# Report on the third round of the PROFILES Curricular Delphi study on Science Education

## Italy (UNIVPM)

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# 1 Introduction

The PROFILES Curricular Delphi Study on Science Education aims to identify the main aspects of science education considered desirable and pedagogically meaningful, as well as which competences qualification should be enhanced and which scientific fields or concepts should be dealt with.

The study consists of three phases. In the first round of our study written questionnaires were submitted to 173 participants. The questions concerned the following four aspects of teaching and learning:

- I: Situations, contexts, motives;
- IIa:(basic) concepts and topics;
- IIb: Scientific fields and perspectives;
- III: Qualification;
- IV: Methodical Aspects.

After the first round many interesting categories were found (see Report on the first round, UNIVPM).

In the part I of second round, on the basis of the given responses, the most significant categories were identified; while on the basis of the responses of the part II hierarchical cluster analyzes were carried out (see Report on the second round, UNIVPM). Through hierarchical cluster analyses three concepts concerning different suggestions about desirable scientific literacy were identified:

- **Concept A** (relevant issues and motivations to improve learning, the interaction among students and communication skills): concept A includes most aspects and themes through which student interest is increased. Once the student has acquired the basic knowledge, he should be able to apply the knowledge and he also should be able to formulate critical questioning. Furthermore, interactive lessons and the improvement of communication skills promote the development of emotional personality.

- **Concept B** (intellectual development mainly related to the current scientific research, technical devices, occupation): concept B shows the importance of technological development and current scientific research. The motivation and determination play an important role in science education, such as the ability to work and perform experiments self-dependently. Discussions and debates encourage the curiosity and the interest of the students.
- **Concept C**: (general personality development through innovative methodical aspects which promote the inquiry-based science learning): the concept refers mainly to the different methodological aspects that can be used to improve the learning of science and inquiry based learning. Using cooperative learning, concept maps or problem solving techniques, personality and reasoning skills of the students are developed, furthermore an interdisciplinary approach is also promoted. The experimental activity, the references to everyday life and the teamwork are very important to increase students' interest in science subjects and to improve their learning. The

subjects on which the scientific literacy should be based are mainly mathematics, chemistry and physics.

This third and final round is about the assessment of Concepts A, B and C. In particular, participants were asked to assess the priority of the three concepts and their realization in practice. The opinion of participants were also asked with reference to different educational levels:

- pre-school;
- elementary level;
- lower secondary education;
- higher secondary education.

The study was aimed to the same group of participants who attended the first and second round, this group is divided into 4 sub-groups:

- students at school (Ss);
- university students (Us);
- science teachers (St);
- scientists (S).

This report describes the methods used and the results obtained in the third round.

# 2 Leading questions of the third round

In order to assess the concepts identified in the second round, in this third phase the following questions were addressed:

- which priority regarding concepts of desirable science education can be identified in the participants' assessments?
- to what extent are the respective concepts of desirable science education realized in current science educational practice?
- What kind of priority-practice differences can be identified in the participants' assessments?
- which priorities regarding concepts of desirable science education can be identified in the participants' assessments with regard to different educational levels?
- to what extent are the respective concepts of desirable science education realized in current science educational practice with regard to different educational levels?
- what kind of priority-practice differences can be identified in the participants' assessments regarding the different educational levels?
- what differences or similarities there are in the general assessments between the four different sub-groups?

# 3 Method

The questionnaire of the third round was divided into two parts: the part I refers to the general assessment of the concepts, the part II regards the assessment of the concepts with reference to the different educational levels.

The participants were asked to code the data (both as regards the priority that the practice) following a six-tier scale, ranged from 1 to 6 (1 = “very low priority”/ “to a very low extent”; 2 = : “low priority”/ “to a low extent”; 3 = “rather low priority”/ “to a rather low extent”; 4 = “rather high priority”/ “to a rather high extent”; 5 = “high priority”/ “to a high extent”; 6 = “very high priority”/ “to a very high extent”).

Figure 1 and Figure 2 show, respectively, the Part I and the Part II of the questionnaire of the third round.

The data were analysed by means of descriptive and variance analytical methods, taking into account both the two different assessments (priorities and practice) and analysing their differences. The analysis was divided into three parts:
1) general assessment of the concepts related to the total sample of participants;
2) assessment of the concepts differentiated according to different educational levels, related to the total sample of participants;
3) general assessment of the concepts related to the four sub-groups of participants.
In reference to the point 1) and 2) the Wilcoxon signed-rank test was applied in order to evaluate whether the assessments of the three concepts are statistically different.
The assessments of the different subgroups were compared using the Mann-Whitney test.

| **Concepts**<br>**Please assess the following concepts according to the two questions stated** | Which **priority** should the respective concepts have in science education?<br>1 = very low priority<br>2 = low priority<br>3 = rather low priority<br>4 = rather high priority<br>5 = high priority<br>6 = very high priority | *To what e**xtent** are the respective concepts realized in current science education?*<br>*1 = to a very low extent*<br>*2 = to a low extent*<br>*3 = to a rather low extent*<br>*4 = to a rather high extent*<br>*5 = to a high extent*<br>*6 = to a very high extent* |
|---|---|---|
| Concept A:<br>relevant issues and motivations to improve learning, the interaction among students and communication skills | [1] [2] [3] [4] [5] [6] | *[1] [2] [3] [4] [5] [6]* |
| Concept B:<br>intellectual development mainly related to the current scientific research, technical devices, occupation | [1] [2] [3] [4] [5] [6] | *[1] [2] [3] [4] [5] [6]* |
| Concept C:<br>general personality development through innovative methodical aspects which promote the inquiry-based science learning | [1] [2] [3] [4] [5] [6] | *[1] [2] [3] [4] [5] [6]* |

