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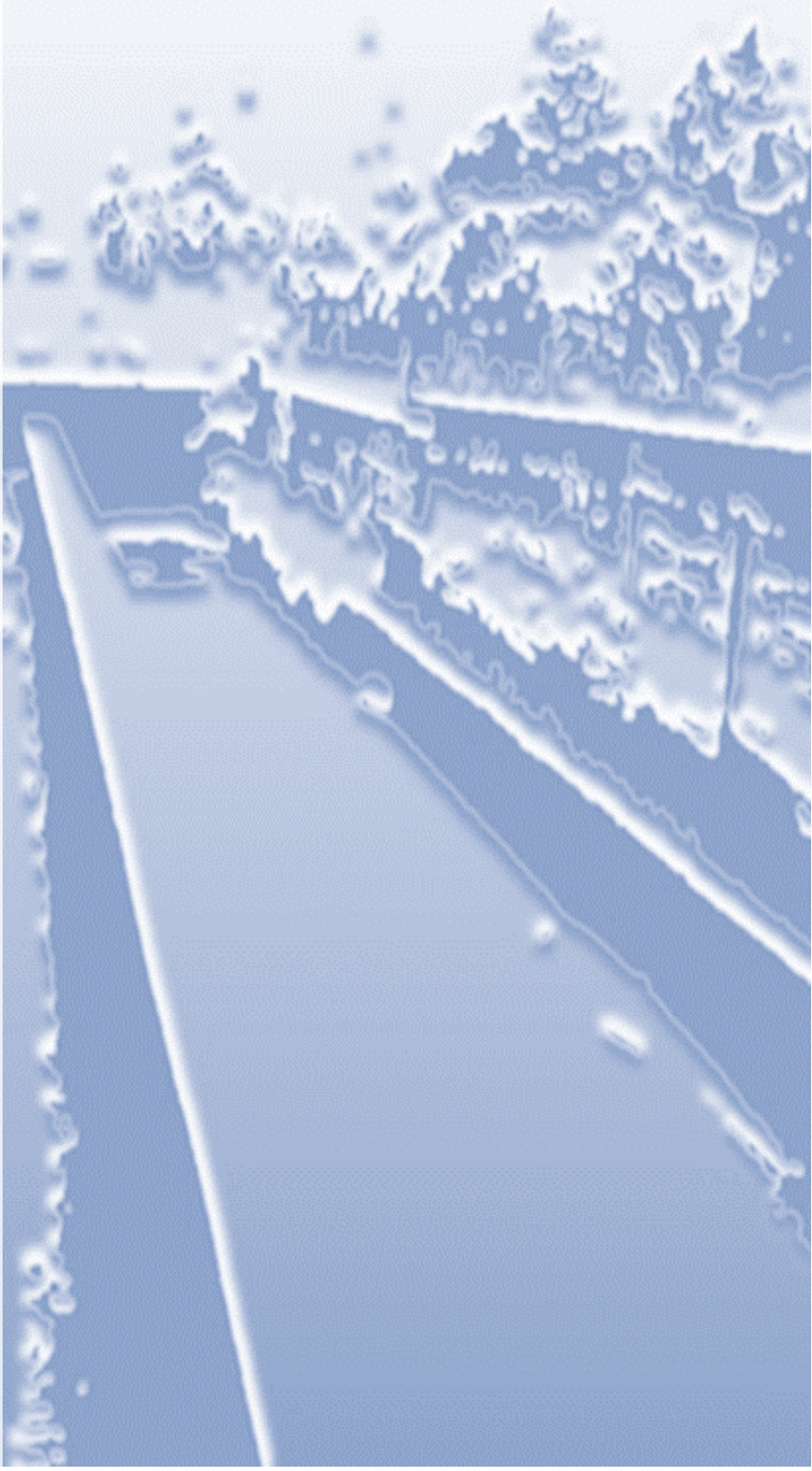
DAYLIGHTING RIVERS
SCIENCE EDUCATION FOR CIVIC ECOLOGY

REPORT OF FINDINGS

EVALUATION OF THE MODULES AND ASSESSMENT OF THE INTERVENTION'S EFFICACY



Project partners

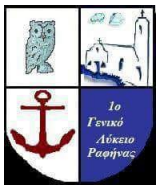


Photo of the front and back cover: Vincenza Somma (Sensale High Schools)

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Evaluation of the Modules and Assessment of the Intervention's Efficacy

1. Introduction

As a result of growing concern about the quantity and quality of water, policies on water and water usage are developed and special programmes are designed and carried out in the European Union, as in the whole world. This situation led researchers from different scientific fields to collaborate to focus on the sustainable management of water resources.

Education constitutes an important dimension among these studies. Because it is a clear fact that young generations, who understand the importance of environmental protection, will protect the existing water resources very well. Therefore, it is essential to introduce water and water use to students at earlier levels of education.

One of the water resources is rivers. Rivers have played crucial roles in human life for centuries. River is the general name given to large streams that generally flow into seas, lakes, or another large stream, especially in terms of their width and the amount of water they carry. In some cases, it is seen that it disappears under the ground or dries completely before reaching another water. Large streams are called rivers or streams, while smaller ones are called streams.

Starting from their sources, rivers flow downhill with the effect of gravity and continue their flow until they reach a sea or lake. However, there are situations where rivers lose all their water by evaporation in arid areas. In some cases, it happens that a river enters the ground at a certain point and continues its way to form groundwater from some rock types. Again, some rivers are used intensely in man-made industrial areas and this may cause the river's waters to be exhausted before they can continue their natural flow. While 97% of the water on Earth is found in oceans, one third of the potable water is in black glaciers; Almost all the rest is in underground resources. While lakes contain only 0.5% of potable water, the proportion of water available in river canals is 0.025%, which is half of this, which equates to four thousandths of the world's total water reserves.

Countries of the Mediterranean region present common traits due to similar environmental variables such as climate, vegetation and landforms, and also similar land use and urbanization approaches and impacts. Unrestrained urbanization in many towns has changed the course of rivers or even covered them over in order to locate neighbourhoods and new infrastructures, and it has also contributed to the sealing of productive soils.

The tremendous consequences of these interventions include the reduction in water infiltration and retention, and thus in underground water recharge and quality. In Italy, for instance, about two square meters of soil are lost every second due to urbanization. In addition, for the last 30 years these countries have been constantly recording evidence of climate change, with an increasing trend of extreme events like droughts and floods due to heavy rains, with impacts on living systems and in agricultural production.

Human activity spurred by economic growth has affected river quality in countless urban areas and has exacerbated environmental risks with repercussions for the local economy, environment, landscape and health. All these issues have raised the importance of public awareness at all levels of society, regarding the causes of environmental degradation and the need to acquire a more sustainable lifestyle. Civic ecology can be of aid in raising such awareness, and the integration of these issues into the educational curriculum of the younger generation is crucial. Equally important is "learning to learn" – to enhance critical thinking, questioning and investigation, applying a rational method to discern information in critical ways and to produce information by data collection, analysis, and discussion.

There are lots of studies on the usage of rivers in education. For example, Leigh et al (2019) indicate that river education can change students' attitudes. The overall positive response to statements may reflect underlying environmental awareness and pre-existing interest of participants enrolled in environmental and biology degrees, but not necessarily specific knowledge of rivers. General environmental education across the wider community could improve attitudes towards rivers, particularly when they are not flowing or in regions where they are uncommon or inconspicuous, and could support positive protection measures and innovative, inclusive management. They also highlighted that attitudes towards Temporary Rivers and the role that education can play in changing students' attitudes.

Steward (2004) examines Murray river as an outdoor education programme in south-eastern Australia. Steward, in his research, draws attention to the need for consideration of epistemological and ontological dimensions of practice that may shape the educational consequences of experiences.

River studies can be performed in a multidisciplinary way and used as an opportunity to find connections and relationships between school subjects and to allow students to move from a condition of passive learners to active investigators.

The Daylighting Rivers project promotes activities that can be integrated into different school subjects, and which relate to contexts that are familiar to the students (i.e., their neighbourhood and local river, rural areas around their town). These activities encourage critical evaluation of tangible issues, such as the impact of policy choices on the economic development of the community and stimulate student interest by drawing on their prior knowledge and associations.

Recognized as an especially effective approach to student engagement, inquiry-based learning (IBL) puts the students at the centre of the learning process and promotes scientific investigation. IBL methodologies emphasize the student's role in the learning process: students take an active role in exploring a certain phenomenon, asking questions, and debating in order to enhance skills such as critical thinking, communication and collaboration. The teacher can adopt different specific methods such as brainstorming and discussion groups, and experiment by either guiding the students or leaving them free in their exploration. By engaging students in the learning process, with practical hands-on activities, understanding is more effective.

In the age we currently live in, we suffer from serious water problems. In order for our planet to be sustainable for humans, water resources must be protected. (Seckler et al., 1999; Tundisi, 2009).

United Nations Organizations develops policies for the serious management and protection of the world's water resources. Through these policies, action plans are prepared for the protection of water resources both on a national and global scale. At the United Nations Conference on Environment and Development held in 1992, it was decided to celebrate "March 22" as "World Water Day" to draw attention to the importance of water. This decision was adopted by the United Nations General Assembly and put into practice worldwide. In this context, studies have been initiated by many organizations around the world for the protection of fresh water resources. For example, the years 2005-2013 have been accepted as "decade of Water for Life". Through these studies, it was stated to the society that fresh water resources are globally priority issue and society should understand the protection of water resources (Obara et ali 2015).

DAYLIGHTING RIVERS is a European project co-funded by the Erasmus+ Program which engages secondary school students in hands-on, interdisciplinary investigations of their local environment. Daylighting rivers means bringing to the light the rivers that have been hidden under concrete, and as broader meaning, it also means discovering, knowing the rivers, and underlining the importance of river ecosystem.

The main aim of the DAYLIGHTING RIVERS project was to raise students' awareness on the importance of saving and protecting river ecosystems and understanding the causes of the main threats, especially in urban environment. Central focus is on studying changes in the urban land cover, and particularly the riverways that flow through the city, with an emphasis on the ways in which urban growth and river management impact local ecosystems (Striano, Di Grazia, Ugolini, 2020)

1.1. The Aims of IO5

Three aims were targeted in Intellectual Output-5 (IO5):

The first aim of IO5 was to investigate the teaching and learning modules' suitability and feasibility in the schools in terms of level of challenge for implementation, cost of implementation, level of commitment, effectiveness for transversal learning and type of competences and skills addressed. This investigation was done internally (before the implementation) using daylighting rivers project's schools' teachers and students' opinions. To find out suitability and feasibility of the modules, two semi-structured interview forms were designed digitally. The analyses of this interview forms from teachers and students helped the revision of modules with additional resources, explanations which are useful for the implementation.

The second aim of IO5 was to develop survey tools to investigate effectiveness of the intervention with the teaching and learning modules in the classrooms in terms of whether it…

a) increases the acquisition of competences and skills,
b) increases the attitude of students toward STEM,
c) decreases the career decision-making difficulties,

d) increases career decision-making self-efficacy,
e) increases teaching self-efficacy and effectiveness.

Responsible partner, ICASE developed questionnaires for teachers and students separately. All questionnaires were implemented as anonymous to the teachers and students. In order to reach more teachers and students and protect the environment, online questionnaires were used for the implementation phase. As it indicated in the proposal, ICASE was responsible for preparation of the questionnaires as survey tools; and teachers from project's schools (SENSALE, RAFI NA LYCEUM, MANUEL ESPINOSA) were responsible for the implementation of this survey tools to their students and providing data to ICASE.

European Competition was planned at the end of the project. Many schools showed their interest to this competition. Because of Covid19 situation, only several teams from schools participated to this competition. **The third aim of IO5** was to collect data from students to assess the learning process and competence and skills acquisition. The data collected from the evaluation, was also used for the elaboration.

This report presents results from the analysis of data collected from students and teachers from project's schools: SENSALE, RAFI NA LYCEUM, MANUEL ESPINOSA.

1.2. The Daylighting Rivers Project's Schools

The schools that participated in the Daylighting Rivers survey are all secondary schools, however they differ in terms of orientation or specialization in their offered curricula. A brief description follows:

Liceo Scientifico Sensale and Liceo Scientifico Copernico, Italy

Both schools are Scientific schools of upper secondary education (ages 14-19 years old) in Italy. Although this kind of school does not provide qualifications for a specific profession, it aims to prepare young people to continue in scientific as well as humanistic studies at the university and allows them to participate in public competitions and access the military academies.

Students in scientific schools should acquire the following knowledge and skills:

- Understanding the specific formal language of mathematics, knowing how to use the typical procedures of mathematical thinking, knowing the fundamental contents of the theories that underlie the mathematical description of reality.
- Acquiring the fundamental contents of the physical sciences and natural sciences (chemistry, biology, earth sciences, astronomy), increasing their confidence in applying procedures and methods of investigation, increasing the decision-making capacity in the field of applied sciences.
- Being able to critically use information technology (IT) and informatics in general for educational purposes, understanding the methodological value of IT in the formalization and modelling of complex processes and in the identification of procedures.

The scientific subjects taught are Math, Natural Sciences that include specific objectives in Earth sciences, Biology and Chemistry, Earth Sciences, and Physics.

Liceo Scientifico Sensale (project partner) is in Nocera Inferiore (SA), Campania region and Liceo Scientifico Copernico is in Prato, (PO), Tuscany region. These schools are both highly appreciated for the high quality of their teaching and the interaction with local authorities and other institutions. Both schools have active collaborations with universities, research centres but also other organisations and institutions. For instance, both have been collaborating with the project partner organisations IBIMET-CNR and WREF.

1st Lyceum and 1st Gymnasium of Rafina, Greece

The 1st Lyceum of Rafina (project partner) is a General Lyceum, similar to the vast majority of Lycea (upper secondary education schools for ages 15-18, consisting of 3 grades) in Greece, therefore offering general education to its students. In terms of science education, the core of science subjects includes Mathematics (incl. Algebra and Geometry), Physics, Chemistry and Biology. In each of the 3 grades, students have an option to select either optional subjects (e.g., on the first-grade students may select Geology and Management of Natural Resources) or an orientation group. The Science orientation group in the 2nd grade includes the subjects of Mathematics and Physics, while the Science Studies orientation group in the final 3rd grade includes Mathematics, Biology, Physics, Chemistry, and Information Technology.

