# DEVELOPMENT AND VALIDATION OF THE FIRST VERSION OF A QUESTIONNAIRE FOR MEASURING PRE-SERVICE PRIMARY TEACHERS' SCIENCE CONTENT KNOWLEDGE

# DESARROLLO Y VALIDACIÓN DE LA PRIMERA VERSIÓN DE UN CUESTIONARIO PARA DETERMINAR EL CONOCIMIENTO CIENTÍFICO DE MAESTROS DE PRIMARIA EN FORMACIÓN

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## ABSTRACT

A first version of an instrument to assess science conceptual knowledge in pre-service primary teachers is elaborated and validated. A multiple-choice test with 50 items was proposed. Four content areas of science from the curriculum of Primary Education in Spain were considered: natural environment and its conservation, biological diversity, health education and the human body, matter and energy. A sample of 83 pre-service teachers from a spanish university participated in the statistical validation process. Both external consistency (Test-Retest correlation) and internal consistency (Kurder-Richardson's 20th formula) were above 0.7. Item difficulty and discrimination indices were analysed as well as distractor election. Although some adjustments should be made, indicators suggest that the instrument is appropriate for its purpose. Furthermore, remarkable results about participants' poor conceptual mastery and misconceptions were identified. Implications of these findings are discussed.

**Keywords**: Trainee elementary school teachers, science concepts, conceptual knowledge, instrument validation.

## RESUMEN

Se ha elaborado y validado una primera versión de un instrumento para evaluar el conocimiento de conceptos científicos de los maestros de primaria en formación. Se ha un propuesto un cuestionario de opción múltiple de 50 ítems. En él se han tenido en cuenta las cuatro áreas científicas del currículum de la Educación Primaria en España: medio natural y su conservación, diversidad biológica, educación para la salud y el cuerpo humano, y materia y energía. En el proceso de validación estadístico han participado 83 maestros de primaria en formación, estudiantes de una universidad española. Tanto la consistencia externa (correlación Test-Retest), como la interna (Fórmula 20 de Kurder-Richard), son del orden de 0.7. Asimismo, se han analizado los índices de dificultad y de discriminación de los ítems, y la elección de los distractores. Todos los indicadores sugieren que el cuestionario es apropiado para el objetivo propuesto, aunque son necesarios algunos ajustes. Por otro lado, los participantes han puesto en evidencia un pobre dominio conceptual y algunas concepciones alternativas. Finalmente, a partir de los resultados obtenidos se discuten algunas implicaciones.

**Palabras clave**: Estudiantes de Magisterio, conceptos de ciencia, conocimiento conceptual, validación de un instrumento.

## INTRODUCTION

Teachers need to develop knowledge, skills, and attitudes in many domains, such as subject matter knowledge, general pedagogical knowledge, knowledge of the context of learning, and pedagogical content knowledge or knowledge that is specific to teaching a particular subject area (Goodnough & Hung, 2009). It should be noted that, according to Kaya's (2009) study, without strong content knowledge, strong pedagogical content knowledge is impossible to achieve.

Teacher's content knowledge is a critical component in teaching as it affects what teachers teach and how they teach (Lewthwaite & MacIntyre, 2003). Mellado (2000) emphasized the importance of subject-matter knowledge as a necessary but not sufficient condition for pre-service teachers' training. In fact, literature has shown a strong relationship between science teachers' competence and their content knowledge (Alexander, 2000).

However, some studies on primary teachers renewed the concern about their poor science background knowledge (Appleton, 2003; Campanario, 1998; Cañal, 2000; Hackling *et al.,* 2007; Macdonald & Hoban, 2009). Lack of science content knowledge is often cited as the cause of teachers' inability to teach science effectively (Fleer, 2009) and can lead their students to misconceptions (Kaptan & Korkmaz, 2001). In the Harlen's (1997) study primary teachers expressed low confidence in teaching science, which was linked to a lack of understanding of scientific ideas.

In spite of the relevance of elementary teachers' science content knowledge, there is very little research available on this issue (Diamond *et al.*, 2013). The main goal of this study is to design and to validate a tool for assessing spanish primary teachers' science content knowledge. This study also tries to identify teachers' misconceptions, weaknesses and strengths in different science content knowledge areas.