Figure 1 –PART I of the questionnaire of the third round

| **Concepts**<br>**Please assess the following concepts according to the two questions stated** | Educational level | Which **priority** should the respective concepts have in science education?<br>1 = very low priority<br>2 = low priority<br>3 = rather low priority<br>4 = rather high priority<br>5 = high priority<br>6 = very high priority | *To what e**xtent** are the respective concepts realized in current science education?*<br>*1 = to a very low extent*<br>*2 = to a low extent*<br>*3 = to a rather low extent*<br>*4 = to a rather high extent*<br>*5 = to a high extent*<br>*6 = to a very high extent* |
|---|---|---|---|
| Concept A:<br>relevant issues and motivations to improve learning, the interaction among students and communication skills | Pre-school | [1] [2] [3] [4] [5] [6] | *[1] [2] [3] [4] [5] [6]* |
| | Elementary level | [1] [2] [3] [4] [5] [6] | *[1] [2] [3] [4] [5] [6]* |
| | Lower secondary education | [1] [2] [3] [4] [5] [6] | *[1] [2] [3] [4] [5] [6]* |
| | Higher secondary education | [1] [2] [3] [4] [5] [6] | *[1] [2] [3] [4] [5] [6]* |
| Concept B:<br>intellectual development mainly related to the current scientific research, technical devices, occupation | Pre-school | [1] [2] [3] [4] [5] [6] | *[1] [2] [3] [4] [5] [6]* |
| | Elementary level | [1] [2] [3] [4] [5] [6] | *[1] [2] [3] [4] [5] [6]* |
| | Lower secondary education | [1] [2] [3] [4] [5] [6] | *[1] [2] [3] [4] [5] [6]* |
| | Higher secondary education | [1] [2] [3] [4] [5] [6] | *[1] [2] [3] [4] [5] [6]* |
| Concept C:<br>general personality development through innovative methodical aspects which promote the inquiry-based science learning | Pre-school | [1] [2] [3] [4] [5] [6] | *[1] [2] [3] [4] [5] [6]* |
| | Elementary level | [1] [2] [3] [4] [5] [6] | *[1] [2] [3] [4] [5] [6]* |
| | Lower secondary education | [1] [2] [3] [4] [5] [6] | *[1] [2] [3] [4] [5] [6]* |
| | Higher secondary education | [1] [2] [3] [4] [5] [6] | *[1] [2] [3] [4] [5] [6]* |

Figure 2 –PART II of the questionnaire of the third round

# 4 Sample structure

The questionnaires have been distributed to all those who attended the first and second round.
Our sample is divided into the following four subgroup:
- students;
- university students;
- science teachers;
- scientists.

In Table 1 a comparison between the number of participants of the three different rounds is shown. As we can see, there is an overall data reduction (53 %) between the first and the second round and it becomes even more pronounced in the third phase of this study (43 %). With reference to this third round, Table 2 shows in detail the structure of our sample.

Table 1: Participants of the first, second and third round

| **Sample Structure** | | | | | Total |
|---|---|---|---|---|---|
| | Students at school | University students | Science teachers | Scientists | |
| Number of participants round 1 | 44 | 59 | 28 | 42 | 173 |
| Number of participants round 2 | 12 | 34 | 20 | 26 | 92 |
| Number of participants round 3 | 4 | 16 | 25 | 27 | 72 |
| Participation rate between rounds 1 and 2 | 27% | 58% | 71% | 62% | 53% |
| Participation rate between rounds 1 and 3 | 9% | 27% | 89% | 64% | 42% |

Table 2: Detailed sample structure of the third round

| Group | Subgroup | | Number | Total number |
|---|---|---|---|---|
| Students | Students at school without advanced science courses | Biology | | 4 |
| | | Chemistry | | |
| | | Physics | | |
| | | Science | 0 | |
| | Students at school with advanced sciences courses | Biology | | |
| | | Chemistry | | |
| | | Physics | | |
| | | Science | 4 | |
| | | | | |
| Teacher Students and trainee teachers ("young teachers") | University students in the education program | Biology | | 16 |
| | | Chemistry | 16 | |
| | | Physics | | |
| | | Science | | |
| | Trainee science teachers | Biology | | |
| | | Chemistry | | |
| | | Physics | | |
| | | Science | | |
| | | | | |
| Teachers and trainee teacher educators (experienced teachers) | Science teachers | Biology | 3 | 25 |
| | | Chemistry | 7 | |
| | | Physics | 4 | |
| | | Mathematics | 1 | |
| | | Science | 10 | |
| | Science trainee teachers educators | Biology | | |
| | | Chemistry | | |
| | | Physics | | |
| | | Science | | |
| | | | | |
| Educators, didactics, and in-service teacher educators | Chemistry | | | |
| | Physics | | | |
| | Biology | | | |
| | General Science/Primary Science | | | |
| | | | | |
| Scientists | Chemists | | 1 | 27 |
| | Biologists | | 4 | |
| | Physicists | | 3 | |
| | Others | | 19 | |

# 5 Results

In this chapter the results obtained from data collected are reported and discussed.
First, the results of the overall assessment provided by the entire sample are reported, then the opinions regarding different educational levels are reported and finally the general assessment of the different subgroup are shown.