The 1st Gymnasium of Rafina is housed at the same building complex as the 1st Lyceum and is a General Gymnasium, similar to the vast majority of Gymnasia (lower secondary education schools for ages 12-15, consisting of 3 grades), offering general education to its students. The science subjects taught are Math, Physics, Biology, Geography, Chemistry, and Information Technology.

Both schools are located in Rafina, a small coastal town 28 km to the east of the Greek capital Athens. They both have active collaborations with research centres, including the project partner PRISMA.

IES Miguel Espinosa, Spain

IES Miguel Espinosa (project partner) is a secondary school that offers compulsory (4 grades) and non-compulsory (2 grades) secondary education for students aged 12-18. It serves students from different backgrounds, though most of them come from middle class families who live in the neighbourhood. The school is deeply concerned about meeting students' diversity and therefore provides a variety of programmes such as an English-Spanish bilingual programme and vocational training programmes for students with special needs. It also offers facilities, resources, and support for physically and mentally disabled students and all the general studies for standard students. Regarding science education, all students have compulsory subjects related to the fields of Mathematics, Technology, Physics and Chemistry and optional subjects in the fourth grade of compulsory education and in both grades of non-compulsory education (Mathematics, Biology, Physics, Chemistry, IT, Industrial technology, Geology, Economy, Business Management)

The school is located close to the city centre of Murcia (Murcia region), which is the seventh city in number of inhabitants in Spain (more than 400,000).

2. Analysis of Interview Forms for Learning Units

The modules created were firstly assessed internally (before the implementation) from the teachers and students in terms of suitability and feasibility in the school. The criteria for assessment were level of challenge for implementation, cost of implementation, level of commitment, effectiveness for transversal learning and type of competences and skills addressed. Two interview-forms were developed and addressed to the two target groups (students and teachers) for this purpose. In this section, the feedback from the two target groups were reported.

The teachers and students were informed that the interview forms are prepared for them to evaluate the feasibility and suitability of the learning units. Learning units were defined as the teaching-learning sequences which involve learning activities in five steps, namely Orientation, Conceptualization, Investigation, Conclusion and Discussion. They were kindly asked to read each description and evaluation criterion carefully, and response in as much detail as possible.

From the feedback of the two groups, the modules were revised or improved with additional resources, explanations, etc. useful for the implementation.

2.1. Analysis of Teacher Feedback

In total, 5 different learning units were assessed by 5 teachers. The learning units assessed were…

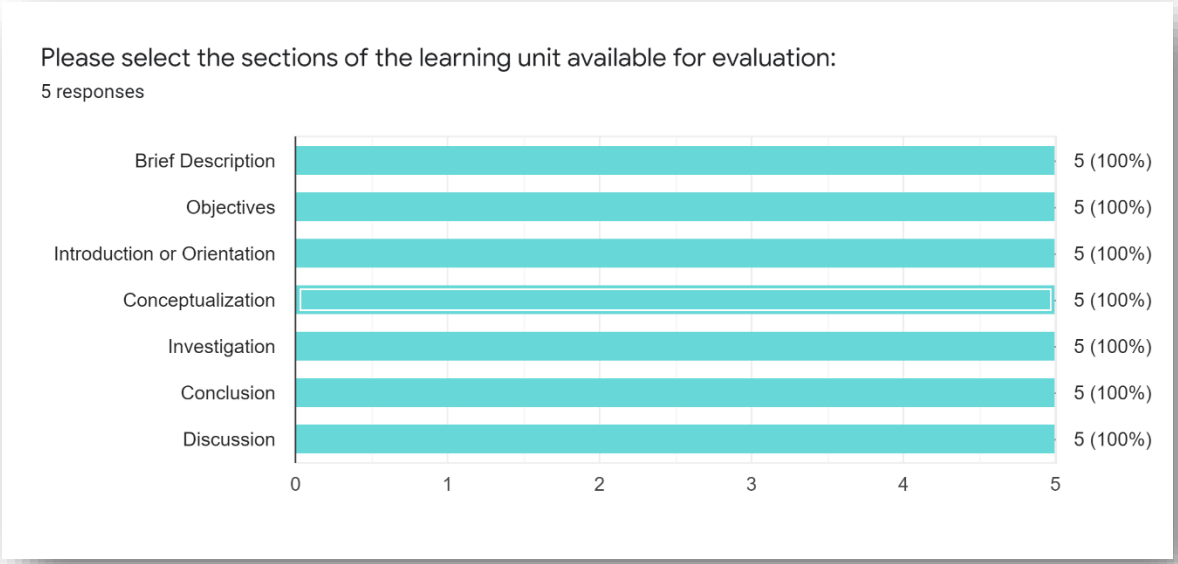
- Investigation of Little Meander (Kaystros) river basin area and water cycle
- Hydraulic aspects
- The river and the geology
- The ecosystem of the estuary of the river and eutrophication
- River impacts on art and history.

The Findings and Discussion

The first question was about the structure of the learning units. Teachers were asked if the learning units include all the necessary sub-parts.
This criterion assesses if the learning unit was developed in accordance with Daylighting Rivers methodology. According to this, the structure should have…

1. A brief description of the learning unit
2. Objectives
3. Introduction or orientation
4. Conceptualization
5. Investigation
6. Conclusion, and
7. Discussion parts.

The teachers' feedback to this question is shown in Graph 1.

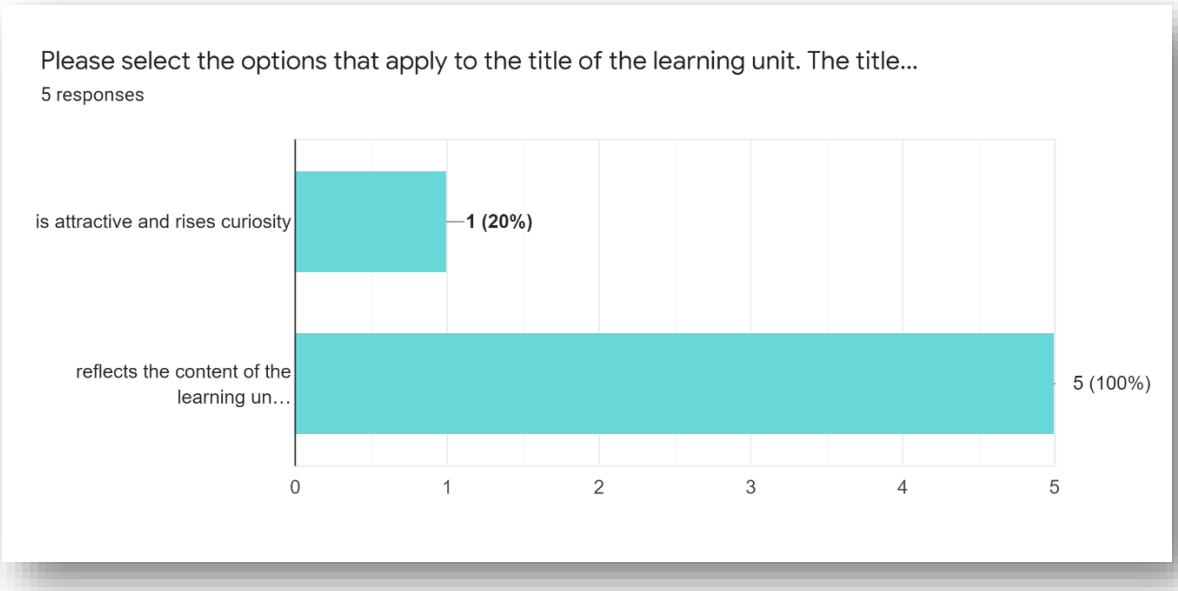


Graph 1. The sub-sections of the learning unit assessed by the teachers.

According to Graph 1, the teachers indicated that all evaluated learning units have the necessary sub-sections.

The results showed that the learning units had been developed in accordance with the Daylighting Rivers methodology.

Another requirement of the Daylighting Rivers methodology was the use of attractive title, which raises curiosity as well as reflects the content of the learning unit. The teachers' feedback is given in Graph 2.



Graph 2. The teachers' feedback in relation to the title of the learning unit.

According to the teachers' responses given in Graph 2, only 1 out of 5 learning units has an attractive title that rises curiosity. This learning is the one, entitled "Investigation of Little Meander (Kaystros) river basin area and water cycle". The titles of the other 4 out of 5 learning units were not found to be attractive and curiosity enhancing by the teachers. These 4 learning units' titles were revised in this respect.

The teachers, on the other hand, thought that the titles reflect the content of the learning well in all 5 learning units.

The questions in the rest of the interview form are divided into 5 sections. These are…

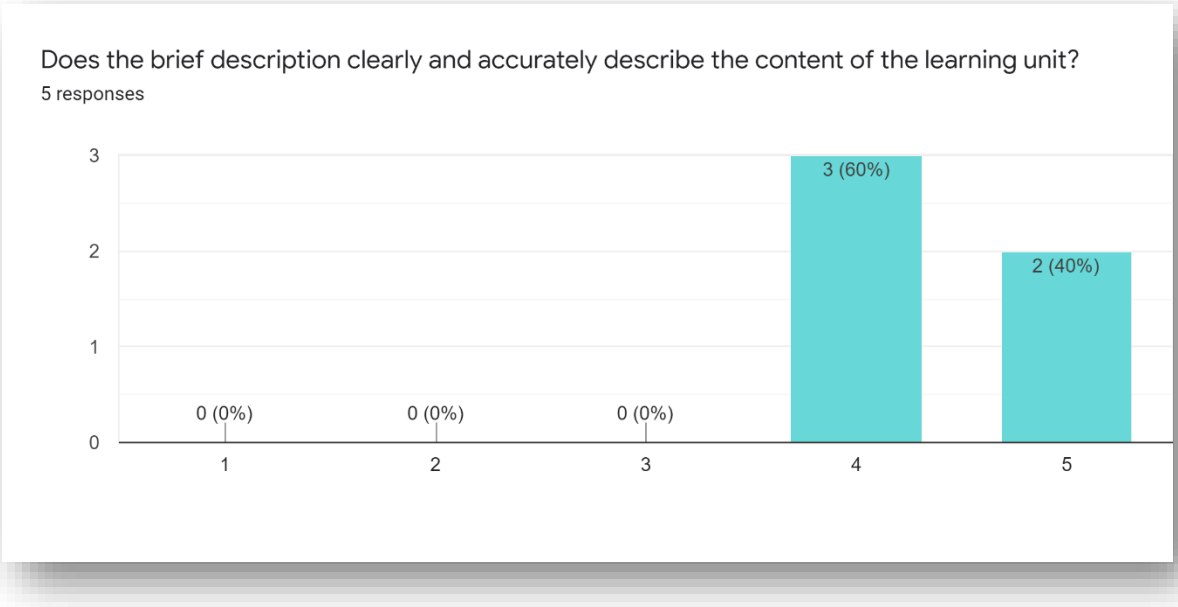
1- The assessment of the Brief Description
2- The assessment of the Learning Unit
3- The assessment in terms of Transversal Learning Opportunities
4- The assessment in terms of Competences and Skills, and
5- Other comments that the teachers would like to make.

2.1.1. The assessment of the Brief Description

Brief description is the general introduction to the learning unit. The holistic picture of the learning unit should be provided here with an introduction to the key concepts and the big idea of the learning unit.

The teachers were asked to assess the brief description in terms of whether the brief description clearly and accurately describe the content of the learning unit, and whether the objectives correctly and adequately address the content and skills that students will have at the end of the learning unit. The teachers were kindly asked to elaborate their responses.

The teachers' feedback to the first question qualitatively was given in Graph 3.



Graph 3. The assessment of the brief description in terms of clarity and accuracy the description of the content.

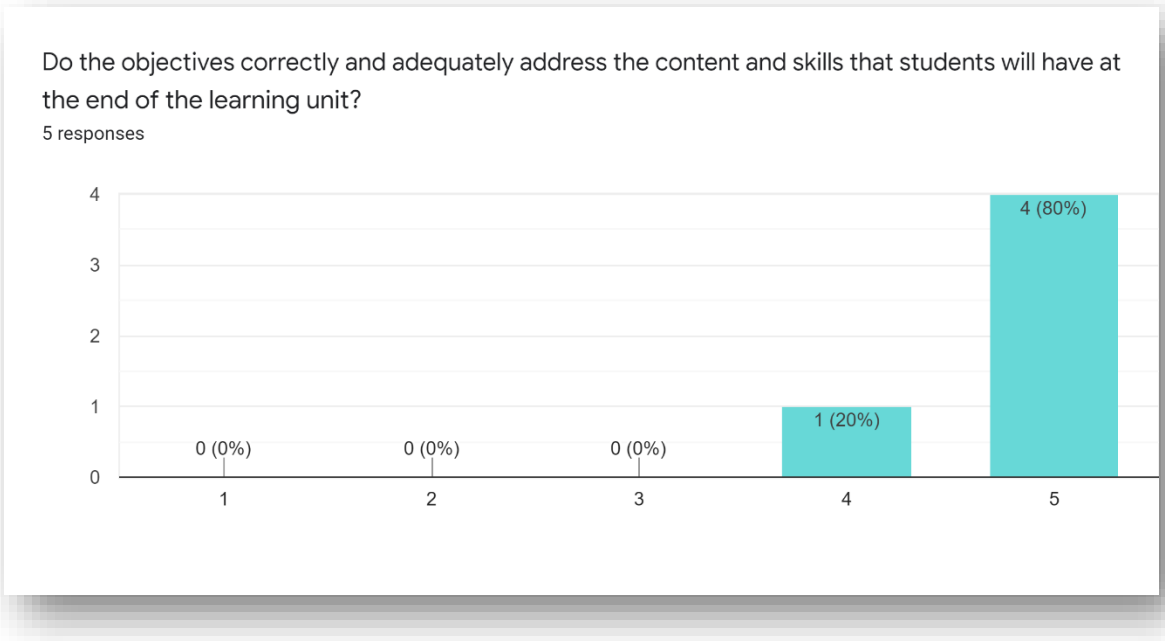
According to Graph 3, 2 out of 5 learning units were assessed to have perfect clarity and accuracy in their brief description, while 3 learning units were almost perfectly does. These 3 learning units were those, entitled “Investigation of Little Meander (Kaystros) river basin area and water cycle”, “Hydraulic aspects” and “The river and the geology”.