## METHODOLOGY

### 2.1. Instrument design and development

According to Jarrett *et al.* (2012), multiple-choice instruments are suitable for data collection in educational surveys. In order to design a multiple-choice instrument for assessing spanish primary teachers' science conceptual knowledge, several steps were taken. First, a full revision of national curriculum documents was made to determine the main subject areas involved in Primary Science in Spain. Four areas of curricular content (or "blocks") are distinguished in national curriculum documents: natural environment and its conservation ("Environment" onwards), biological diversity ("Life" onwards), health education and the human body ("Health"), and matter and energy ("Energy"). The content in these blocks is similar to the science content recommended by the AAAS' report (1989) and it has been taken into account in other instruments, such as in Laugksch and Spargo's (1996) one.

National curriculum documents for spanish elementary science mentione a long list of scientific concepts. In order to keep the minimum set of concepts covering the maximum knowledge, a set of well-known and widely used textbooks in Spain were analysed. Page by page, the textbooks were carefully examined, paying attention to the expositive content as well as to the application tasks. We took into account the concept frequency and the relationship among the concepts in the main ideas of the lessons to determine the most outstanding concepts. A set of 50 scientific concepts resulted from that analysis. Each main concept was associated to specific basic science knowledge. These concepts were considered as "core" concepts in primary school, and important for further scientific learning (propaedeutic role). Of course, these concepts should also be considered very important in the training science curriculum of pre-service primary school teachers, as they will have to instruct their students in these concepts.

This set of main concepts was considered to elaborate a Primary Science Concepts Questionnaire (PSCQ-1 onwards). We covered the aforementioned four curricular blocks. The researchers elaborated the items trying to maintain the independence of the 50 concepts. In that way, answering a particular item correctly did not require knowledge of other main concepts. In order to keep conceptual knowledge independent from other types of knowledge, each item had a purely conceptual nature. Thus, giving the right answer to the items did not involve procedural skills but only definitions, knowing taxonomic or

partonomic relations, application contexts, or specific functions for body organs.

Five options were provided for each item: a correct one, three distractors and an open one to be written by the participant. Instructions to fill in the instrument informed that there was only a correct option in each item. Instructions also asked students to use the open option just and only if they considered erroneous the four options provided. In that way, we could obtain feedback about possible errors in the item design, reading obstacles or if the options provided were inadequate. Appendix 1 shows the resulting questionnaire PSCQ-1 (the open option in each item has been excluded for space reasons).

### 2.2. Procedure and participants

The validation procedure followed two main steps. In the first step a group of three professors of various ranks, experts in science education, analysed the 50 items proposed. They should judge whether they were suitable for Primary School or not. They suggested a few changes and adjustments. According to their suggestions, some replacements and re-writing were made. In addition, two experts considered that certain items (for instance, #8 and #21) involved geography concepts and not geology concepts, and suggested the possibility of remove them from the questionnaire. This recommendation was taken into account to improve the instrument at the end of the validation phase.

In the second step five intact groups (classroom groups formed by the university authorities) of pre-service primary school teachers from a spanish university participated in the study. Participants were enrolled in “Science for Primary School-Teachers”, a compulsory subject. In order to assess the consistency and reliability of the questionnaire, a Test-Retest procedure was followed, with a two week delay between the first and the second administration. The Test and the Retest took place in the final quarter of the course. Participants spent around 45 minutes to fill in the questionnaire in each administration. Each item was evaluated as correct (1 point) or incorrect (0 points).

We obtained valid data from 83 male and female students, aged 19-51, with an average of 22 years old. These subjects made up our sample.

## RESULTS AND DISCUSSION

### 3.1. Global results

A global mean score was obtained from the 50 items taken together. In the first administration of the questionnaire, the average percentage of correct answers reached 61% corresponding to a mean score of 30.5 over 50, with a standard deviation, SD, of 6.5. The quartiles were defined by the scores 26.0; 31.0; 35.0. In the Retest, the average of correct answers was 66 percent, corresponding to a mean score of 33.0 over 50 (SD = 6.0). The quartiles were defined by the scores 28.5; 33.0; 37.0. The Kolmogorov-Smirnov test showed that both the Test and the Retest distributions were not significantly different from Gaussian distributions (Test and Retest: $p > 0.20$).

The content blocks obtained similar (normalized) mean percentages of correct answers in the first administration (from 60% in “Life”, to 65% in “Environment”), and in the Retest (from 61% in “Health”, to 68% in “Environment”).