## 5.1 General assessment by the total sample

The following description refers to the general assessment both to priority and practice, as well as to priority-practice differences.

### 5.1.1 Priority assessment

Referring to the priority assessment, Table 3 shows the mean values and standard deviation obtained for each of three concepts. As it can be seen, the highest mean value was obtained with reference to the Concept A (mean value = 5.4); the concepts B and C are considered equally important and in both cases the priority is considered "high" (mean value=5). In the same table (Table 3) in order to compare the general assessments of the three concepts also the significance values, obtained from Wilcoxon signed-rank test, are shown. From the obtained values, it can be noticed that the assessment of Concept A differs in a statistically significant way from the assessment related to Concept B and C. The concept B and C, instead, do not differ in a statistically significant way.

Table 3: Priority assessment by the total sample – mean value, standard deviation and significance test values (Wilcoxon signed-rank test)

| Concept A: Relevant issues and motivations to improve learning, the interaction among students and communication skills. | | Concept B: Intellectual development mainly related to the current scientific research, technical devices, occupation. | | Concept C: General personality development through innovative methodical aspects which promote the inquiry-based science learning. | | Significance value | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | A/B | A/C | B/C |
| Mean value | Standard deviation | Mean value | Standard deviation | Mean value | Standard deviation | <0.001 | 0.0012 | 0.8858 |
| 5.4 | 0.83 | 5.0 | 0.83 | 5.0 | 0.97 | | | |

### 5.1.2 Practice assessment

Referring to the practice assessment of the total sample, in Table 4 it can be seen that for all three concepts the obtained mean values are quite low, in fact, all of them are lower than 3. Furthermore, the significance values (Wilcoxon signed-rank test), reported in the same table, show that the assessment of the three concepts does not differ in a statistically significant way.

In Figure 4 both the mean values obtained with reference to the "priority assessment" that those obtained with reference to the "practice assessment" are listed, in the graph is well highlighted the different assessment of the two considered aspects: the mean values related to the practice are always much lower than those obtained with reference to the priority.

Table 4: Practice assessment by the total sample – mean value, standard deviation and significance test values (Wilcoxon signed-rank test)

| Concept A: Relevant issues and motivations to improve learning, the interaction among students and communication skills. | | Concept B: Intellectual development mainly related to the current scientific research, technical devices, occupation. | | Concept C: General personality development through innovative methodical aspects which promote the inquiry-based science learning. | | Significance value | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | A/B | A/C | B/C |
| Mean value | Standard deviation | Mean value | Standard deviation | Mean value | Standard deviation | 0.1570 | 0.1013 | 0.8215 |
| 2.9 | 1.00 | 2.8 | 1.10 | 2.7 | 1.09 | | | |

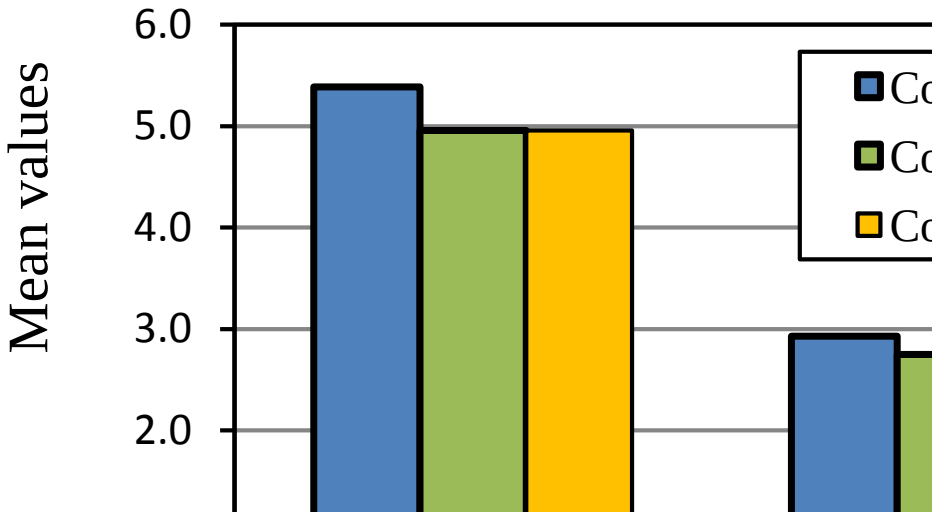


Figure 3: Mean values of the priority and practice assessment by the total sample

### 5.1.3 Priority-Practice differences

In the present study also the priority-practice differences were analyzed. Table 5 shows the obtained mean values and standard deviation. The mean values are shown also in Figure 4. According to these data, it can be noted that the greatest gap between priority and practice occurs for Concept A (mean value = 2.5), however, the values are not very different from each other (for the concept B the mean value is 2.2 and for concept C is equal to 2.3).
The significance values, listed in Table 5, are greater than 0.05, therefore, according to our total sample, the priority-practice differences between the three concepts don't change in a statistically significant way.