The teachers’ elaboration on their feedback for the 3 “almost perfectly” brief descriptions were given below:

> “I suggest to add more information about the investigation and the materials available.”
>
> “The text clearly describes the content of the learning unit. A small clarification is necessary (identified in the review document).”
>
> “It misses a brief note about how the students will work on the topic.”

These elaborations guided the developers of the learning units “to add more information” to the learning unit “Investigation of Little Meander”, to make “a small clarification” to the learning unit “Hydraulic aspects”, and to add a “brief note about how the students will work on the topic” in the brief descriptions of the learning unit “The river and the geology”.

The second question in relation to the brief description was whether the objectives correctly and adequately address the content and skills that students will have at the end of the learning unit. The teachers’ feedback on this question were given quantitatively in Graph 4.



Graph 4. The assessment of the brief description in terms of the clarity and adequacy of the objectives.

According to Graph 4, the teachers assessed 4 out of 5 learning units as having a brief description with objectives that correctly and adequately address the content and skills that students will have at the end of the learning unit. Only 1 learning unit, namely “The ecosystem of the estuary of the river and eutrophication”, was assessed as not having a brief description with the criteria. Although

the teacher was asked to elaborate on her/his response, she/he did not. Yet, the brief description of the learning unit was revised in terms of the objectives that correctly and adequately address the content and skills that students will have at the end of the learning unit.

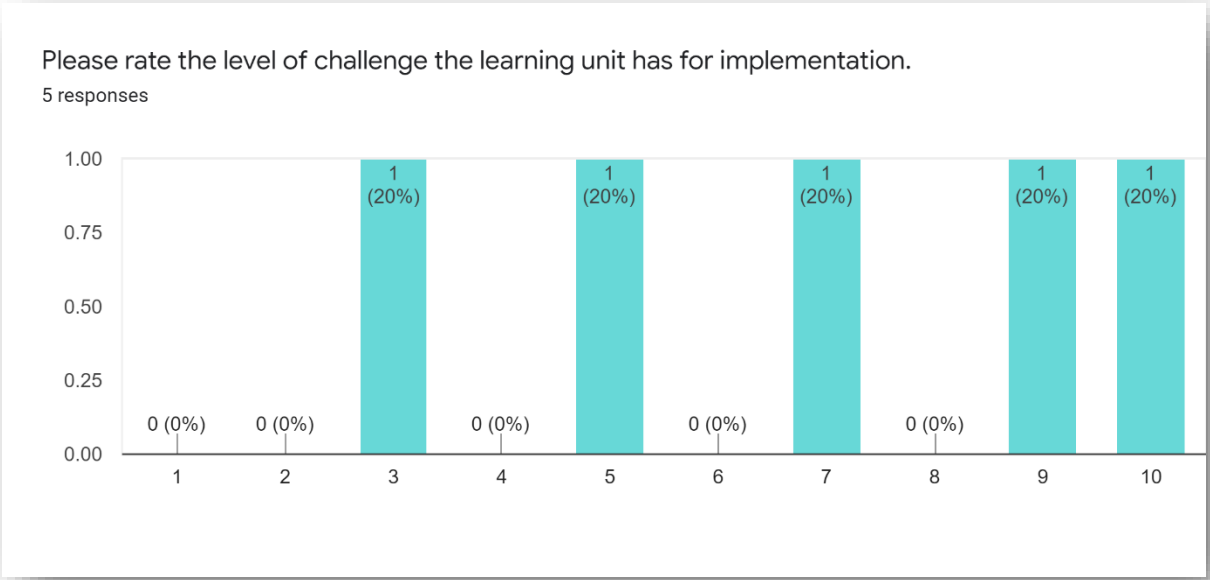
2.1.2. The assessment of the Learning Unit

The learning units were assessed for the following criteria:

- The level of challenge the learning unit has for implementation,
- The cost of implementation for the learning unit, and
- The level of commitment required for implementing the learning unit.

The teachers were kindly asked to elaborate their responses.

The teachers' assessment of the level of challenge the learning unit has for implementation were given in Graph 5. The responses were diverse for each learning unit.



Graph 5. The teachers' rate of the level of challenge the learning units have.

According to Graph 5, the learning unit, entitled "The ecosystem of the estuary of the river and eutrophication" was too challenging for implementation with the target age group. The teacher did not provide any elaboration about why she/he thought that it was too challenging or any suggestion. Yet, the developers of this learning unit made adjustments to reduce the level of challenge.

The teacher, who assessed the learning unit that is entitled "Investigation of Little Meander (Kaystros) river basin area and water cycle", indicated that the level of challenge in this learning unit is remarkably high (9 out of 10). The teacher explained her/his response as the following:

> "The template does not include information about the students' age which is important to add. I would say this activity suitable for 16-18 y.o. students. In addition, I think that the level of challenge increases by asking students to provide a Water Management Plan in the

conclusion. Adding a definition would help them. Moreover, I would suggest to add an appropriate Worksheet for the WMP."

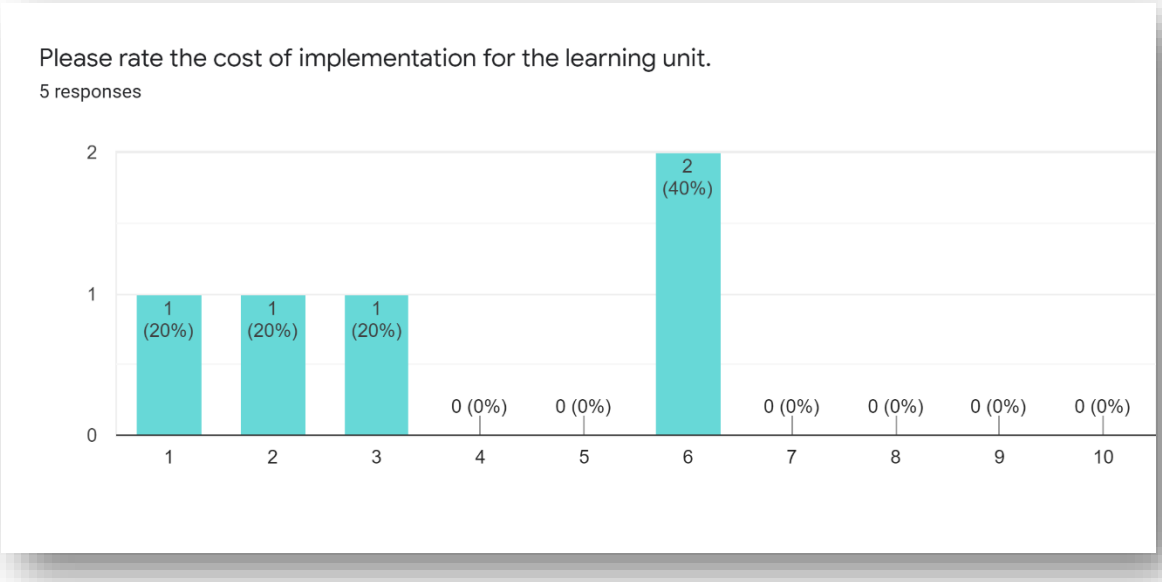
In response to this feedback from the teacher, the developers of the learning unit added information on students' age (16-18 years old) and added a template for "Water Management Plan" to the end of the learning unit.

The teacher who assessed the learning unit that is entitled "The river and the geology" indicated that the learning unit has almost ideal level of challenge for the students. The teacher provided the following feedback for the developers: "The information about the age group is not provided in the template. In my opinion this activity can be performed by students of all grades (12-18 y.o.)" Based on this feedback, the developers did not change the learning unit's level of challenge, but they added the information about the appropriate age group, which is, as the teacher guessed, 12-18 years old.

The learning unit that is entitled "River impacts on art and history" was assessed to have slightly above the appropriate level of challenge by the teacher. However, the teacher did not provide feedback on his/her response. For this reason, the developers of the unit did not change the level of challenge for this learning unit.

The "Hydraulic aspects" learning unit was assessed to have low level of challenge for the targeted age group. The teacher explained that "The only challenge foreseen for the students relates to their ability to read thematic maps and consequently analyse spatial information." In response to this feedback, the developers of the learning added more activities to increase the level of challenge.

Secondly, the teachers were asked to rate the cost of implementation for the learning unit and provide feedback on their response. Graph 6 reports the teachers' response to the assessment.

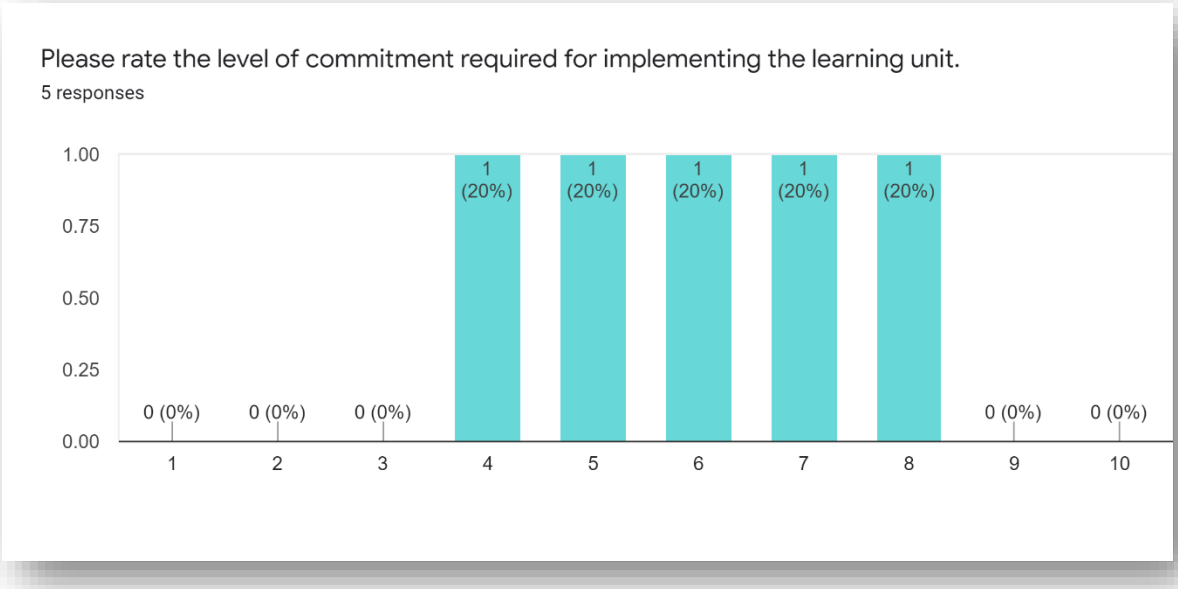


Graph 6. The teachers' assessment of the learning in terms of the cost of implementation.

The teachers assessed the cost of implementation between “almost no cost of implementation” (1) and “too much expense for implementation” (10). According to Graph 6, the teachers did not think the 3 learning units close to “almost no cost of implementation”, while 2 of them having costs above the appropriate level. The 3 learning units, which were assessed to have “almost no cost of implementation”, are “River impacts on art and history” (assessed 3 out of 10), “The river and the geology” (assessed 2 out of 10), and “Hydraulic aspects” (assessed 1 out of 10). Only the teacher, who assessed the “River impacts on art and history”, did not provide any feedback regarding her/his response. The teacher, who assessed “The river and the geology”, explained that “It may need to rent a bus (if possible, students can go to the river by public means of transport)”. The feedback did not suggest any alterations, so the cost remained the same. The teacher, who assessed ““Hydraulic aspects”, explained that “The material necessary (thematic maps, spatial info regarding flood risks and hazards) is prepared by competent public bodies and therefore is usually available for free.”. Therefore, the developers did not change the cost for the learning unit.

On the other hand, the two learning units, namely “The ecosystem of the estuary of the river and eutrophication” and “Investigation of Little Meander (Kaystros) river basin area and water cycle” were assessed to have costs above the appropriate level. The teacher, who assessed the former did not explain her/his response. The teacher, who assessed the latter, explained that “Outdoor activity might include the bus rent and reagents or specific equipment for the analysis of the water. Maybe we should give this information at the beginning of the template.” Based on this feedback, the developers of the unit added the information of the equipment necessary for the water analysis.

The last assessment in relation to the learning unit was the level of commitment required for implementing the learning unit. The teachers were asked to rate the level of commitment between “little or very low commitment” (1) and “too much commitment” (10). The teachers’ responses were given Graph 7. The responses were diverse for each learning unit.



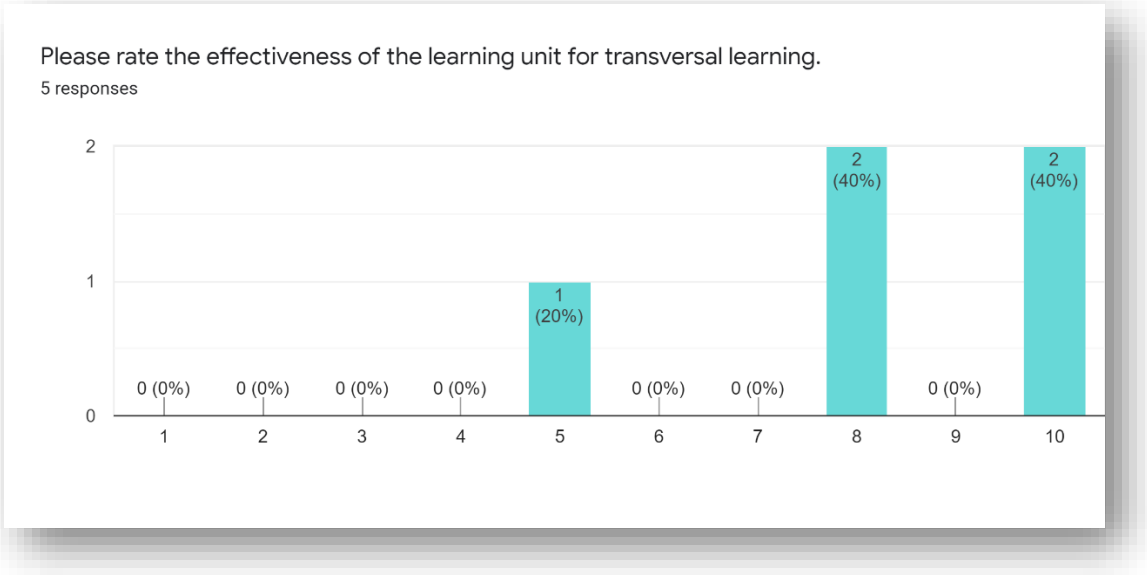
Graph 7. The teachers’ assessment of the level of commitment in the learning units.