A 2x4 Administration (Test/Retest) x Block (Environment/Life/Health/Energy) repeated measures ANOVA, was conducted. Significant differences, with a moderate to high effect size and good statistical power were obtained for the main effect of the Administration factor, i.e., the Test-Retest comparison ($F = 9.764$; $p = 0.003$; $\eta^2 = 0.14$; $P = 0.89$). Thus, Retest (second administration of the questionnaire) obtained better global score than the Test (first administration). This was probably due to the well-known “learning effect” when the same test is administered twice to the same subjects.

Significance was also obtained for the main effect of the Block factor, with a moderate effect size but with an insufficient statistical power ($F = 2.941$; $p = 0.040$; $\eta^2 = 0.13$; $P = 0.67$). Thus, once the Test and Retest scores were collapsed, there were intra-block differences. Post-hoc analysis showed the significant differences in the “Environment/ Life” ($t = 2.316$; $p = 0.024$) and “Environment/ Health” ($t = 2.477$; $p = 0.016$) comparisons.

Finally, there was not significant “Administration x Block” interaction ($p = 0.252$), so Test-Retest differences were statistically similar in the four blocks.

### 3.2. Item difficulty indices

We also explored the difficulty index (the proportion of correct answers) of each of the 50 items in the Test and in the Retest. In the first administration (the "Test"), these indices had values between 0.12 (the most difficult one) and 0.93 (the easiest one). A 25 per cent of the items had a difficulty index lower than 0.46, and the other quarter of the items had a difficulty index higher than 0.75. In the Retest, the difficulty indices ranged from 0.09 to 0.96. A quarter of the items had a difficulty index below 0.54 and another quarter had a difficulty index over 0.82.

We can define as "normal" those items with difficulty indices within 0.65 and 0.84 (Aiken, 2003). Thus, 54 per cent were "normal items" in PSCQ-1 when Test and Retest were considered together. However, the distribution was not symmetric: only 10% were "difficult" items (i.e. difficulty index over 0.85) and 36% were easy items (i.e. difficulty index 0.65 or below). Among the "easy" items, only 10% were very easy items (difficulty index less than 0.30).

### 3.3. Item discrimination indices

In addition, we calculated the discrimination indices, D, in a classical way. Thus, we considered the upper 27% subgroup (the subjects with the 27 per cent highest global scores) and the lower 27% subgroup in the sample. Then, for each item, we computed the difference $D_k = U_k - L_k$, where k is the particular item, $U_k$, is the proportion of correct answers to item k in the upper group, and $L_k$ is the proportion of correct answers to item k in the lower group (Kelly, 1939). Answer options with positive D-values are those selected by the high-score group of students more frequently than by low-score group. Items with D-values over 0.30 are usually considered good discriminants. On the other side, D-values near to 0 indicate low o not discrimination between high and low skilled students according to that instrument. In the first administration of the PSCQ-1, 16% of the items (#1, #9, #11, #12, #31, #43, #44 and #49) obtained low discrimination values (D < 0.10). The remaining items obtained good discrimination values. In the second administration (Retest) only 8% of the items (#16, #20, #24 and #31) obtained low D-values. In both administrations, none of the low discrimination items resulted of special difficulty for the subjects. These items had non-significant item-total (point-biserial) correlation values (p > 0.10), in coherence with their low discrimination values. Thus, in order to improve the questionnaire these items should be revised.

### 3.4. Non-functional distractors

Non-functional distractors (NFD) have been defined by DiBattista and Kurzawa (2011) as answer wrong options in multiple-choice items obtaining very low election proportion, or a very low discrimination index. The first criterion (low election proportion) let us identify a first group of NFD: those selected by less than 5 per cent of the participants. Considering the Test and Retest together, 30 per cent of the items had two NFD, whereas 68 per cent had none or only one NFD in PSCQ-1. Detailed inspection let us split the items having more than one NFD in two different subgroups: very easy items and items pointing out some conceptual error or wrong learning. Some items were so easy (high proportion of correct answers) that the wrong options could not reach 5% in two or three distractors at the same time. The only item having three NFD (item #12) fits this case. In the other subgroup we found items with a wrong option selected with high frequency, and then, with the other two wrong options having less than 5 per cent of selection.

