biology

| Item | | Mann-Whitney U test significance* |
|---|---|---|
| 1. | The objectives of the activity are well designed. | $U$ = 1 549.0, $z$ = –1.990, $p$ = .047<br>$MR_{Ch}$ = 67.17; $MR_{Bio}$ = 56.21 |
| 2. | Instructions for students are clear and have logical structure. | $U$ = 1 533.0, $z$ = –2.036, $p$ = .042<br>$MR_{Ch}$ = 67.42; $MR_{Bio}$ = 55.93 |
| 3. | The *difficulty* of the activity is adequate to students' knowledge. | $U$ = 1 480.5, $z$ = –2.310, $p$ = .021<br>$MR_{Ch}$ = 68.22; $MR_{Bio}$ = 55.03 |
| 7. | The duration of the activity is optimal. | $U$ = 1 183.5, $z$ = –3.962, $p$ = .000<br>$MR_{Ch}$ = 72.79; $MR_{Bio}$ = 49.91 |
| 8. | The activity fits to our state educational curriculum. | $U$ = 1 172.5, $z$ = –4.057, $p$ = .000<br>$MR_{Ch}$ = 72.96; $MR_{Bio}$ = 49.72 |
| 9. | Students learn science with this activity. | $U$ = 1 263.5, $z$ = –3.762, $p$ = .000<br>$MR_{Ch}$ = 71.56; $MR_{Bio}$ = 51.28 |

| Item | | Mann-Whitney U test significance* |
|---|---|---|
| 10. | The number of “gaps” in the worksheet to be filled in by the students is optimal. | *U* = 1 138.5, *z* = –4.068, *p* = .000<br>$MR_{Ch}$ = 73.48; $MR_{Bio}$ = 49.13 |
| 11. | The activity increases students’ *motivation* and *curiosity*. | *U* = 1 272.0, *z* = –3.766, *p* = .000<br>$MR_{Ch}$ = 71.43; $MR_{Bio}$ = 51.43 |
| 12. | The activity supports the developing of students’ *creative thinking and working*. | *U* = 1 458.0, *z* = –2.566, *p* = .010<br>$MR_{Ch}$ = 68.56; $MR_{Bio}$ = 54.65 |
| 14. | The activity is *enjoyable* for students. | *U* = 1 476.0, *z* = –2.512, *p* = .012<br>$MR_{Ch}$ = 68.29; $MR_{Bio}$ = 54.95 |
| 15. | The activity encourages students in *working in groups*. | *U* = 1 521.5, *z* = –2.290, *p* = .022<br>$MR_{Ch}$ = 67.59; $MR_{Bio}$ = 55.73 |
| 16. | The activity enables students to *apply their knowledge*. | *U* = 1 513.0, *z* = –2.215, *p* = .027<br>$MR_{Ch}$ = 67.72; $MR_{Bio}$ = 55.59 |

* Asymptotic significances are displayed.

Running the Mann-Whitney U test, 12 of the questionnaire items with statistical difference between chemistry and biology were found. In all of these items, we are not able to compare the median values between the groups because the distributions of the scores for both considered groups were not similar. Statistical significances for these items confirming the mentioned differences can be found in Table 5. The differences in mean values are displayed in Figure 3. In three items (number 4, 5 and 6) the Mann-Whitney U test was run only with in-service teachers’ data. However, the statistically significant differences between chemistry and biology were not recorded.

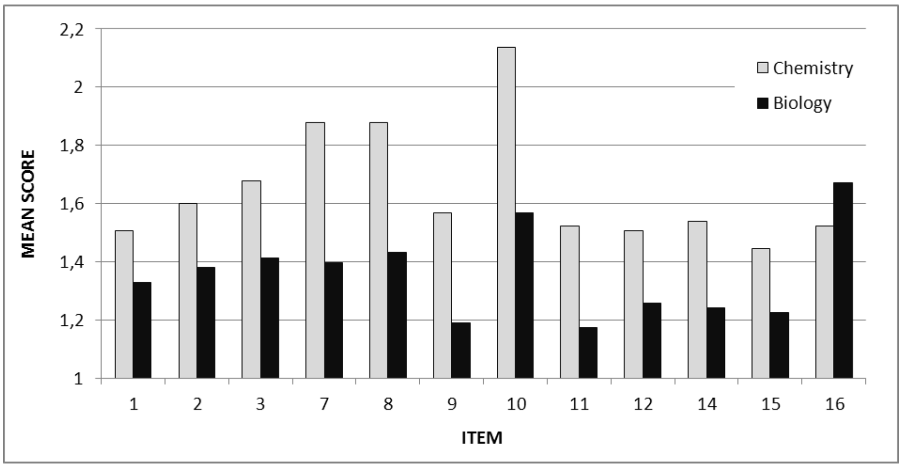


Figure 3: Mean scores for Chemistry and Biology activities
(See Table 2 for specific item numbers.)