The learning unit, entitled “Investigation of Little Meander (Kaystros) river basin area and water cycle”, was rated 7 in the scale. The teacher commented that “The level of commitment is not excessive”. For the learning unit “Hydraulic aspects”, the teacher rated 4 in the scale and commented “Only a little commitment is required in terms of time and effort.” For the “The river and the geology” learning unit, the teacher rated 5, which refers to just the appropriate level of commitment. The teacher did not make any further comments. The learning unit, entitled “The ecosystem of the estuary of the river and eutrophication” was rated 8 in the scale by the teacher. This indicates a higher level of commitment than expected. The teacher provided further feedback by writing that “The activities are a little complex, but we believe that if the students are properly guided the activity can be successfully implemented”. Lastly, for the learning unit “River impacts on art and history”, the teacher rated 6 in the scale, which is also close to the appropriate level of commitment. Based on the ratings and the provided feedbacks by the teachers, the developers of the learning units did not change the level of commitment for the learning units.

2.1.3. The assessment in terms of Transversal Learning Opportunities

Transversal Learning opportunities were defined in the interview as those that 1) recognize the learners as core participants, encourage their active engagement and develop in them an understanding of their own activity as learners, 2) are founded on the social nature of learning and actively encourages well-organised co-operative learning, 3) help teachers become highly attuned to the learners' motivations and the key role of emotions in achievement, 4) are acutely sensitive to the individual differences among the learners, including their prior knowledge, 5) devise programs that demand hard work and challenge from all but without excessive overload, 6) operate with clarity of expectations using assessment strategies consistent with these expectations with a strong emphasis on formative feedback to support learning, and 7) strongly promote horizontal connectedness across areas of knowledge and subjects as well as to the community and the wider world.

Considering this definition, the teachers were asked to assess the learning units in terms of the transversal learning opportunities. The teachers, specifically, were asked to rate the effectiveness of the learning unit for transversal learning between “having no transversal learning opportunities at all” (1) and “having adequate number of transversal learning opportunities” (10) and elaborate their responses. Their assessment is given in Graph 8.



Graph 8. The teachers' assessment of the learning units in terms of transversal learning opportunities.

According to Graph 8, the teachers rated 2 of the learnings units as having adequate number of transversal learning opportunities. These learning units are "River impacts on art and history" and "Investigation of Little Meander (Kaystros) river basin area and water cycle". The teachers did not comment further on these learning units in relation to the transversal learning opportunities.

Two other learning units, namely "The ecosystem of the estuary of the river and eutrophication" and "Hydraulic aspects" were rated 8 in the scale by the teachers. This rating refers to almost having adequate number of transversal learning opportunities in the learning unit. The teacher, who assessed the latter learning unit explained her/his response such that "It can be further improved in terms of transversal learning by allowing the students to reach their own hypothesis and break it down to sub-questions." This feedback was taken into consideration by the developers of the learning unit and the unit was divided into sub-questions/sections.

The learning unit, entitled "The river and the geology", was rated 5 by the teacher. This rating feres to moderate amount of transversal learning opportunities in a unit. The teacher explained her/his response by writing "The learning unit offers different activities related to river studies, geomorphology, soil science, geology." Because the feedback did not clearly indicate what needs to be changed, the developers tried to enrich the learning unit based on their understanding of the transversal learning opportunities.

2.1.4. The assessment in terms of Competences and Skills

The learning units are designed to develop students' certain competences and skills at the completion of the learning unit. These competences and skills are identified based on the 21st century skills, modelled by Partnership for 21st Century Learning. The model was given below in Figure 1. For a detailed description of the competences and skills given in the model, the teachers were provided the related website (http://www.p21.org/our-work/p21-framework).

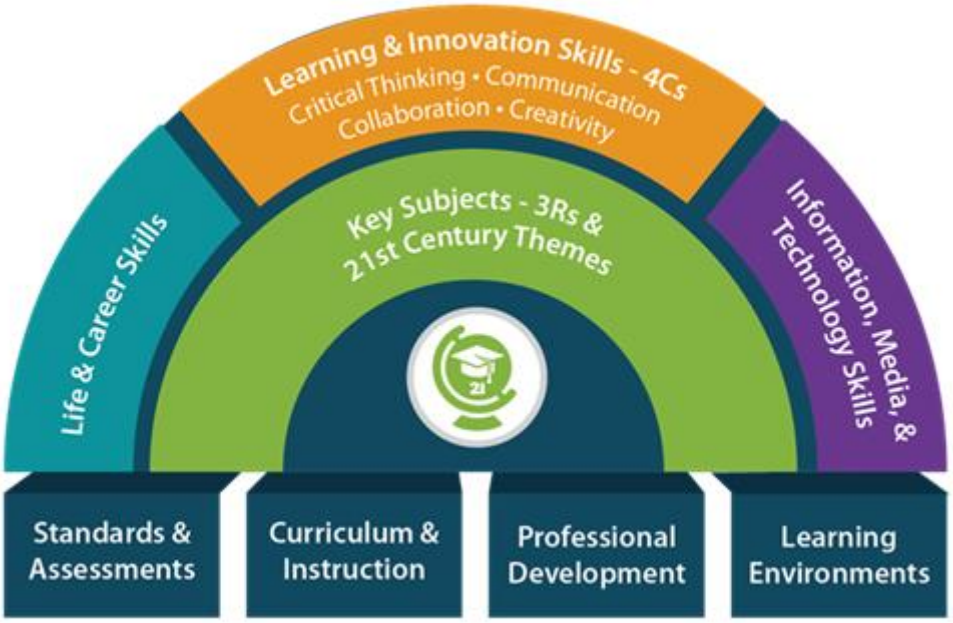
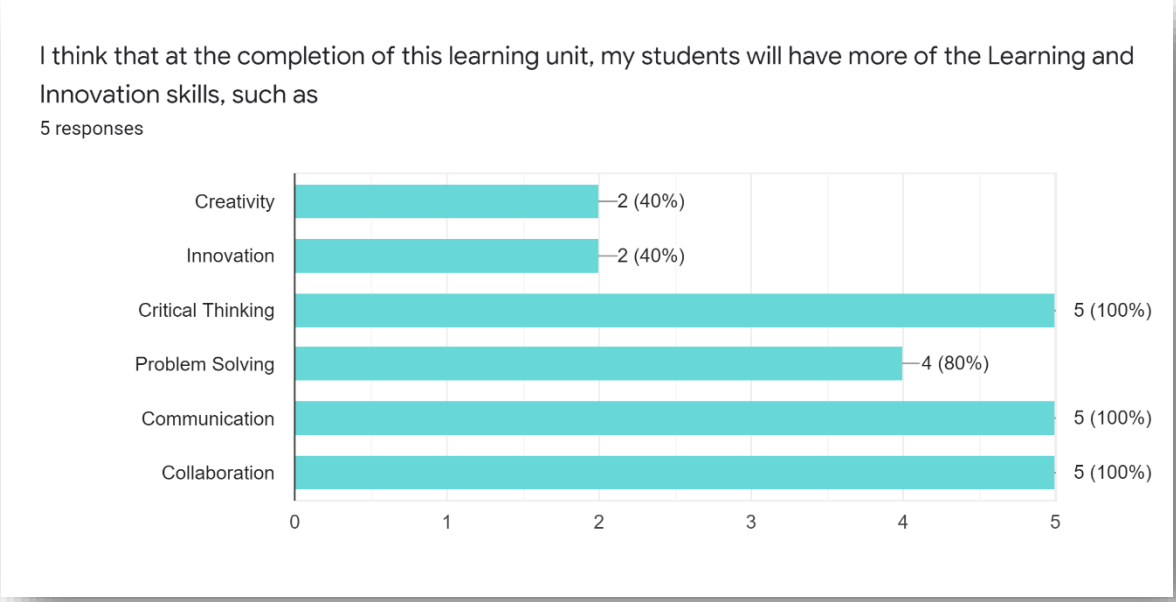


Figure 1. 21st century skills

The teachers were asked to assess the learning units in terms of three groups of competences and related skills, namely learning and innovation skills, information, media and technology skills, and life and career skills.

First, the teachers' assessment of the learning units in terms of learning and innovation skills are given in Graph 9.

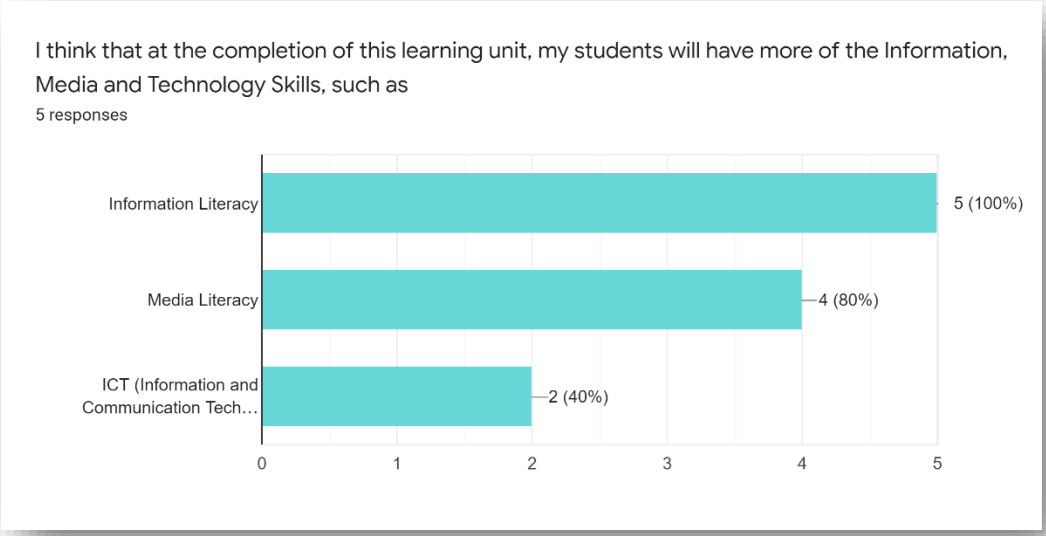


Graph 9. The assessment of the learning unit in terms of learning and innovation skills.

In the assessment of learning units in terms of learning and innovation skills, the teachers indicated that all learning units are designed with components that help to develop students' critical thinking, communication, and collaboration skills. In terms of developing students' problem-solving skills, 4 learning units were assessed to be well-designed but 1 learning unit, which is "The river and the geology", was assessed not having components to develop this skill. Two of the skills were indicated to be lack in 3 of 5 learning units. These skills are creativity and innovation skills. Only the learning units "Investigation of Little Meander (Kaystros) river basin area and water cycle" and "Hydraulic aspects" were assessed to be effective in developing students' creativity and innovation skills.

Based on teachers' assessment, the learning unit "The river and the geology" was the weakest unit in terms of developing learning and innovation skills. The two learning units, namely "Investigation of Little Meander (Kaystros) river basin area and water cycle" and "Hydraulic aspects" had the best design in terms of addressing students' learning and innovation skills. Considering this assessment, the developers added components to improve the learning units in terms of learning and innovation skills.

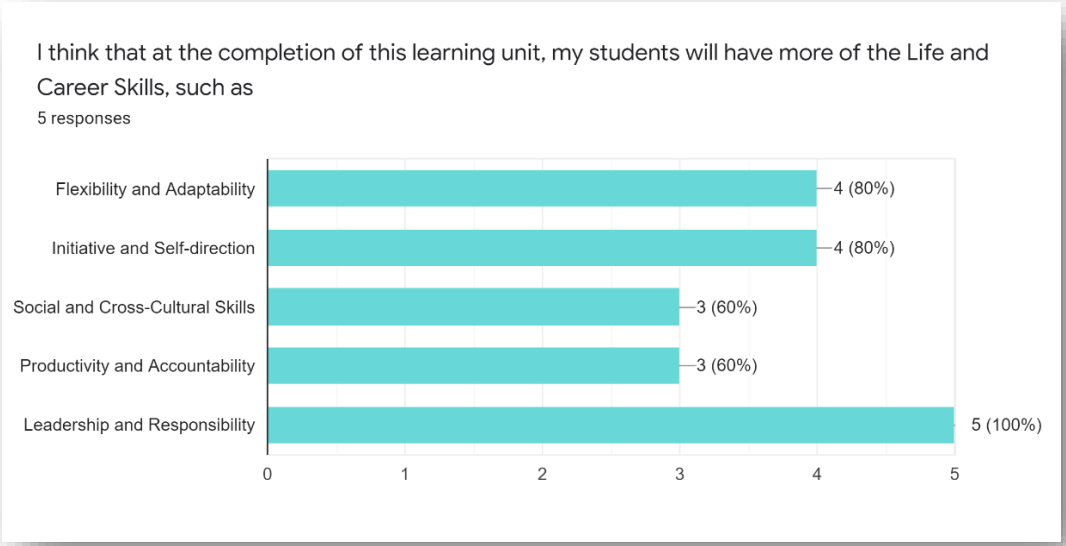
Second, the teachers assessed the learning units in terms of information, media, and technology skills. Their responses are given in Graph 10.



Graph 10. The assessment of the learning unit in terms of information, media, and technology skills.

The teachers' assessment of the learning units in terms of information, media, and technology skills revealed that all learning units were integrated components that develop information literacy skills. 4 of the 5 learning units also were successful in addressing students' media literacy skills, while the learning unit "The river and the geology" was assessed as not developing media literacy skills. "The river and the geology" learning unit was also assessed poor in terms of addressing students' ICT (Information and Communication Technologies) Literacy. The other two learning units, which were assessed to be poor in developing students' ICT Literacy, were "The ecosystem of the estuary of the

river and eutrophication" and "River impacts on art and history". These learning units were revised to improve their content to address the media literacy and ICT literacy.



Graph 11. The assessment of the learning unit in terms of life and career skills.

Lastly, the teachers were asked to assess the learning units in terms of the potential to develop students' life and career skills. Their responses are given in Graph 11 above.