The second DiBattista and Kurzawa criterion for NFD (positive discrimination) determines those distractors selected by the upper-score group of students more frequently than by the lower-score group. We detected one of this type of NFD in item #2 and another one in item #31. These wrong options selected by competent students should be reviewed. Appendix 1 shows the percentages of distractor election in every item of PSCQ-1.

### 3.5. Internal consistency (reliability)

The PSCQ-1 is far from a "single construct" measuring instrument. Each of the 50 items involved just one concept, and these concepts were selected to be independent so that the maximum knowledge could be covered. Concepts involved can or cannot be related in subjects' memory. Thus, item-item correlations do not necessarily have to be high or significant. Although concepts involved in the items can be considered nearly independent, reliability was measured by the Kurder-Richardson's 20th formula ("KR-20 value"). It seemed reasonable to find some significant correlations between certain

items, as university students with a high level of science knowledge have usually studied various scientific subjects and, conversely, university students with a low level of science knowledge have chosen other academic options and do not probably remember much of their past knowledge, whatever the scientific conceptual block or scientific topic may be.

Reliability values were high enough in the first administration (Test: KR-20 = 0.78) as well as in the second administration (Retest: KR-20 = 0.79). Therefore, the PSCQ-1 reliability was considered enough (George & Mallery, 2003). We computed the KR-20 values when one item is removed. The KR-20 values did not change significantly and kept in the range [0.75 - 0.78] in the Test, and in the range [0.76 – 0.80] in the Retest. Hence, these results did not suggest that any item should be removed, although eliminating a couple of items would increase the KR-20 values a little bit. These results suggest that, globally, the PSCQ-1 can be used for a reliable assessment of elementary science concept knowledge of spanish pre-service teachers.

### 3.6. External consistency (consistency over time)

The Test-Retest correlation was used to calculate external consistency. The Pearson's correlation was high and significant for the global scores ($r = 0.89$; $p < 0.001$) so consistency was considered good enough. Regarding blocks, the Test-Retest correlations were also significant ($p < 0.001$) and high enough (from $r = 0.66$ for "Life" to $r = 0.77$ for "Energy").

Regarding between-block correlations (Tables 1A and 1B), all the Pearson's coefficients reached significance (Test: $p < 0.005$; Retest: $p < 0.001$), although the values were not very high. If we keep in mind that differences in the conceptual content of the blocks were maximised in the instrument, the values can be considered good enough.

***Table 1A.*** *Test: between-blocks correlation values*

| Pearson's coefficient | Energy | Health | Life |
|---|---|---|---|
| **Health** | 0.49 | | |
| **Life** | 0.38 | 0.35 | |
| **Environment** | 0.45 | 0.39 | 0.40 |

***Table 1B.*** *Retest: between-blocks correlation values*

| Pearson's coefficient | Energy | Health | Life |
|---|---|---|---|
| **Health** | 0.57 | | |
| **Life** | 0.46 | 0.49 | |
| **Environment** | 0.59 | 0.60 | 0.41 |

In summary, the PSCQ-1 showed good consistency and suitable reliability, although some items need reconsideration.

### 3.6. Pre-service Primary teachers' conceptual knowledge

The Appendix 1 shows the percentage of correct answer in each item. Table 2 shows the most difficult items (average score lower than 0.20) in each blocks in PSCQ-1 and their average percent of success in brackets.

***Table 2.*** *The easiest and the most difficult items in each concept block (Test and Retest percentage has been averaged).*

| | Easiest items | Most difficult items |
|---|---|---|
| **Environment** | #23, Epicentre (94%) | #18, Galaxy definition (34%) |
| **Life** | #10, Invertebrates (82%) | #31, Virus (29%) |
| **Health** | #32, Respiratory system (79%) | #35, Excretory system (12%) |
| **Energy** | #12, Properties of matter (94%)<br>#43, Kinetic energy (90%)<br>#39, Volume units (84%)<br>#40, Density (84%) | #2, Propagation of sound (14%)<br>#46, the Earth Charter (18%) |

The analysis of wrong options may be of great educational interest. Some items obtained low levels of success in both administrations (Test and Retest) so revealing a poor conceptual mastery, but not a clear conceptual error. In these items, at least two distractors obtained a high frequency compared to the one in the correct option. Items #2, #31 and #46 defined this group.