Table 5: Priority-Practice differences related to the total sample – mean value, standard deviation and significance test values (Wilcoxon signed-rank test)

| Concept A: Relevant issues and motivations to improve learning, the interaction among students and communication skills. | | Concept B: Intellectual development mainly related to the current scientific research, technical devices, occupation. | | Concept C: General personality development through innovative methodical aspects which promote the inquiry-based science learning. | | Significance value | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | A/B | A/C | B/C |
| Mean value | Standard deviation | Mean value | Standard deviation | Mean value | Standard deviation | 0.1738 | 0.1077 | 0.9505 |
| 2.5 | 1.28 | 2.2 | 1.33 | 2.3 | 1.41 | | | |

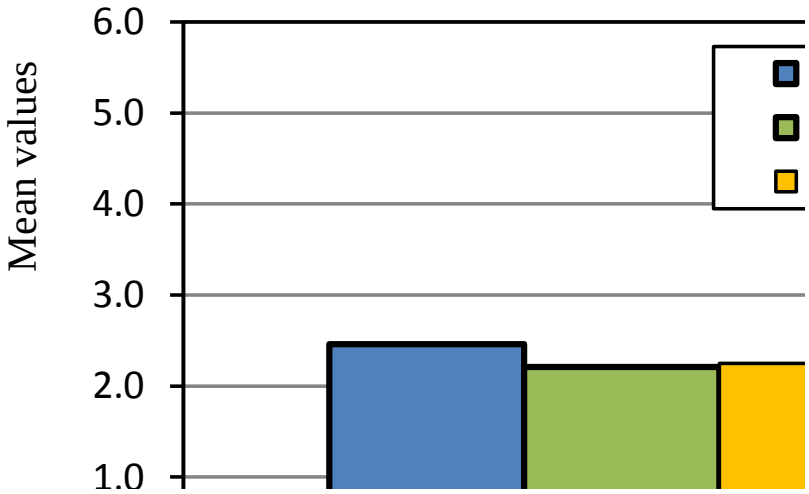


Figure 4: Mean values of the priority-practice differences related to the total sample

### 5.1.4 Summary

In order to summarize the general assessment of the three concepts, we can say that the concept A is considered the most important (it includes relevant issues and motivations to improve learning, the interaction among students and communication skills). Anyway, according to the opinion of the total sample, for all the three concepts there is a big gap between their importance and their application in science learning. This priority-practice difference is mainly evident with regard to the concept A.

## 5.2 Assessment by the total sample regarding different educational levels

In the present study participants were asked to give their opinion about the compared concepts also with reference to different educational levels: pre-school, elementary level, lower secondary education and higher secondary education.
In the following paragraphs the obtained results are discussed, they are differentiated according to the priority assessment, the practice assessment and the priority-practice difference.

### 5.2.1 Priority assessment

With regard to the priority assessment, differentiated according to 4 educational levels, in Table 6 the mean values and significance values are listed. As we can see from the observation of the mean values, in the opinion of our sample, for all educational levels science education should be based on the concept A, especially as regards the higher secondary education. The concept B is the least important, mainly with reference to pre-school.
Based on the significance values, it can be noted that the three concepts differ in a statistically significant way with regard to the assessment of the following educational level: pre-school, elementary level and lower secondary education. In relation to the assessment of the higher secondary school, the concepts don't differ from each other in a statistically significant way.

In Figure 5 the mean values regarding the different educational levels are displayed. From the graph we can see that the priority assessment of the three concepts increases with the educational level. Furthermore, we can see that the gap between the mean values of the concepts decreases with increasing educational level.

Table 6: Priority assessment by the total sample regarding different educational levels – mean values and significance test values (Wilcoxon signed-rank test)

| Educational level | Mean values | | | Significance value | | |
|---|---|---|---|---|---|---|
| | Concept A: Relevant issues and motivations to improve learning, the interaction among students and communication skills. | Concept B: Intellectual development mainly related to the current scientific research, technical devices, occupation. | Concept C: General personality development through innovative methodical aspects which promote the inquiry-based science learning. | A/B | A/C | B/C |
| Pre-school | 4.5 | 2.4 | 3.4 | <0.0001 | 0.0003 | <0.0001 |
| Elementary level | 4.9 | 3.0 | 3.9 | <0.0001 | <0.0001 | <0.0001 |
| Lower secondary education | 5.3 | 4.1 | 4.7 | <0.0001 | 0.0004 | 0.0008 |
| Higher secondary education | 5.5 | 5.2 | 5.2 | 0.0895 | 0.0522 | 0.8563 |

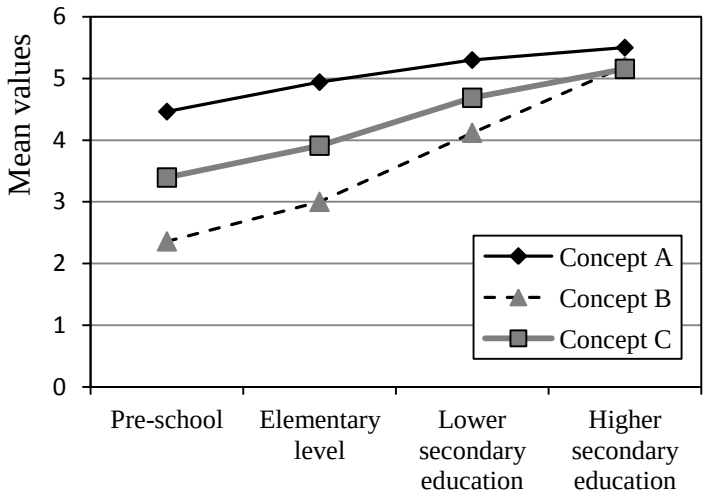


Figure 5: Priority assessment by the total sample – Mean values regarding different educational levels