The teachers' assessment showed that all learning units have the potential to develop students' leadership and responsibility taking skills. However, "River impacts on art and history" was only assessed to develop "social and cross-cultural skills" in addition to the "leadership and responsibility taking skills". The learning unit, entitled "Hydraulic aspects" was found to be successful in developing all other skills, except "social and cross-cultural skills". The learning unit, entitled "Investigation of Little Meander (Kaystros) river basin area and water cycle" was found to have lack of opportunities to develop "social and cross-cultural skills" as well as "productivity and accountability skills". The developers of the learning units revised the learning units to integrate components to develop the skills, assessed to be missing by the teachers.

Other comments that the teachers made.

Two of the teachers made further comments in relation to the learning units they assessed. One teachers' comment was as follows:

> "The Learning Unit refers to a specific context, but it can be adapted to any other context with similar issues. The activities include a wide range of tools and approaches, however, in the conclusion, students are asked to provide a Water Management Plan - which I think it is too much after the former investigations. I would suggest to include a definition of a WMP or a description of what the teacher is expected to achieve from the students through the WMP. Include a worksheet for the implementation of the WMP might help. Moreover, it is not clear which is the worksheet for the investigation using GIS."

The teacher, who made the comment assessed the learning unit entitled “Investigation of Little Meander (Kaystros) river basin area and water cycle”. Her/his comment was taken into account in developing the learning unit. The revised learning unit, based on the comments by the teacher, included a WMP. Moreover, the learning unit was improved to inform the worksheet for the investigation using GIS.

The other teacher commented that…

> “I would suggest to give teachers an example of expected worksheet that students should create by themselves.”

This comment was discussed in the meetings, but the final decision was to allow students’ creativity instead of expecting a structured answer.

2.2. Analysis of Student Feedback

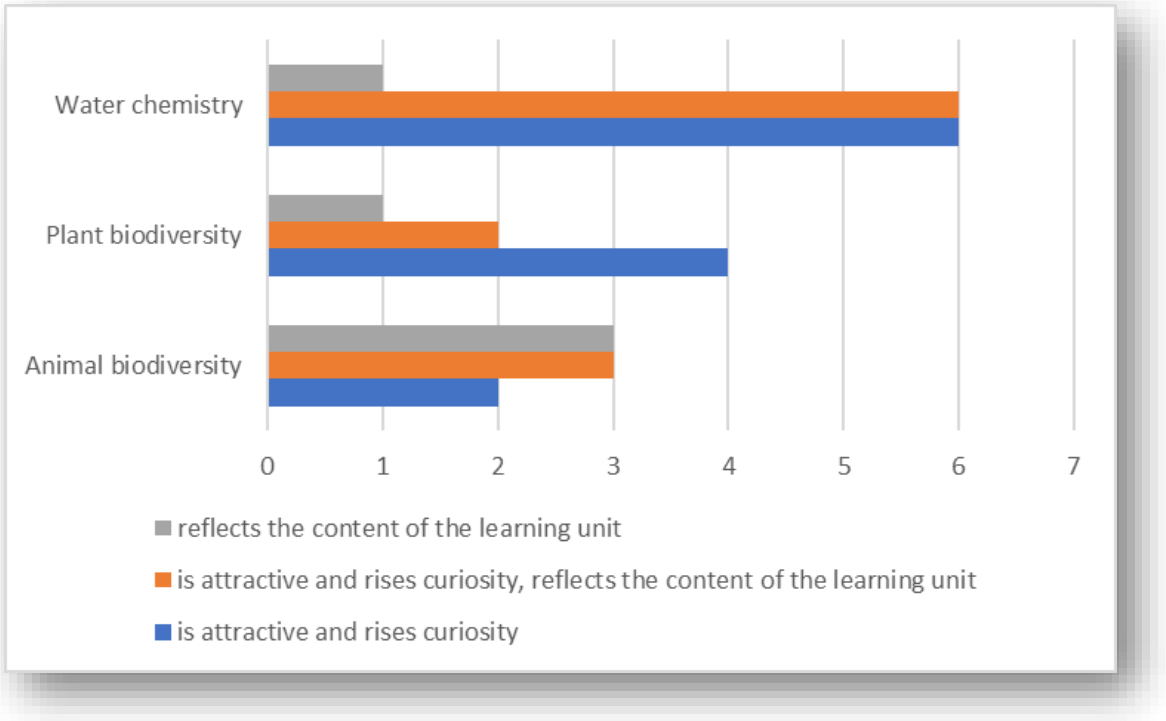
In total, 3 different learning units were assessed by 28 students. The learning units assessed were…

- River ecosystems: plant biodiversity (assessed by 7 students)
- River ecosystems: animal biodiversity (assessed by 8 students)
- Water chemistry (assessed by 13 students)

It should be noted that one learning unit could be assessed by more than one student. Therefore, as one student assess the learning unit having all the good properties, another student might assess the same unit as not good enough. Therefore, the analysis of students’ feedback differed from the analysis of teachers’ feedback.

The Findings and Discussion

An important requirement of the Daylighting Rivers methodology was the use of attractive title, which raises curiosity as well as reflects the content of the learning unit. The first question asked to students to assess the title in terms of these properties. The students’ feedback is given in Graph 12.



Graph 12. The students' feedback in relation to the title of the learning unit.

According to Graph 12, the learning unit, entitled "Water chemistry", was assessed as only "attractive and raises curiosity" but not "reflecting the content of the learning unit" by 6 students, while it was assessed as only "reflecting the content of the learning unit" but not "attractive and raises curiosity" by 1 student. The number of students who thought that the "Water chemistry" title is both "attractive and raises curiosity" and "reflecting the content of the learning unit" was 6.

The learning unit, entitled "Plant biodiversity", was assessed as only "attractive and raises curiosity" but not "reflecting the content of the learning unit" by 4 students, while it was assessed as only "reflecting the content of the learning unit" but not "attractive and raises curiosity" by 1 student. The number of students who thought that the "Plant diversity" title is both "attractive and raises curiosity" and "reflecting the content of the learning unit" was 2.

The learning unit, entitled "Animal biodiversity", was assessed as only "attractive and raises curiosity" but not "reflecting the content of the learning unit" by 2 students, while it was assessed as only "reflecting the content of the learning unit" but not "attractive and raises curiosity" by 2 students. The number of students who thought that the "Animal biodiversity" title is both "attractive and raises curiosity" and "reflecting the content of the learning unit" was 3.

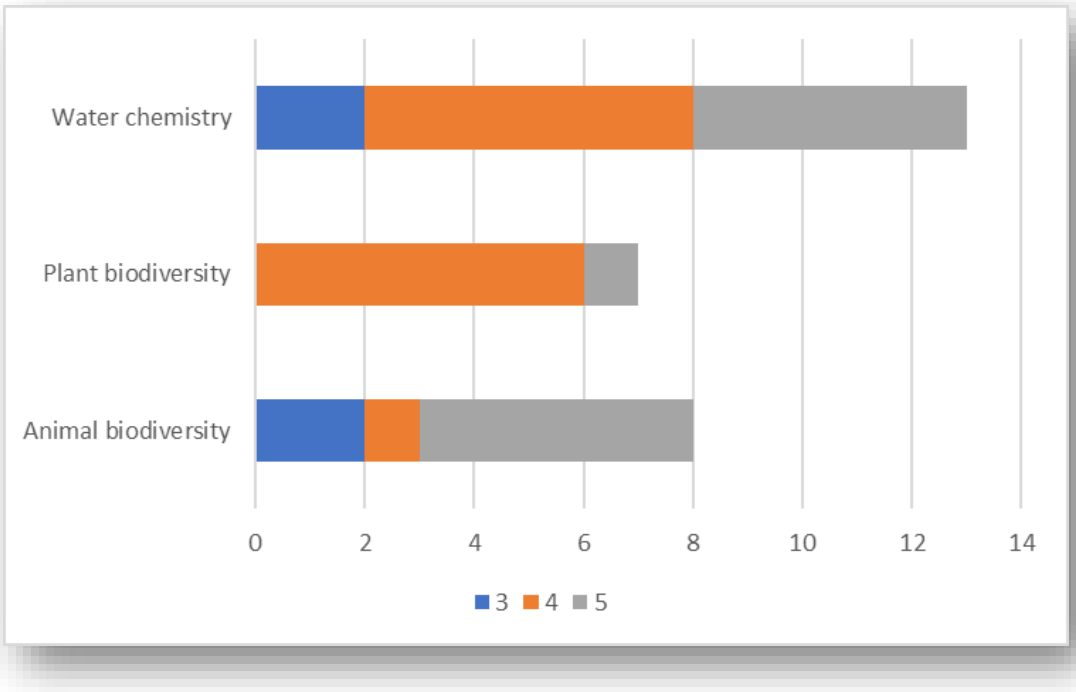
The questions in the rest of the interview form are divided into 5 sections. These are…

1- The assessment of the Brief Description
2- The assessment of the Learning Unit
3- The assessment in terms of Learning Opportunities
4- The assessment in terms of Competences and Skills, and
5- Other comments that the students would like to make.

2.2.1. The assessment of the Brief Description

The students were asked to assess the brief description in terms of whether the brief description clearly and accurately describe the content of the learning unit, and whether the objectives correctly and adequately address the content and skills that they will have at the end of the learning unit. The students were kindly asked to elaborate their responses.

The students' feedback to the first question qualitatively was given in Graph 13.



Graph 13. The assessment of the brief description in terms of clarity and accuracy of the description of the content.

According to Graph 13, the learning unit, entitled "Water chemistry", was assessed to have perfect clarity and accuracy of the content of the learning unit in its brief description (rated 5) by 5 students, while 6 students rated the learning unit as almost perfectly reflecting the content of the learning unit (rated 4). The number of students who thought that the brief description in "Water chemistry" has moderate clarity and accuracy of the content of the learning unit (rated 3) was 2.

The learning unit, entitled "Plant biodiversity", was assessed to have perfect clarity and accuracy of the content of the learning unit in its brief description (rated 5) by 1 student, while 6 students rated the learning unit almost perfectly reflecting the content of the learning unit (rated 4).

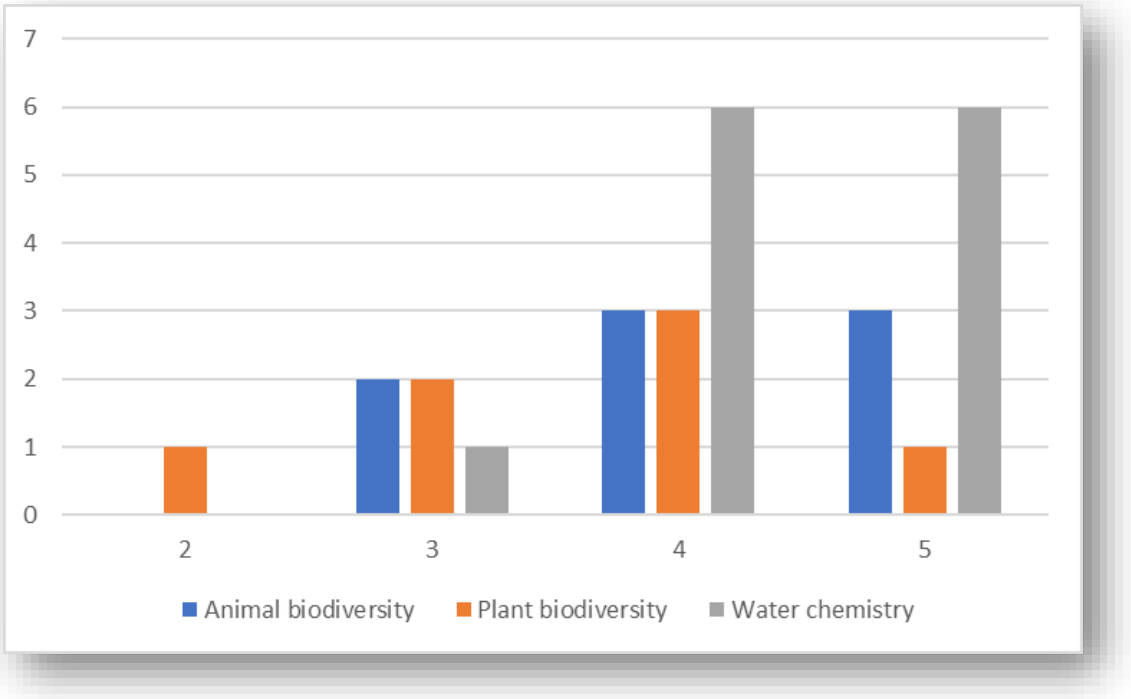
The learning unit, entitled "Animal biodiversity", was assessed to have perfect clarity and accuracy of the content of the learning unit in its brief description (rated 5) by 5 students, while 1 student rated the learning unit almost perfectly reflecting the content of the learning unit (rated 4). The number of students who thought that the brief description in "Animal biodiversity" has moderate clarity and accuracy of the content of the learning unit (rated 3) was 2.

The students' elaboration on their feedback for the lower ratings to the clarity and accuracy of the description of the content of the learning unit in brief descriptions are given below:

> "It's more extense than only water chemistry"
>
> "It has described the content of the learning unit but not at all. There are things that we don't know"

Considering these feedbacks, the brief descriptions were revised by the developers of the learning units.

The second question in relation to the brief description was whether the objectives given in the brief description correctly and adequately address the content and skills that the students will have at the end of the learning unit. The students' feedback on this question were given quantitatively in Graph 14.



Graph 14. The assessment of the brief description in terms of the clarity and adequacy of the objectives.

According to Graph 14, 1 student assessed the "Plant diversity" learning unit as having the objectives that do not address the content and skills that the students would like to have at the end of the learning unit. The student expressed her/his concern as writing "I don't remember anything about we do", a response which shows the objectives did not have clear connection with the content.