Other items suggested troubling misconceptions in future teachers. This was found because in these items typical and well-known conceptual errors were associated to distractors specifically designed to this purpose. Test-Retest comparison let us focus on potential

conceptual errors or persistent incorrect learning. Obviously, we expected such misconceptions would be present in a small percentage of future primary school-teachers, but this was not the case in some topics. In these items only one distractor obtained a high frequency compared to the one in the correct option. This was the case of items #11, #17, #18, and #35, for which the wrong answers concentrated on a single option which reached such a high frequency that it overpassed the one in the correct option. In other items, #3, #22, #30 and #38, the wrong answers also concentrated on a single distractor but its frequency was lower than the frequency of the correct option. Information about both subgroups of items is provided in Table 3.

***Table 3.*** *Most frequent errors in the sample. Percentages of election in the distractors and in the correct answer are given in brackets.*

| Question | Frequent Error | Correct Answer |
|---|---|---|
| -What is the name given to the leaves that form the calyx of a flower? #11 | Petals (48%) | Sepals (31%) |
| -What colour is obtained if all the colours of the rainbow are mixed? #17 | Black (49%) | White (45%) |
| -What is the name given to the groups formed by gas, interstellar dust and thousands or millions of stars? #18 | Nebulas (50%) | Galaxies (34%) |
| -In the excretory system, what duct connects to the outside of the body? #35 | Anus (74%) | Urethra (12%) |
| -What is the name given to the movement of the Earth around the Sun? #3 | Rotation (21%) | Revolution (79%) |
| -What part of a volcano is the conduit? #22 | Orifice connecting volcano to the exterior (29%) | Pipe by which magma flows up (70%) |
| -Which is the organ responsible for filtering the blood and rids of waste products? #30 | Liver (28%) | Kidneys (70%) |
| -What is the name given to the cells resulting from the fertilization? #38 | Gamete (30%) | Zygote (67%) |

The analysis of the discrimination indices for these eight items revealed that in the former subgroup (the first four items) the error was generalized in the sample, but in the latter subgroup the misconception was associated to the less skilled students (27% of subjects with the lowest scores in the whole questionnaire) but not to the high skilled students (27% of subjects with the highest scores in the whole questionnaire).

These results are consistent with previous evidence of pre-service teachers' misconceptions and conceptual errors in different science subjects obtained in previous studies (Bisard *et al.*, 1994; Keles *et al.*, 2010; Kikas, 2004; Schoon & Boone, 1998; Trundle *et al.*, 2002).

## CONCLUSIONS AND IMPLICATIONS

The main objective of this work was designing and validating an instrument to assess elementary science concept knowledge in pre-service primary teachers. The instrument was elaborated after analysing some national curriculum documents and bestselling textbooks. This analysis resulted in a set of 50 most-relevant selected concepts in elementary science. Each single item was elaborated using just one different concept. Only conceptual knowledge was necessary to give the correct answer to each item. At the end of the validation study we obtained suitable Test-Retest consistency and enough reliability for the PSCQ-1. Therefore, the proposed questionnaire can be considered as an appropriate instrument to assess Primary School teachers' knowledge of elementary science concepts, at least in Spain, though some indicators of conceptual or statistical nature provided evidence of the need to perform some changes and adjustments in the questionnaire.

In addition, conducting this study let us perceive some troubling issues that should be considered. Our participants, pre-service primary school-teachers, have exhibited poor conceptual knowledge in some items. This fact should warn us of the way primary school teachers are being trained in elementary science at university. Although the average scores in Test and in the Retest (61-66%) were in line with the average (65%) obtained by the National Science Foundation 2012 survey (NSB, 2014) for its wide adult sample, we expected primary school teachers have better science knowledge that

adult general population.

On the other hand, some items have highlighted possible pre-service teachers' misconceptions in elementary science concepts. Some misconceptions were widely distributed in the sample. For instance, as shown in Table 3, almost 50 percent of the subjects considered “petals” as the name of the leaves forming the calyx in a flower (the correct option, “sepals” obtained 31 percent of choice) or they said that blending the rainbow colours together results in colour “black” instead of “white” (45 percent chose the correct option ). Near 80 percent chose the “anus” as a duct, a part of the excretory system connecting to the outside of the body (only 12 percent of the answers were correct: “urethra”). It is always difficult to determine the origin of such misconceptions but probably active learning methods (Michael, 2006) such as giving the students more opportunities to deal with experimental work, and engaging in inquiry learning could solve part of these problems.