In eleven of twelve statistically differently perceived items, the Biology activities were evaluated more positively compared to those for Chemistry. The most notable differences were recorded in items considering (i) the duration of the activity, (ii) its overlap with the national educational curriculum, (iii) its ability to teach science, (iv) the number of tasks in the activity to be answered by students and (v) its ability to increase students' motivation and curiosity. Among the several reasons that can explain the differences between the perception of Biology and Chemistry activities, we point the next ones: (1) Biology activities are more related to everyday life, and so to personal interests of participants. This assumption is coherent with our previous study (Urban-Woldron et al., 2013) in which the Chemistry activities related to everyday contexts were perceived as more interesting to the students than the other Chemistry and Physics activities. (2) Biology and Chemistry activities analysed in this research were not designed at the same time. In concrete, Biology activities were designed after the implementation of Chemistry activities, so the activity designers could learn from their previous mistakes and experience. For this reason Biology activities obtained a better perception. (3) Biology teachers are less used to technology in their practical activities than Chemistry teachers (Šorgo and Kocijancic, 2012). For this reason, Biology teachers gave a higher added value to these activities in comparison to their Chemistry mates. However, more research is needed to clarify the mentioned differences of perception among the activities.

Finally, we were interested in whether the participating teachers can be clustered according to their responses. Teachers participated in different subjects (chemistry and biology) were processed separately. A hierarchical cluster analysis (using Ward's method of clustering) of data for biology didn't reveal a tendency to create clusters. Therefore, it is not discussed in further text. However, a hierarchical cluster analysis of data for chemistry showed that the participants can be grouped into two reasonable clusters. A subsequent non-hierarchical cluster analysis (*K*-means) provided final cluster centers depicted in Figure 4 where two clusters can be clearly distinguished. Cluster 1 includes nine teachers of more optimistic agreement with most of the considered items. Furthermore, the cluster membership analysis uncovered that Cluster 1 involves all pre-service teachers and one in-service teacher. On the other hand the most of the in-service teachers belong to Cluster 2 reporting a bit more careful answers. These facts rely to our previous findings described in Table 3 and Figure 1.

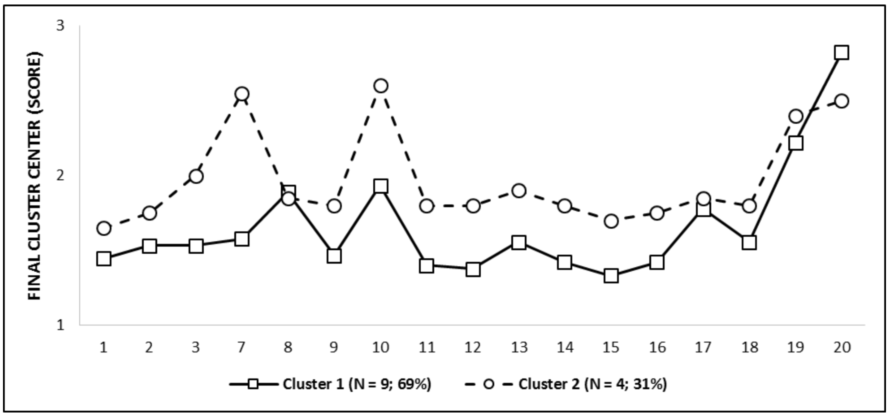


Figure 4: Cluster analysis - final cluster centers for Chemistry activities
(See Table 2 for specific item numbers.)

## CONCLUSION

The results presented in the paper combine all activities together in order to provide the overall view to the topic. However, to evaluate the proposed work, the results for particular activities need to be considered separately to catch their peculiarity and individual aspects. In our inspection, significant differences were found in almost all questionnaire items when considered particular activity as an influencing factor (the results are not provided in this paper). Nevertheless, this is not surprising, as each activity has its own specifics, unique background and uses different "scientific" approaches to solve the experimental tasks. Of course, in relation to revising and improving the particular activities, we need to consider the responses from the teachers individually, as has already been mentioned before.

With such complex information we will be able to identify the main limitations and imperfections of our activities that are necessary to know in order to prepare the final form of the activities.

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