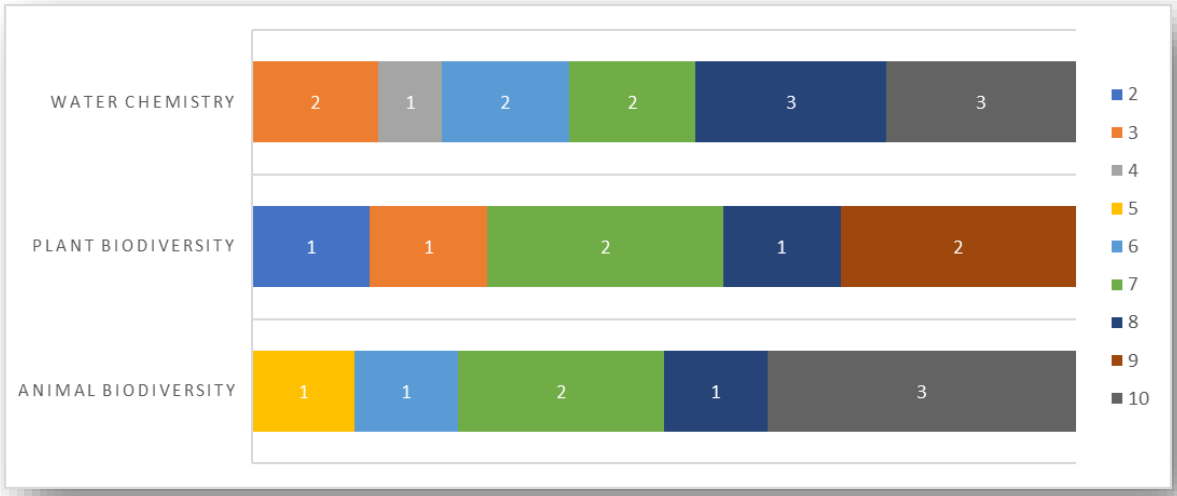
Other students rated the learning units as having moderate clarity of the objectives (3), or perfectly (5) and almost perfectly (4) having objectives that address the content and skills that the students would like to have at the end of the learning unit.

2.2.2. The assessment of the Learning Unit

The learning units were assessed for the following criteria:

- The level of challenge the learning unit has for implementation, and
- The level of commitment required for implementing the learning unit.

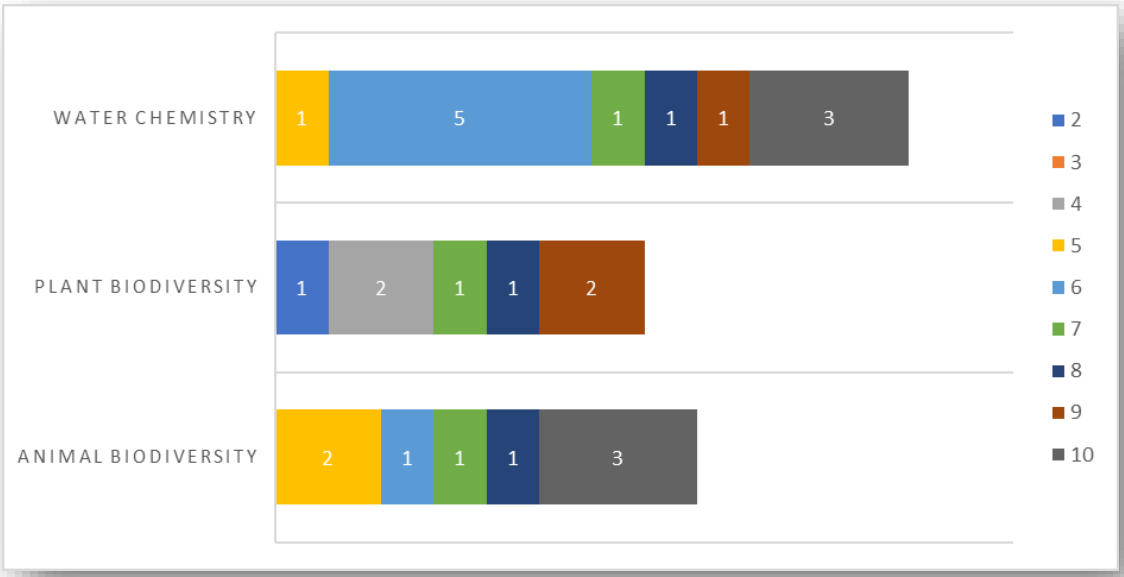
The students' assessment of the level of challenge the learning unit has for implementation were given in Graph 15.



Graph 15. The students' assessment of the level of challenge the learning units have.

The students' response to the level of challenge the learning unit has for implementation were in diverse range. For example, the learning unit, entitled "Plant biodiversity" was assessed between almost not challenging at all (rated 2) and almost too challenging (rated 9). Similarly, the learning unit, entitled "Water chemistry" was assessed between not challenging (rated 3) and too challenging (rated 10). The almost consistent responses were given to the assessment of the learning unit "Animal biodiversity", that is, students assessed this unit between moderately challenging (rated 5) and challenging (rated 8).

The last assessment in relation to the learning unit was the level of commitment required for implementing the learning unit. The students were asked to rate the level of commitment between "little or very low commitment" (1) and "too much commitment" (10). The students' responses were given Graph 16.



Graph 16. The students' assessment of the level of commitment the learning units have.

The students' assessment of the level of commitment was diverse. For example, for the "Water chemistry" learning unit, students mostly rated 6, which slightly above the moderate level of commitment. For the "Plant diversity" learning unit, the most frequent ratings were 4 (slightly below the moderate level of commitment) and 9 (requires much commitment). This result shows the level of commitment differs for each student significantly. The students' assessment of the learning unit "Animal biodiversity" was between moderate (rated 5) and too much (rated 10). For this learning unit, the responses were closer.

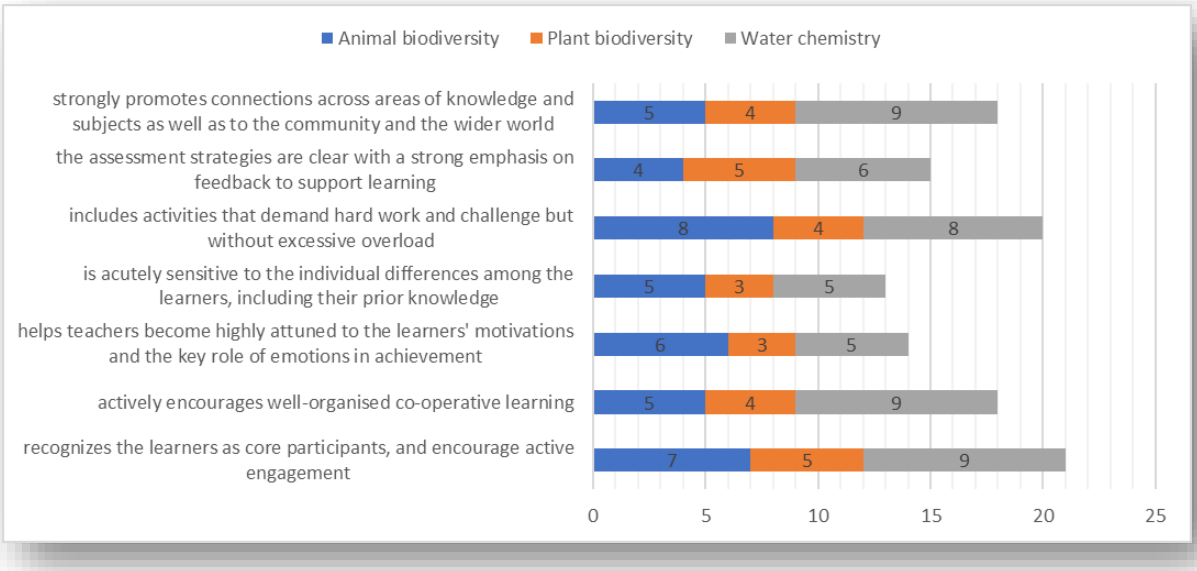
2.2.3. The assessment in terms of the Learning Opportunities

The students were asked to assess the learning units in terms of the learning opportunities. The question was "Please check the boxes next to statements that apply for this learning unit. "Do you feel like if the learning unit..." or "You would like a learning unit that...".

There were 7 statements in relation to the learning opportunities targeted. These were…

- recognizes the learners as core participants, and encourage active engagement,
- actively encourages well-organised co-operative learning,
- helps teachers become highly attuned to the learners' motivations and the key role of emotions in achievement,
- is acutely sensitive to the individual differences among the learners, including their prior knowledge,
- includes activities that demand hard work and challenge but without excessive overload,
- the assessment strategies are clear with a strong emphasis on feedback to support learning, and
- strongly promotes connections across areas of knowledge and subjects as well as to the community and the wider world.

The students' responses were given in Graph 17.



Graph 17. The students' assessment of the learning units in terms of the learning opportunities.

The students' responses were evaluated for each unit. For the learning unit, entitled "Animal biodiversity", all the students, who assessed this learning unit, agreed that the learning unit "includes activities that demand hard work and challenge but without excessive overload". The number of students, who agreed that "the assessment strategies are clear with a strong emphasis on feedback to support learning" was low (n=4) compared to other learning opportunities evaluated.

The learning unit "Plant biodiversity" was assessed by 7 students. There was not a learning opportunity that all students agreed that the learning unit has. However, the students who thought that the learning unit has "the assessment strategies are clear with a strong emphasis on feedback to support learning" and "recognizes the learners as core participants and encourage active engagement" were more (n=5) compared to other learning opportunities. The students who thought that the learning unit "is acutely sensitive to the individual differences among the learners, including their prior knowledge" were only 3.

The assessment of the learning unit "Water chemistry" was also diverse. However, more students (n=9) agreed that the learning unit "strongly promotes connections across areas of knowledge and subjects as well as to the community and the wider world", "actively encourages well-organised co-operative learning" and "recognizes the learners as core participants and encourage active engagement". The least agreed learning opportunities were "is acutely sensitive to the individual differences among the learners, including their prior knowledge" and "helps teachers become highly attuned to the learners' motivations and the key role of emotions in achievement".

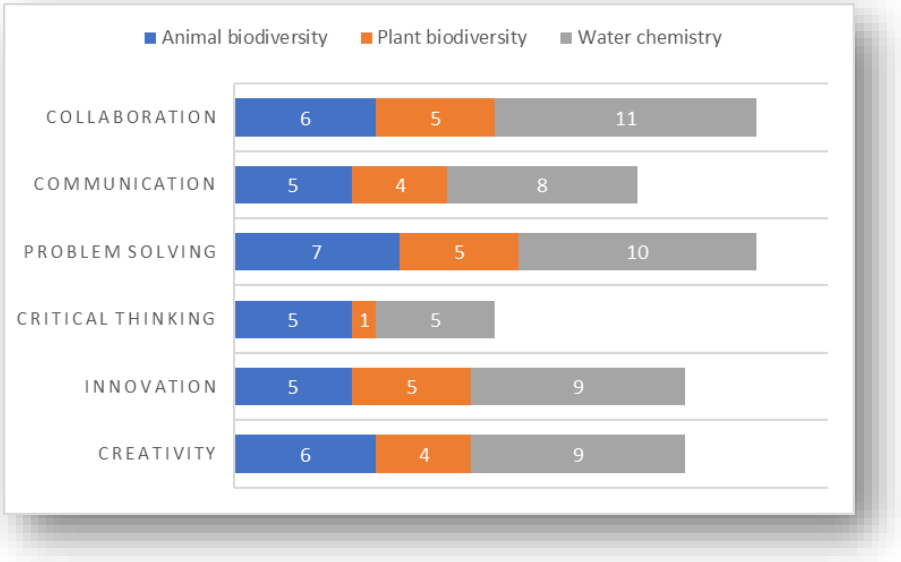
The developers take these assessments into consideration when revising the learning units.

2.2.1. The assessment in terms of Competences and Skills

The learning units are designed to develop students' certain competences and skills at the completion of the learning unit. These competences and skills are identified based on the 21st century skills, modelled by Partnership for 21st Century Learning. The model was given in Figure 1.

The students were asked to assess the learning units in terms of three groups of competences and related skills, namely learning and innovation skills, information, media and technology skills, and life and career skills.

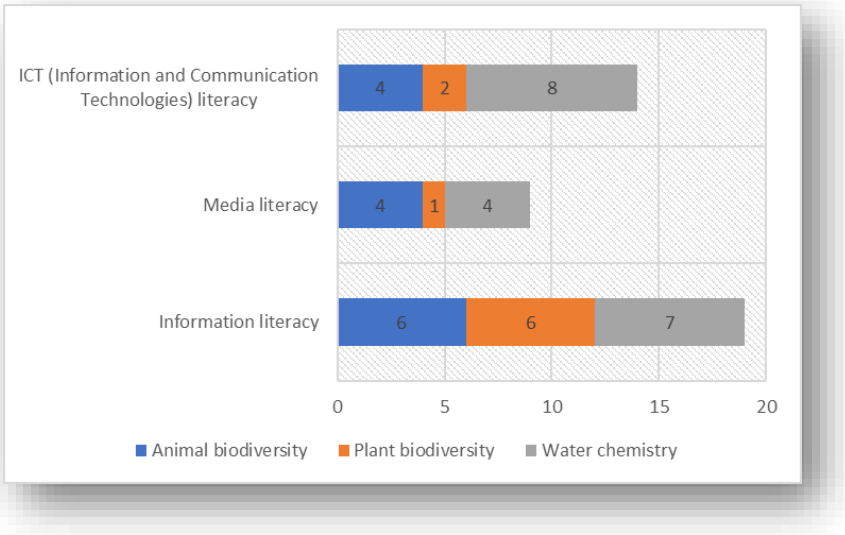
First, the students' assessment of the learning units in terms of learning and innovation skills are given in Graph 18.



Graph 18. The students' assessment of the learning units in terms of learning and innovation skills

In terms of learning and innovation skills, the students' assessed the learning units whether the learning unit contributes to the development of those skills, namely creativity, innovation, problem-solving, critical thinking, communication, and collaboration. The students, who assessed the learning unit "Animal biodiversity", agreed that the learning unit develops problem-solving skills (n=7) most effectively, and contributes to the development of other learning and innovation skills. The assessment of the learning unit "Plant biodiversity" revealed that only 1 student thought that the learning unit develops critical thinking skill. That is, the learning unit was poorly designed to contribute to the development of this skill. However, the students found the unit successful in terms of developing collaboration, problem-solving, and innovation skills. The learning unit "Water chemistry" was found to be effective in developing collaboration skill by 11 students. Similarly, 10 students agreed that the learning unit was well-designed to address problem-solving skill. The least agreed skill was critical thinking. This result means that the learning unit did not support critical thinking well enough.