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## APPENDIX 1.

**The questionnaire to assess primary teachers' science conceptual knowledge.**

The correct option in each item has been highlighted (*). The percentage of subjects choosing each answer option is shown. Blank answers are not considered. (Test and Retest have been averaged).

| QUESTION | ANSWER OPTIONS (*correct answers) | PERCENTAGE |
|---|---|---|
| 1. Which is the characteristic of sound that tells us the difference between a high sound and a low sound? | a) Volume | 1% |
| | b) Intensity | 6% |
| | c) Pitch* | 68% |
| | d) Timber | 25% |
| 2. In which medium the sound travels faster? | a) Solids* | 14% |
| | b) Liquids | 21% |
| | c) Gases | 28% |
| | d) Vacuum | 37% |
| 3. What is the movement of the Earth around the Sun called? | a) Rotation | 21% |
| | b) Precession | 0% |
| | c) Revolution* | 79% |
| | d) Circumference | 0% |
| 4. How long does it take the Moon to orbit the Earth? | a) 21 days | 21% |
| | b) 28 days* | 68% |
| | c) 365 days | 6% |
| | d) 7 days | 2% |
| 5. Which state change of matter is produced when water vapour is cooled and become liquid water? | a) Condensation* | 84% |
| | b) Melting | 7% |
| | c) Solidification | 9% |
| | d) Evaporation | 0% |
| 6. What kind of device is used for measuring wind speed? | a) Weathercock | 14% |
| | b) Pluviometer | 0% |
| | c) Anemometer* | 49% |
| | d) Barometer | 36% |
| 7. Which of the following statements is correct? | a) Minerals like marble and granite are of great utility for construction | 25% |
| | b) Rocks have low value for human beings due to their few applications | 1% |
| | c) Rocks are made of minerals* | 64% |
| | d) Minerals are made of rocks | 8% |
| 8. What type of relief is a gulf? | a) A steep rock face, near vertical, at the edge of the sea | 4% |
| | b) A part of land extending into the sea | 19% |
| | c) A portion of the ocean or sea extending into the land* | 75% |
| | d) A piece of land nearly surrounded by water but connected to continent | 2% |
| 9. Which is the function of phloem in a plant? | a) Absorbing rays from solar light | 9% |
| | b) Carrying elaborated sap from the leafs to the rest of the plant* | 47% |
| | c) Carrying raw sap from the roots to the rest of the plant | 30% |
| | d) Absorbing water and mineral salts from the soil | 9% |
| 10. Which of the next animal groups are invertebrates? | a) Birds | 0% |
| | b) Fishes | 1% |
| | c) Insects* | 82% |
| | d) Amphibian | 15% |