### 5.2.2 Practice assessment

Table 7 shows the mean values and the significance values obtained with reference to the practice assessment, differentiated for four educational levels. Regarding the lower and the higher secondary education, Concept B has the highest mean value (in both cases the mean value is equal to 3.1); while, with reference to pre-school and elementary level, the highest mean value (3.6) was obtained for concept A.

In order to compare the assessment of the three concepts regarding different educational levels the Wilcoxon signed-rank test was applied. The significance values are listed in Table 7. It can be noted that with reference to pre-school and elementary level all the significance values are lower than 0.05 and therefore the collected data differ in a statistically significant way. Instead, with regard to lower and higher secondary education the data samples do not differ in a statistically significant way.

Finally, in the graph of Figure 6 we can observe that the mean values of the three concepts are different in the case of preschool and elementary level, while they become substantially similar for the two higher levels of education.

Table 7: Practice assessment by the total sample regarding different educational levels – mean values and significance test values (Wilcoxon signed-rank test)

| Educational level | Mean values | | | Significance value | | |
|---|---|---|---|---|---|---|
| | Concept A: Relevant issues and motivations to improve learning, the interaction among students and communication skills. | Concept B: Intellectual development mainly related to the current scientific research, technical devices, occupation. | Concept C: General personality development through innovative methodical aspects which promote the inquiry-based science learning. | A/B | A/C | B/C |
| Pre-school | 3.6 | 2.0 | 2.4 | **<0.0001** | **<0.0001** | **0.002** |
| Elementary level | 3.6 | 2.3 | 2.7 | **<0.0001** | **<0.0001** | **0.0057** |
| Lower secondary education | 2.9 | 3.1 | 3.0 | 0.0534 | 0.3310 | 0.2514 |
| Higher secondary education | 2.9 | 3.1 | 3.0 | 0.0833 | 0.3310 | 0.3677 |

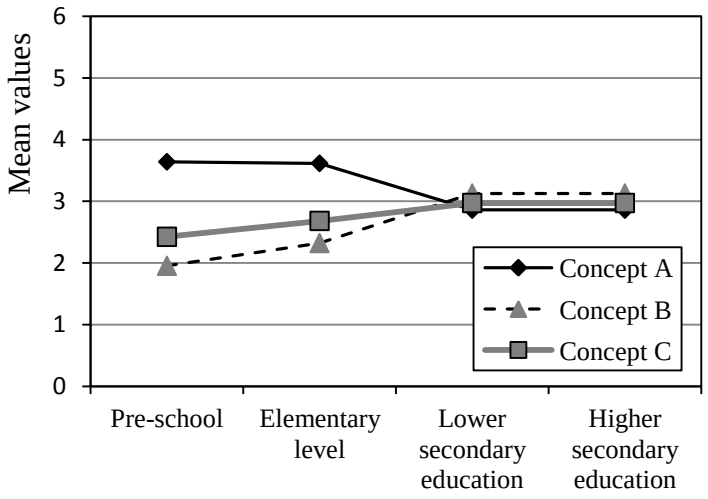


Figure 6: Practice assessment by the total sample – Mean values regarding different educational levels

### 5.2.3 Priority-Practice differences

Table 8 shows the mean values of the priority-practice differences (PPD) of the total sample regarding different educational levels, as well as the significance test values (Wilcoxon signed-rank test). The highest mean values for science education at pre-school occur for Concepts A and C (in both cases the mean value is = 0.9).
The highest priority-practice differences for elementary level, lower and higher education appear for Concept A.

In Figure 7 we can see that the smallest priority-practice differences at all educational levels occur for Concept B ("Intellectual development mainly related to the current scientific research, technical devices, occupation"). With reference to all three concepts, the mean values increase with the educational level.

Table 8: Priority-practice differences of the total sample regarding different educational levels – mean values and significance test values (Wilcoxon signed-rank test)

| Educational level | Mean values | | | Significance value | | |
|---|---|---|---|---|---|---|
| | Concept A: Relevant issues and motivations to improve learning, the interaction among students and communication skills. | Concept B: Intellectual development mainly related to the current scientific research, technical devices, occupation. | Concept C: General personality development through innovative methodical aspects which promote the inquiry-based science learning. | A/B | A/C | B/C |
| Pre-school | 0.9 | 0.4 | 0.9 | **0.0102** | 0.8185 | **0.0082** |
| Elementary level | 1.3 | 0.7 | 1.2 | **0.0003** | 0.5087 | **0.0187** |
| Lower secondary education | 2.2 | 1.5 | 1.7 | **<0.0001** | **0.0065** | 0.0842 |
| Higher secondary education | 2.5 | 2.0 | 2.1 | **0.0125** | 0.0517 | 0.6050 |