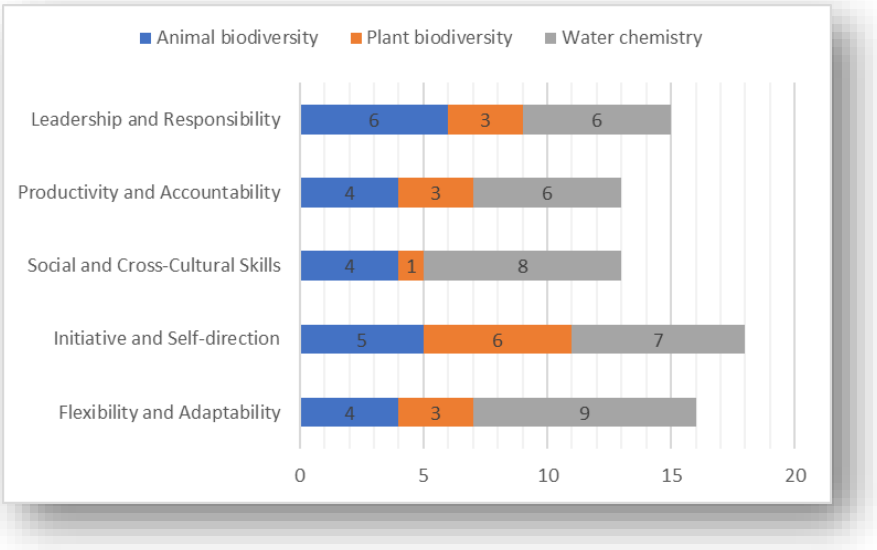
The second set of skills was media and technology skills. The skills in this set were information literacy, media literacy and ICT (Information and Communication Technologies) literacy. The students2 assessment of the learning units for these skills was given in Graph 19.



Graph 19. The students' assessment of the learning units in terms of media and technology skills.

The students' assessment of the "Animal biodiversity" learning unit in terms of media and technology skills showed that 6 students agreed that the learning unit contributes to the development of information literacy skills, while 4 students agreed that the learning unit develops media and ICT literacy skills. The students' assessment of the "Plant biodiversity" learning unit showed that 6 students agreed that the learning unit contributes to the development of information literacy skills, while 2 students agreed that the learning unit develops ICT literacy, and 1 student thought that the learning unit develops media literacy. The students' assessment of the "Water chemistry" learning unit showed that 8 students agreed that the learning unit contributes to the development of ICT literacy, while 7 students agreed that the learning unit develops information literacy, and 4 students thought that the learning unit develops media literacy.

Lastly, the students were asked to assess the learning units in terms of contributing to the development of life and career skills. The students' responses are given in Graph 20.



Graph 20. The students' assessment of the learning units in terms of life and career skills.

The life and career skills that were asked to be assessed were leadership and responsibility, productivity and accountability, social and cross-cultural skills, initiative and self-direction, and flexibility and adaptability.

The students, who assessed the learning unit "Animal biodiversity", agreed that the learning unit develops leadership and responsibility (n=6) most effectively, and contributes to the development of other life and career skills. The assessment of the learning unit "Plant biodiversity" revealed that only 1 student thought that the learning unit develops social and cross-cultural skills. That is, the learning unit was poorly designed to contribute to the development of this skill. However, the students found the unit successful in terms of developing initiative and self-direction. The learning unit "Water chemistry" was found to be effective in developing flexibility and adaptability by 9 students. Similarly, 8 students agreed that the learning unit was well-designed to address social and cross-cultural skills. The least agreed skills were leadership and responsibility, and productivity and accountability. This result means that the learning unit did not support these life and career skills well enough.

Finally, some of the student comments are provided below:

> "Very amazing."
>
> "Communication with students from other institutes should be facilitated and more money invested in higher quality resources to carry out the activity."
>
> "It was quite hard but finally we had success."

3. Comparative Analysis of Surveys

In the Daylighting Rivers Project, ICASE adapted survey tools to investigate if the intervention with the learning units in the classes a) increases the acquisition of competences and skills; b) increases the attitude of students toward STEM, c) decreases the career decision-making difficulties, d) increases career decision-making self-efficacy, e) increases teaching self-efficacy and effectiveness. The surveys were anonymous and were submitted in the piloting phase. Online forms were used.

In this section, the comparative analysis of surveys, which were applied to investigate the changes pre- and post- implementation of the learning units, were given. The comparisons were done between schools participating to the project.

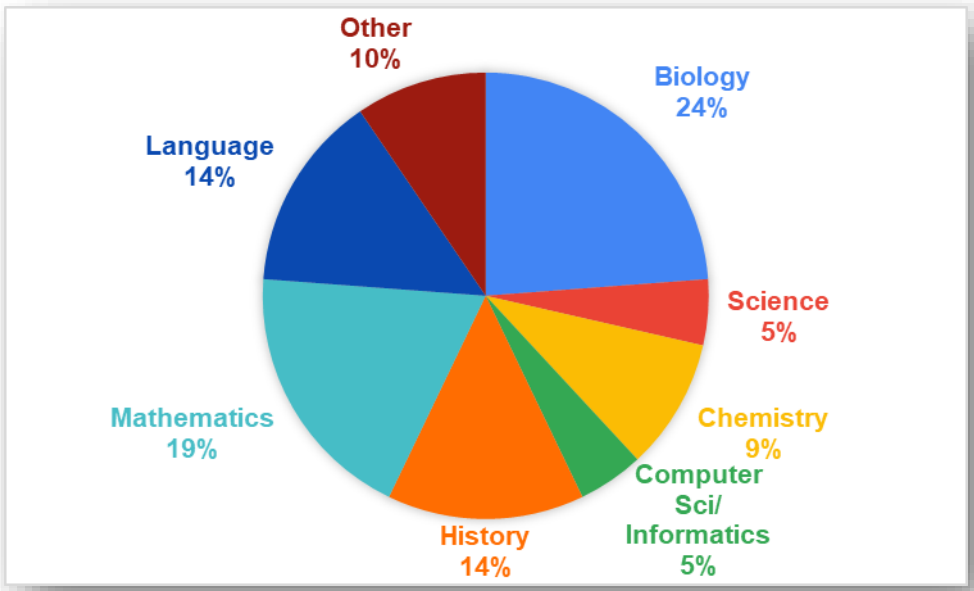
3.1. Methodology

The cross-sectional survey design methodology was used in this research. In the survey design methodology, the pre- and post- implementation of the learning units by the schools was measured. The measures were also adapted to this methodology. For this reason, the perceived changes by the participants after participating to the project were reported. The online surveys were applied after the implementation of technology and IBL-based learning units in all three schools in partner countries.

3.1.1. Participants

The population of the study were all teachers and students who participated in the implementation of the Daylighting Rivers learning units. In these analyses, we did not choose a sample because the whole population was in reach. The population of the study were in 3 partner countries, namely, Italy, Spain, and Greece. The students were secondary level students. In total, the participants were 11 students and 4 teachers from Athens, Greece, 23 students and 10 teachers from Murcia, Spain, and 33 students and 7 teachers from Salerno, Italy.

The teachers' teaching majors were given in Graph 21.



Graph 21. The majors of the teachers, who participating in the pilot phase of the Daylighting Rivers Project.

There were teachers from 8 different majors. 5 of them were biology teachers, 4 of them were mathematics teachers. There were 3 history and 3 language teachers, and 1 science, 2 chemistry teachers as well as 1 computer science/ informatics teacher and 2 other majors. This distribution of teachers' majors is important to indicate that STEM is not only for science and mathematics teachers but can be part of any lesson integrated with different disciplines. Therefore, the participation of teachers from different majors was one of Daylighting Rivers Project's successes. This participation is also an indication that the learning units developed in the Daylighting Rivers Project are integrated units that bring different disciplines together.

3.1.2. Data collection

Data were collected by four questionnaires described below. There were two questionnaires, namely Change in Attitudes towards STEM Questionnaire, and Change in Career Decision Self-Efficacy Questionnaire, applied to the students and two questionnaires, namely Change in Science Teaching Efficacy Beliefs, and Change in Science Teaching Effectiveness, applied to the teachers. The questionnaires were transferred to Google Drive cloud in the form of a survey. After the

implementation of a learning unit, the teachers and the students were shared the link to the questionnaire and they individually signed into the document and responded to the questionnaires. The data gathered were deposited in Google Drive. The questionnaires used in the research were as the following:

Teacher Questionnaires:

Change in Science Teaching Effectiveness Questionnaire. The instrument was developed by Çavaş, et. al. (2013) to determine science teachers' implementation of inquiry-based science education in their classrooms. The original instrument consists of four parts: The first part, which consist 4 questions, focuses on the demographic information about science teachers including gender, grade level, teaching subject and length of science teaching experience. In this analysis, we did not collect any demographic data of the teachers. Only, we asked for their majors and the schools that they work at. The second part consists of 11 Likert-type items which measure science teachers' perception about their students' expectations from their science courses. We did not use this part of the questionnaire because it does not relate to this analysis. In the third part, three different inquiry settings are given to teachers and they are asked to indicate their preferences as a percentage. We also skipped this part. The fourth part of the questionnaire includes 27 items. The subjects were asked to respond using a five-point scale (from almost never to almost always). The score 1 represented the option "almost never" while score 5 on the scale represented the category "almost always". All items were positively written.

In this project, we only used the fourth part of the questionnaire. In this part, 7 IBSE stages (identifying and posing appropriate scientifically oriented questions; Making prediction / Developing hypothesis; Designing and conducting investigations; Identifying Variables; Collecting data; Analysing data to develop patterns; Communicating and connecting explanation) were tested, whereby each was described on three levels of the inquiry teaching (structured, guided, and open).

The original questionnaire was administered to a convenience sample of 788 science teachers (434-primary science teachers; 354-physics, chemistry, and biology teachers). To determine reliability of the whole scale and sub-scales, Cronbach alpha coefficients were calculated. The researchers reported that the whole scale and each sub-scale are reliable with alpha values > 0.80.

Change in Science Teaching Efficacy Beliefs Questionnaire. Riggs (1988) and Riggs and Enochs (1990) developed the instrument, entitled the Science Teaching Efficacy Belief Scale (STEBI-A). STEBI-A was designed to measure in-service science teaching self-efficacy beliefs. The STEBI-A contained 25 items measuring two scales with names more clearly denoting their relationships with Bandura's two-factor theory, Personal Science Teaching Efficacy Belief and Science Teaching Outcome Expectancy. Riggs and Enochs (1990) recorded alpha values of 0.92 for the PSTE and 0.77 for the STOE scales. The STEBI A is one of the most extensively tested and used instruments to measure science teaching self-efficacy and has been validated many times in different languages.

Student Questionnaires:

Change in Attitudes towards STEM Questionnaire. Originally named as "Student Attitude toward STEM Questionnaire", the instrument was developed by Mahoney (2010). In line with the design of this analysis, we adapted the questionnaire to ask for students' own perceptions of the change they experienced regarding the items in the original questionnaire. That is, the questionnaire as is used in

this study provide information of the students' perceived change in their attitudes toward STEM. The questionnaire, as in the original version, has four parts, namely awareness or initial interest, perceived ability, value, and commitment or long-term interest. In the original questionnaire, there are 24 items, but each item should be evaluated per STEM discipline, so this makes 96 items to be responded. However, in this study, 12 items were selected (3 from each part) that would be adequate to evaluate the change in students' attitudes toward STEM to inform the Daylighting Rivers project. Each item was evaluated per STEM discipline as in the original questionnaire. The internal reliability, which was estimated though the use of Cronbach's alpha internal consistency coefficient in the original study was between .95-.97 overall for each STEM discipline. In this study, the internal reliability values were between .89-.94, indicating high reliability.

Change in Career Decision Self-Efficacy Questionnaire. The original Career Decision Self-efficacy questionnaire was developed by Presti et al (2012). The questionnaire includes 25 items assessed by Likert type scale. There are 5 categories composing the questionnaire, namely self-appraisal, occupational information, goal selection, planning, and problem solving. In line with the design of this analysis, we adapted the questionnaire to ask for students' own perceptions of the change they experienced regarding the items in the original questionnaire as in the other instrument. The reliability coefficient which was estimated though the use of Cronbach's alpha was .95 in this study.

3.1.3. Data analysis

Data were analysed in two steps: (1) the descriptive analysis of each questionnaire and comparative analysis among high schools, and 2) the correlation to investigate the relationship between questionnaires. The analyses were also examined with respect to each high school (HS). The SPSS Data Analysis Program was used in the analyses.

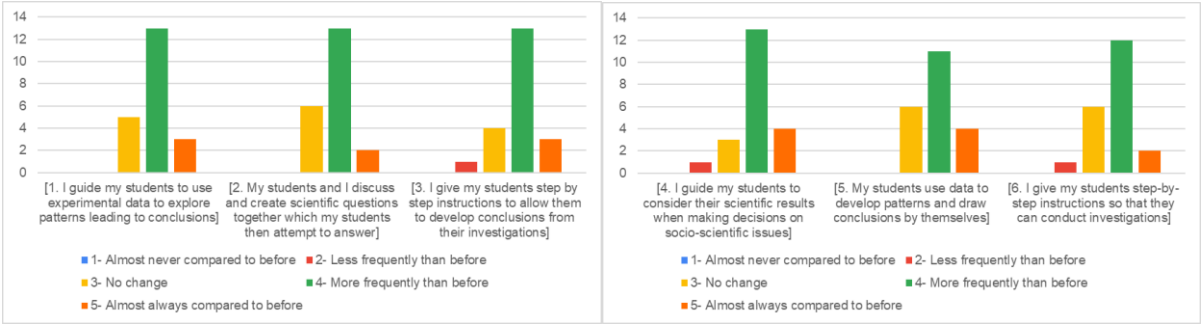
The results and discussion are given below separately for teachers and students.

3.2. Analysis of Teacher Surveys

3.2.1. Change in Science Teaching Effectiveness

There were 27 statements in the Change in Science Teaching Effectiveness survey. The statements were answered in a 5-point Likert type scale, between 1 is almost never compared to before and 5 is almost always compared to before.

The responses of the teachers were in given in Graph 22.



Graph 22. The teachers' responses to Change in Science Teaching Effectiveness survey

The teachers' responses to the items showed that the teachers experienced changes in their teaching effectiveness after implementing the DAYLIGHTING RIVERS learning units. The items that some of the teachers chose "almost never compared to before" were…

16. I provide my students with the relevant literature and other resources to develop their plans for investigations (n=1), and

18. I give my students step-by-step instructions for obtaining data/making observations (n=1).

This finding means these teachers gave up giving step-by-step instructions and providing students resources.