| | | |
|---|---|---|
| 11. What is the name given to the leaves that form the calyx of a flower? | a) Sepals* | 31% |
| | b) Stamens | 9% |
| | c) Petals | 48% |
| | d) Corolla | 11% |
| 12. Which magnitudes or general properties does matter have? | a) Weight and area | 1% |
| | b) Volume and mass* | 94% |
| | c) Volume and shape | 1% |
| | d) Mass and area | 4% |
| 13. What happens when a force is applied to an object? | a) Shape and velocity can be modified* | 66% |
| | b) Size and shape can be modified | 10% |
| | c) Velocity and mass can be modified | 10% |
| | d) Mass and volume can be modified | 12% |
| 14. What kind of changes modify the composition of matter? | a) Physical changes | 11% |
| | b) Chemical changes* | 82% |
| | c) Biological changes | 1% |
| | d) None. Matter does not change | 6% |
| 15. Which of the following mixtures is homogeneous? | a) Water and oil | 8% |
| | b) Water and gas | 14% |
| | c) Iron filing and sulphur powder | 3% |
| | d) Water with salt dissolved* | 75% |
| 16. What is the bending of light rays when they pass from a fast medium to a slower one called? | a) Reflexion | 16% |
| | b) Diffraction | 20% |
| | c) Attenuation | 3% |
| | d) Refraction* | 60% |
| 17. Which colour is obtained if all the colours of the rainbow are mixed? | a) Black | 49% |
| | b) White* | 45% |
| | c) Red | 4% |
| | d) Yellow | 1% |
| 18. What is the name given to the groups formed by gas, interstellar dust and thousands or millions of stars? | a) Nebulas | 50% |
| | b) Constellations | 15% |
| | c) Galaxies* | 34% |
| | d) Planetary systems | 1% |
| 19. Which planets of the Solar System are called the “rocky” planets? | a) Jupiter, Saturn, Uranus and Neptune | 16% |
| | b) Earth and Mars | 19% |
| | c) Mercury, Venus, Earth and Mars* | 55% |
| | d) All Solar System planets are made up by rocks | 8% |
| 20. In which region of the atmosphere is the ozone layer that protects us from harmful radiations? | a) Ionosphere | 13% |
| | b) Troposphere | 23% |
| | c) Mesosphere | 13% |
| | d) Stratosphere* | 49% |
| 21. What is the name given to small natural areas where fresh water is stored? | a) Reservoirs | 12% |
| | b) Ponds* | 79% |
| | c) Rivers | 9% |
| | d) Seas | 0% |
| 22. What part of a volcano is the conduit? | a) Underground pool where magma resides temporary | 1% |
| | b) Orifice connecting volcano to the exterior | 29% |
| | c) Pipe by which magma flows up* | 70% |
| | d) Rocks and solid material formed when lava gets cold | 0% |
| 23. What is the earthquake’s epicentre? | a) The closest point on the Earth surface to the point where the earthquake originates* | 94% |
| | b) It is the measure of the effects produce on people, constructions and on the Earth’s surface | 0% |
| | c) It is the measure of the earthquake’s size and shows the amount of energy released | 0% |
| | d) It is the measure of the earthquake’s size using the MSK scale | 6% |
| 24. What kind of rock is clay? | a) Igneous | 11% |
| | b) Metamorphic | 18% |
| | c) Magmatic | 9% |
| | d) Sedimentary* | 60% |
| 25. What is climate? | a) Meteorological features occurring in a specific region over a long period of time* | 72% |
| | b) Set of atmospheric phenomena occurring in a specific time and | 17% |

| | | |
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| | place | |
| | c) The estate of the atmosphere over a short period of time (e.g. from day to day or week to week) | 0% |
| | d) The meteorological conditions produced by changes in atmospheric pressure | 9% |
| 26. Which is the vital function that flowers accomplish in plants? | a) Respiration | 13% |
| | b) Reproduction* | 79% |
| | c) Nutrition | 3% |
| | d) Interaction | 3% |
| 27. In addition to water and Sun, what gas do the plants need to carry out the photosynthesis? | a) $O_2$ (oxygen) | 21% |
| | b) CO (carbon monoxide) | 3% |
| | c) $CO_2$ (carbon dioxide)* | 73% |
| | d) $N_2$ (nitrogen) | 0% |
| 28. Which of the following statements about the differences between plant cells and animal cells is correct? | a) Animal cells have mitochondria and plant cells do not | 3% |
| | b) Plant cells contain organelles called chloroplasts that animal cells do not* | 72% |
| | c) Plant cells do not have cellular membrane and animal cells do | 23% |
| | d) There are no differences. All living organism are made up of the same cells | 1% |
| 29. Living things can be arranged in levels of complexity. When some tissues co-work to perform the same function, what do they form? | a) Organs* | 77% |
| | b) Apparatus | 13% |
| | c) Molecules | 6% |
| | d) Interwoven systems | 4% |
| 30. Which organ is responsible for filtering the blood to remove waste substances? | a) Stomach | 1% |
| | b) Liver | 28% |
| | c) Kidneys* | 70% |
| | d) Urinary bladder | 1% |
| 31. What biological kingdom do viruses belong to? | a) Fungi | 7% |
| | b) Monera | 26% |
| | c) Protista | 38% |
| | d) In any kingdom* | 29% |
| 32. Where is the exchange among $O_2$ and $CO_2$ produced in the respiratory system? | a) Bronchi | 13% |
| | b) Bronchioles | 8% |
| | c) Pulmonary alveolus* | 79% |
| | d) Trachea | 0% |
| 33. Nutrients pass into the blood in… | a) The large intestine | 16% |
| | b) The small intestine* | 56% |
| | c) The oesophagus | 8% |
| | d) The stomach | 20% |
| 34. Which blood component has the function of carrying oxygen? | a) Plasma | 2% |
| | b) Platelets | 5% |
| | c) White cells | 21% |
| | d) Red cells* | 72% |
| 35. What duct connects the inner body to the outside in the excretory system? | a) Ureter | 11% |
| | b) Anus | 74% |
| | c) Urethra* | 12% |
| | d) Urinary bladder | 2% |
| 36. Which organs form the central nervous system? | a) The brain and the spinal cord* | 60% |
| | b) The cerebrum and the cerebellum | 9% |
| | c) The cerebrum, the cerebellum and the medulla oblongata | 26% |
| | d) The sensory and motor nerves | 3% |
| 37. Which endocrine gland produces insulin? | a) Hypophysis | 15% |
| | b) Thyroid gland | 18% |
| | c) Pancreas* | 65% |
| | d) Ovaries | 0% |
| 38. What is the name given to the cells resulting from the fertilization? | a) Gamete | 30% |
| | b) Ovule | 2% |
| | c) Spermatozoon | 1% |
| | d) Zygote* | 67% |
| 39. Which unit can be | a) Gram (g.) | 4% |