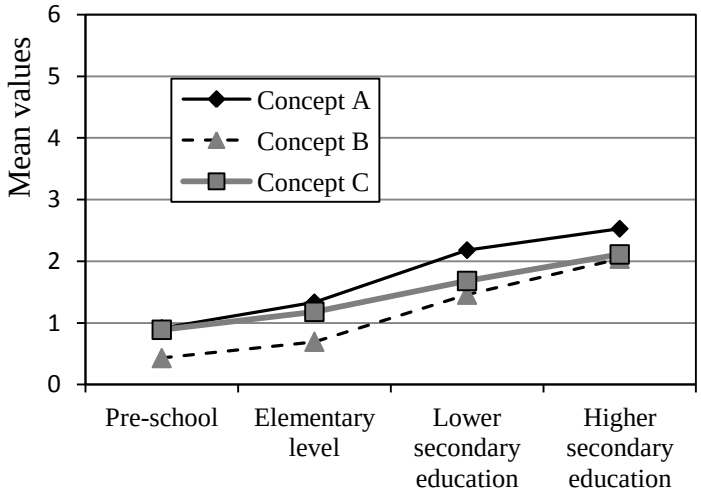


Figure 7: Priority- Practice differences in the assessment by the total sample – Mean values regarding different educational levels

### 5.2.4 Summary

The results related to the assessments of the three concepts by the total sample regarding different educational levels have shown that the Concept A ("Relevant issues and motivations to improve learning, the interaction among students and communication skills") is considered the most important. The priority assessment of the concepts increases with the educational level.
In general, the practice assessment is quite low and, for all three concepts, the priority-practice differences are high.

## 5.3 Concepts of desiderable science education – general assessment by the sub-sample groups

In the following paragraphs, the results related to the general assessment of the concepts by the four subgroups of our participants (students at school, university students, science teacher, scientists) are presented. The data are differentiated according to the priority assessment, the practice assessment and the priority-practice difference.

### 5.3.1 Priority assessments

In Table 9 and 10 the mean values of the general priority assessment by the sub-sample groups are displayed. The same values are plotted in Figure 8, where it can be noted that the Concept A is considered the most important by scientists, science teacher and students at school.
For university student the most important concept is Concept B (which is, however, considered the least important by scientists and science teacher).
Students (both university students and students at school) believe, however, that the Concept C ("General personality development through innovative methodical aspects which promote the inquiry-based science learning") is the less important.

From the significance values shown in Table 9 we can see that, regarding the science teachers' assessment, Concept A differs from Concept B and C in a statistically significant way.
Concept A differs from Concept B also with reference to the scientists' assessment, but, in general, it can be observed that within the different sub-groups the assessments of the three concepts are quite similar.

Table 10 shows the results from the significance test with respect to differences between the assessments by the different sub sample groups (Mann-Whitney-U-Test). As we can see from the significance values, there are no statistically significant differences between the assessments of the sub-sample groups.

Table 9: Priority assessment by the sub-sample groups – mean values and significance test values (Wilcoxon signed-rank test)

| Educational level | Mean values | | | Significance value | | |
|---|---|---|---|---|---|---|
| | Concept A: Relevant issues and motivations to improve learning, the interaction among students and communication skills. | Concept B: Intellectual development mainly related to the current scientific research, technical devices, occupation. | Concept C: General personality development through innovative methodical aspects which promote the inquiry-based science learning. | A/B | A/C | B/C |
| Students at school (Ss) | 5.0 | 4.8 | 4.3 | 0.5930 | 0.1797 | 0.3613 |
| University students (Us) | 5.0 | 5.3 | 4.8 | 0.3454 | 0.3743 | 0.0663 |
| Science teacher (St) | 5.6 | 4.8 | 5.1 | **0.001** | **0.0159** | 0.3388 |
| Scientists (S) | 5.5 | 4.9 | 5.0 | **0.0124** | 0.0582 | 0.6726 |

Table 10: Priority assessment by the sub-sample group – mean values and significance test values (Mann-Whitney-Test)

| Concepts | Significance values | | | | | | Mean values | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ss/Us | Ss/St | Ss/S | Us/St | Us/S | St/S | Ss | Us | St | S |
| Concept A: Relevant issues and motivations to improve learning, the interaction among students and communication skills. | 0.7409 | 0.1641 | 0.2629 | 0.0897 | 0.2529 | 0.4098 | 5 | 5.0 | 5.6 | 5.0 |
| Concept B: Intellectual development mainly related to the current scientific research, technical devices, occupation. | 0.2568 | 0.7043 | 0.6374 | 0.2291 | 0.2136 | 0.9416 | 4.8 | 5.3 | 4.8 | 4.8 |
| Concept C: General personality development through innovative methodical aspects which promote the inquiry-based science learning. | 0.3211 | 0.0878 | 0.1407 | 0.4233 | 0.4586 | 1.0000 | 4.3 | 4.8 | 5.1 | 4.3 |

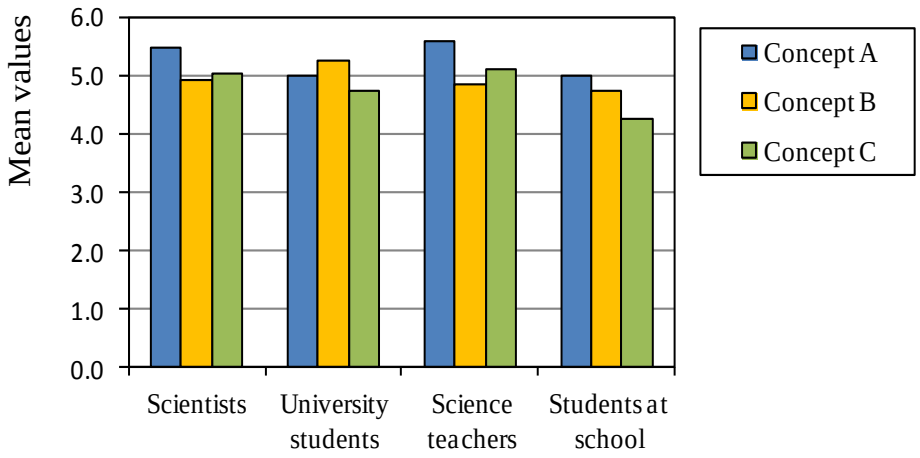


Figure 8: Mean values of the general priority assessment by the sub-sample groups

## 5.3.2 Practice assessments

Table 11, Table 12 and Figure 9 show the results related to the general practice assessments by the four sub-sample groups: Students at school (Ss), University students (Us), Science teacher (St) and Scientists (S).

The highest mean values are in the sub-group of University students. With reference to science teachers we have obtained the lowest mean values. In general, the sub-sample groups did not assess the realization in a very positive way, in fact, the mean values are between 2.4 and 3.5.

The results of Wilcoxon signed-rank test (Table 11) have shown that between the sub-group there are no statistically significant differences in the assessments of the realization of the three concepts. The results of the Mann-Whitney test have highlighted statistically significant differences only between University Students (Us)/Science teacher (St) (Concept C) and University Students (Us)/Scientists (S) (Concept C) as we can see in Table 12.

Table 11: Practice assessment by the sub-sample groups – mean values and significance test values (Wilcoxon signed-rank test)

| Educational level | Mean values | | | Significance value | | |
|---|---|---|---|---|---|---|
| | Concept A: Relevant issues and motivations to improve learning, the interaction among students and communication skills. | Concept B: Intellectual development mainly related to the current scientific research, technical devices, occupation. | Concept C: General personality development through innovative methodical aspects which promote the inquiry-based science learning. | A/B | A/C | B/C |
| Students at school (Ss) | 2.8 | 2.8 | 2.8 | 1.0000 | 1.0000 | 1.0000 |
| University students (Us) | 3.3 | 3.1 | 3.5 | 0.6465 | 0.4413 | 0.1536 |
| Science teacher (St) | 2.7 | 2.6 | 2.4 | 0.6981 | 0.1361 | 0.4080 |
| Scientists (S) | 3.0 | 2.6 | 2.5 | 0.1259 | 0.0735 | 0.5713 |

Table 12: Practice assessment by the sub-sample groups – mean values and significance test values (Mann-Whitney-Test)

| Concepts | Significance values | | | | | | Mean values | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ss/Us | Ss/St | Ss/S | Us/St | Us/S | St/S | Ss | Us | St | S |
| Concept A: Relevant issues and motivations to improve learning, the interaction among students and communication skills. | 0.4497 | 0.8993 | 0.7683 | 0.1606 | 0.4287 | 0.4310 | 2.8 | 3.3 | 2.7 | 3.0 |
| Concept B: Intellectual development mainly related to the current scientific research, technical devices, occupation. | 0.7055 | 0.7280 | 0.7459 | 0.2043 | 0.1957 | 0.9708 | 2.8 | 3.1 | 2.6 | 2.6 |
| Concept C: General personality development through innovative methodical aspects which promote the inquiry-based science learning. | 0.2375 | 0.6353 | 0.7017 | **0.0044** | **0.0112** | 0.9052 | 2.8 | 3.5 | 2.4 | 2.5 |

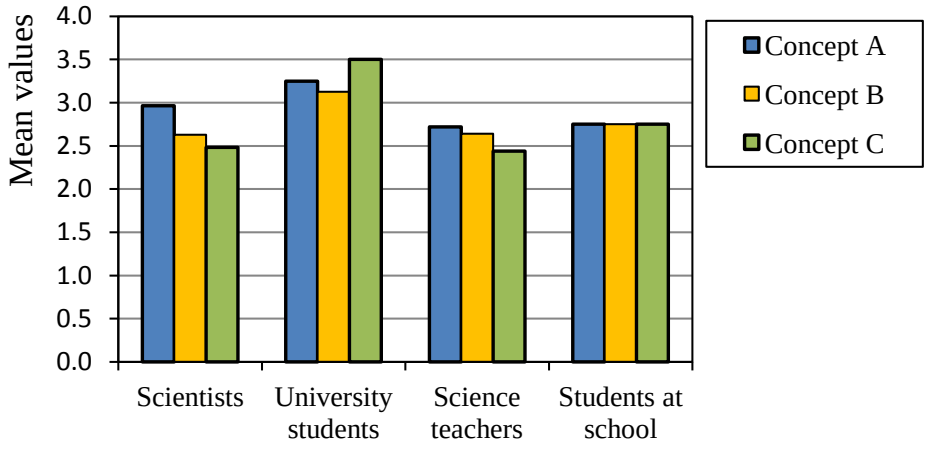


Figure 9: Mean values of the practice assessment by the sub-sample groups

### 5.3.3 Priority-Practice differences

The following part addresses the general priority-practice differences of the sub-sample groups. The obtained results (mean values and significant values) are displayed in Table 13 and 14, as well as in Figure 10.