| | | |
|---|---|---|
| used to measure volume instead of litres and millilitres? | b) Kilogram (Kg) | 11% |
| | c) Cubic centimetre ($cm^3$)* | 84% |
| | d) Metre (m) | 1% |
| 40. Which characteristic property of matter results from dividing mass by volume? | a) Hardness | 1% |
| | b) Weight | 14% |
| | c) Density* | 84% |
| | d) Length | 0% |
| 41. What determines whether an element floats or sinks in a liquid? | a) Its weight compared with that of the liquid | 9% |
| | b) Its mass compared with that of the liquid | 7% |
| | c) Its volume compared with that of the liquid | 8% |
| | d) Its density compared with that of the liquid* | 76% |
| 42. Which of the following statements about energy is correct? | a) It's impossible to store energy in order to use it when necessary | 1% |
| | b) While transferring from one body to another, part of the energy is destroyed | 4% |
| | c) Energy is created from solar rays by solar panels | 20% |
| | d) Energy can be transferred from one body (system) to another* | 73% |
| 43. What kind of energy does a moving object have? | a) Sound energy | 1% |
| | b) Thermal energy | 5% |
| | c) Electromagnetic energy | 4% |
| | d) Mechanic energy* | 90% |
| 44. Which of the following statements about renewable energy sources is correct? | a) They are considered inexhaustible energy sources* | 41% |
| | b) They are at present time the most common energy sources | 2% |
| | c) Thermal solar energy is an energy source that generates electricity by means of photovoltaic solar panels | 50% |
| | d) It does not produce any kind of visual impact | 7% |
| 45. Combustion of petroleum products produces emissions of pollutant gases to the atmosphere, such as sulphur dioxide ($SO_2$). What is the name of the atmospheric phenomenon resulting from the mixture of sulphur dioxide and water vapour from the atmosphere? | a) Greenhouse effect | 9% |
| | b) Global warming | 8% |
| | c) Acid rain* | 81% |
| | d) Cold front | 2% |
| 46. What is the document, considered a very valuable educational instrument, where the fundamental ethical principles for Sustainable Development were established? | a) The Universal Declaration of Human Right | 26% |
| | b) The Charter of the United Nations* | 18% |
| | c) The Earth Charter | 18% |
| | d) The Rio Declaration on Environment and Development | 36% |
| 47. Which movement of charged particles in a closed circuit is produced when electric current flows through it? | a) Protons flow from the positive pole to the negative pole | 15% |
| | b) Electrons flow from the positive pole to the negative pole | 34% |
| | c) Protons flow from the negative pole to the positive pole | 8% |
| | d) Electrons flow from the negative pole to the positive pole* | 38% |
| 48. Which device, based on Faraday's experiments, generates electric current using a magnetic field? | a) Battery | 23% |
| | b) Electric motor | 4% |
| | c) Transformer | 37% |
| | d) Dynamo* | 34% |
| 49. Which of the following methods would you use in order to separate a solid from a liquid in a heterogeneous mixture? | a) Magnetisation | 3% |
| | b) Distillation | 11% |
| | c) Filtration* | 78% |
| | d) Crystallisation | 6% |
| 50. Which of the following chemical reactions takes place without oxygen? | a) Fermentation* | 61% |
| | b) Cellular respiration | 9% |
| | c) Oxidation | 16% |
| | d) Combustion | 13% |