With reference to Concept A and C the largest gaps between priority and practice appear in the assessments of Science teachers (St), while the smallest gaps appear in the group of University Students (Us). For Concept B the largest gaps between priority and practice appear in the assessments of Scientists (S) and the smallest gaps appear in the group of Students at school (Ss).

Within the sub-sample groups, the assessments of the concepts are quite similar. Only between Concept A and B of Science teachers' assessment there are statistically significant differences (see Table 13).

Regarding the sub-sample groups' assessments, significance values displayed in Table 14 show statistically significant differences between University students (Us)/ Science teachers (St), University students (Us)/ Scientists (S) (Concept C) and University students (Us)/ Science teachers (St) (Concept A).

Table 13: Priority-Practice differences of the sub-sample groups – mean values and significance test values (Wilcoxon signed-rank test)

| Educational level | Mean values | | | Significance value | | |
|---|---|---|---|---|---|---|
| | Concept A: Relevant issues and motivations to improve learning, the interaction among students and communication skills. | Concept B: Intellectual development mainly related to the current scientific research, technical devices, occupation. | Concept C: General personality development through innovative methodical aspects which promote the inquiry-based science learning. | A/B | A/C | B/C |
| Students at school (Ss) | 2.3 | 2.0 | 1.5 | 0.4760 | 0.5930 | 0.6547 |
| University students (Us) | 1.8 | 2.1 | 1.3 | 0.4008 | 0.1000 | 0.0051 |
| Science teachers (St) | 2.9 | 2.2 | 2.7 | **0.0277** | 0.5509 | 0.1240 |
| Scientists (S) | 2.5 | 2.3 | 2.6 | 0.6165 | 0.8880 | 0.4566 |

Table 14: Priority-Practice differences of the sub-sample groups – mean values and significance test values (Mann-Whitney-Test)

| Concepts | Significance values | | | | | | Mean values | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ss/Us | Ss/St | Ss/S | Us/St | Us/S | St/S | Ss | Us | St | S |
| Concept A: Relevant issues and motivations to improve learning, the interaction among students and communication skills. | 0.7055 | 0.3428 | 0.6165 | **0.0284** | 0.1416 | 0.2639 | 2.3 | 1.8 | 2.9 | 2.5 |
| Concept B: Intellectual development mainly related to the current scientific research, technical devices, occupation. | 0.7409 | 0.6580 | 0.5756 | 0.7484 | 0.6331 | 0.8475 | 22.0 | 2.1 | 2.2 | 2.3 |
| Concept C: General personality development through innovative methodical aspects which promote the inquiry-based science learning. | 0.6707 | 0.0820 | 0.1488 | **0.0015** | **0.0049** | 0.6669 | 2.5 | 1.3 | 2.7 | 2.6 |

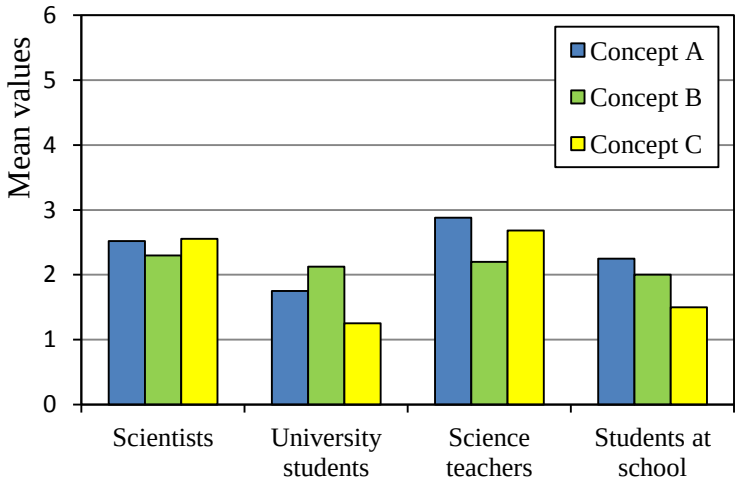


Figure 10: Mean values of the priority-practice differences in the general assessment by the sub-sample groups

### 5.3.4 Summary

The analyses from the general assessment by the sub-sample groups of our sample (Students at school, University students, Science teachers and Scientists) have shown that Concept A ("Relevant issues and motivations to improve learning, the interaction among students and communication skills") is considered the most important by the following sub-sample groups: Students at school, Science teachers and Scientists. For university student the most important concept is Concept B ("Intellectual development mainly related to the current scientific research, technical devices, occupation").

In general, the opinion of the sub-groups is that all the concepts are not much realized in science education and, in all sub sample groups, the largest gap occurs with reference to the category judged as the most important (Concept A for Students at school, University students, Science teachers and Scientists; Concept B for University students)

# References

Report on the first round of the PROFILES Curricular Delphi study on Science Education, Italy (UNIVPM).

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