There were teachers who experienced no change in each item. However, for almost each item, the number of teachers who chose the option "more frequently than before" was more than other options. The items that the number of teachers who chose "no change" was more or equal to the number of teachers who chose "more frequently than before" were…

13. My students propose and use scientific evidence to evaluate risks such as those related to environmental or health related issues (n=8)
27. I provide guidelines for students to relate the results of their investigations to make decisions about socio-scientific issues (n=9).

The accumulative analysis of teachers' responses revealed the statistics in Table 1.

Table 1. The analysis of the teachers' responses to the Change in Science Teaching Effectiveness survey.

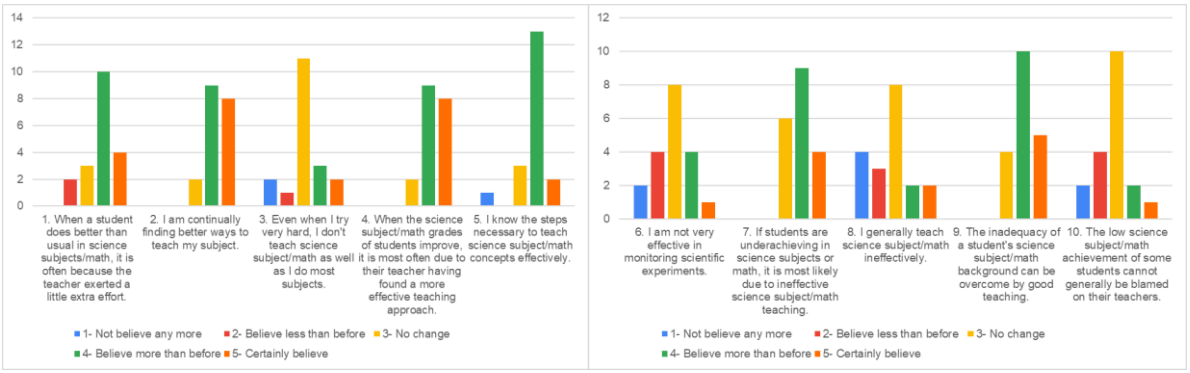
	Mean	Sd	mode	median
After participating in DAYLIGHTING RIVERS learning activities, the change in your teaching approach now, compared to your approach before participating in the Daylighting Rivers learning actions…	3.7	0.5	4	3.8

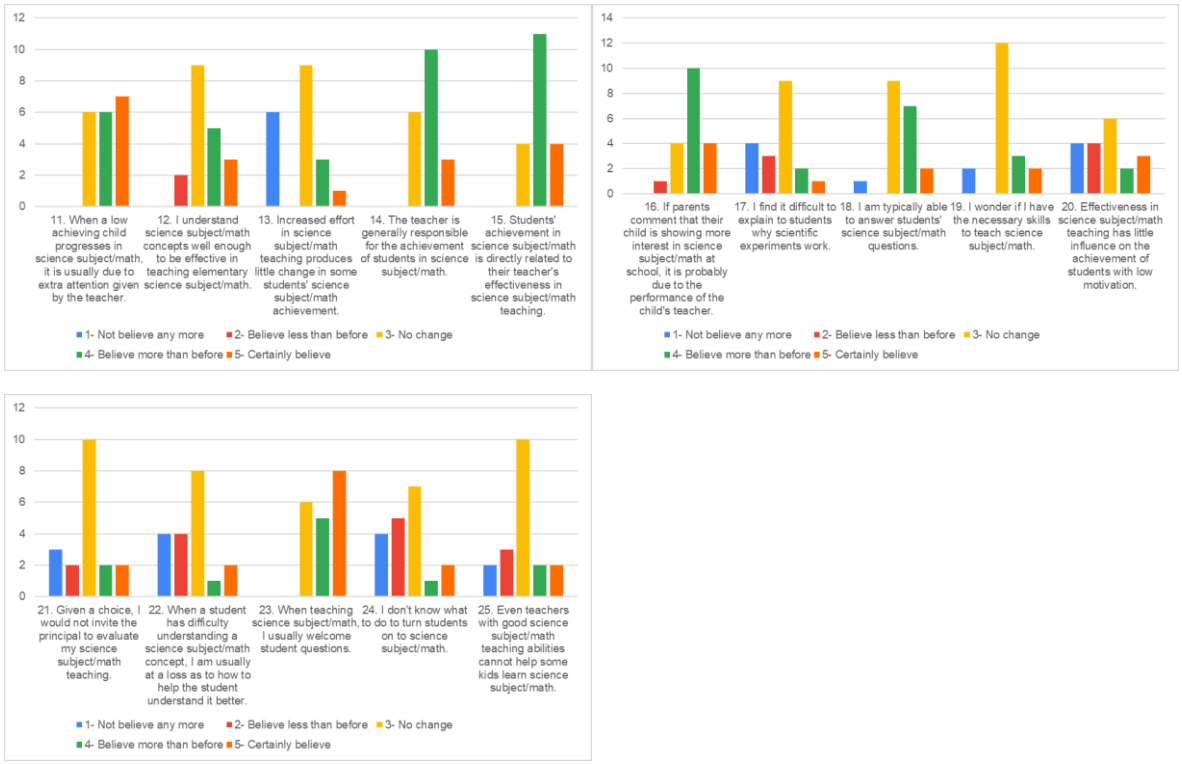
The results in the Table 1 indicate a slightly positive change overall. That is, the number of teachers who chose options "more frequently than before" and "almost always compared to before" were more than the number of teachers who chose other options.

3.2.2. Change in Science Teaching Efficacy Belief

There were 25 statements in the Change in Science Teaching Effectiveness survey. The statements were answered in a 5-point Likert type scale, between 1 is not believe any more and 5 is certainly believe.

The responses of the teachers were in given in Graph 23.





Graph 23. The teachers' responses to Change in Science Teaching Efficacy Beliefs survey

The teachers' responses to the items showed that the teachers experienced changes in their science teaching efficacy beliefs after implementing the DAYLIGHTING RIVERS learning units. However, there were items that most of the teachers did not experience any change in their efficacy beliefs. These items are: 3, 6, 8, 10, 12, 13, 17, 18, 19, 20, 21, 22, 24, and 25. The items that most of the teachers said that they believed they had more efficacy than before are: 1, 2, 4, 5, 7, 9, 14, 15, 16.

This finding means that the teachers did not experience much change in their efficacy beliefs in 12 items out of 25 items, while experienced change in their efficacy beliefs in 13 items out of 25 items.

The accumulative analysis of teachers' responses revealed the statistics in Table 2.

Table 2. The analysis of the teachers' responses to the Change in Science Teaching Efficacy Beliefs survey.

	Mean	Sd	median	mode
The change related to your teaching beliefs now, compared to your approach before participating in the "DAYLIGHTING RIVERS".	3.6	0.5	3.4	3.4

The results in Table 2 indicates very slight change to higher teaching efficacy beliefs in science teaching. Notably, for the following items, after participating in DAYLIGHTING RIVERS, there are more teachers believing that…

11. When a low achieving child progresses in science subject/math, it is usually due to extra attention given by the teacher. (n=7)

23. When teaching science subject/math, I usually welcome student questions. (n=8)

3.3. Analysis of Student Questionnaires

3.3.1. Change in Career Decision Self-Efficacy

There were 25 statements in the Change in Career Decision Self-Efficacy survey. The statements were answered in a 5-point Likert type scale, between 1 is “Not Likely” and 5 is “Very Likely”.

The students’ responses are given in Graph 24.

Graph 24. The students’ responses to items in Change in Career Decision Self-Efficacy survey

In almost all items, the number of students who chose the option “more likely” were more than others. The only item that most of the students chose the option “very likely” was [22- Define the type of lifestyle you would like to live] (n=25). There were also items that most of the students chose the option “no change”. In general, Graph 24 shows that participating in the pilot phase of DAYLIGHTING RIVERS project and implementing the learning units made a positive difference in the participating students’ career decision self-efficacy beliefs. This result is supported by the statistical analysis of the responses.

The accumulative analysis of students’ responses revealed the statistics in Table 3.

Table 3. The analysis of the students' responses to the Change in Career Decision Self-efficacy survey.

	Mean	Sd	mode	median
After participating in DAYLIGHTING RIVERS learning activities, do you think that you have been more able to...	3.7	0.65	3.6	3.8

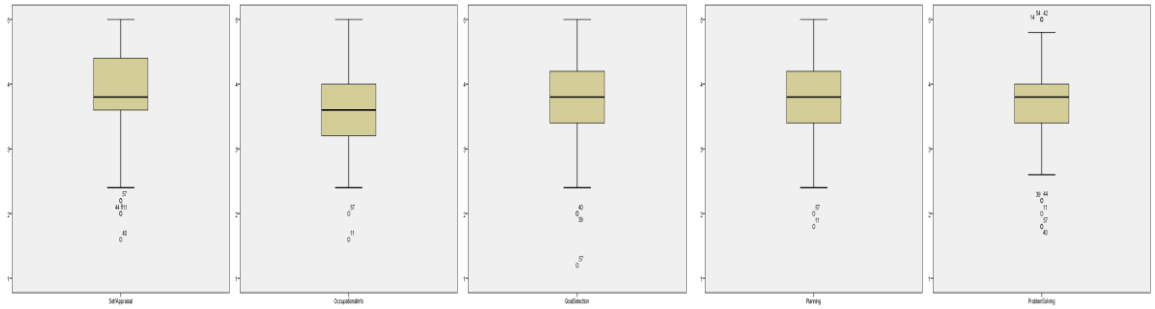
The results in Table 3 indicate a slightly better ability overall. There are only 3 areas that students do not think a change occurred in their ability to:

[10- Find out the employment trends for an occupation over the next 10 years]
[15- Find out about the average yearly earnings of people in an occupation]
[16- Make a career decision and then not worry about whether it was right or wrong]

There is one area that students think a change highly likely occurred in their ability to:

[22- Define the type of lifestyle you would like to live]

The analysis of the change in career decision self-efficacy and for each sub-dimension resulted with the mean values given in Graph 25.



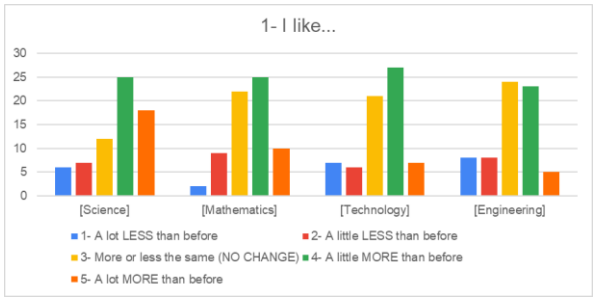
Graph 25. Change in career decision self-efficacy values (self-appraisal, occupational information, goal selection, planning, problem solving)

According to Graph 25, the students' perceived change in career decision self-efficacy is slightly towards a little more likely (μ=3.82, sd=.77 in self-appraisal; μ=3.58, sd=.66 in occupational information; μ=3.68, sd=.71 in goal selection; μ=3.73, sd=.66 in planning; and μ=3.71, sd=.72 in problem solving). Overall, the change in career decision self-efficacy is also slightly towards a little more likely than before (μ=3.70, sd=.65). In other words, students feel slightly more self-efficacy in making career decision in STEM disciplines. The result can be interpreted as the positive impact of the educational modules developed in Daylighting Rivers project in increasing students' self-efficacy in making decisions related to STEM careers.

3.3.2. Change in Attitudes towards STEM

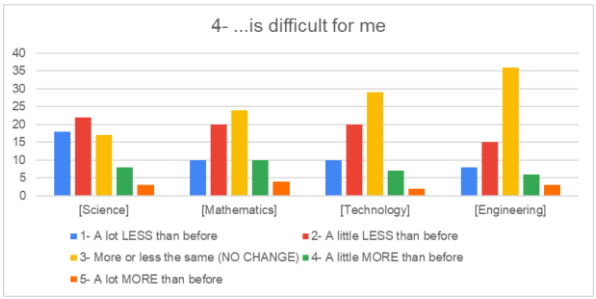
There were 12 statements in the Change in Attitudes towards STEM survey. The statements were answered in a 5-point Likert type scale, between 1 is "a lot LESS than before" and 5 is "a lor MORE than before".

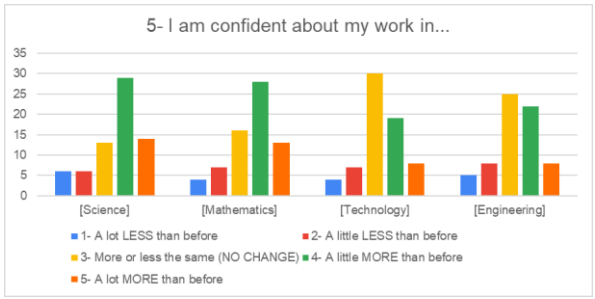
The students' responses are given in Graph 26.

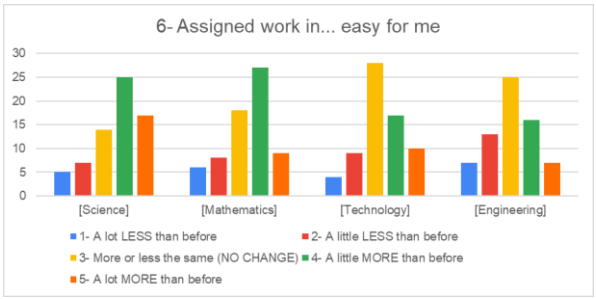

1- I like...
30
25
20
15
10
5
0
[Science]
[Mathematics]
[Technology]
[Engineering]
1- A lot LESS than before
2- A little LESS than before
3- More or less the same (NO CHANGE)
4- A little MORE than before
5- A lot MORE than before

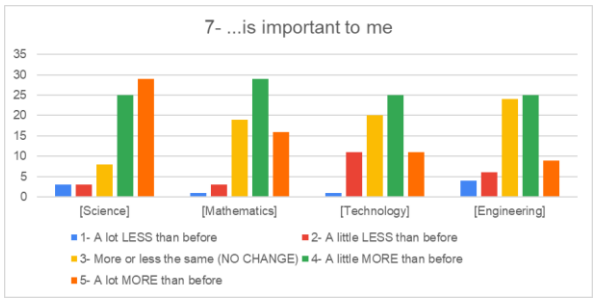

2- I enjoy learning about...
30
25
20
15
10
5
0
[Science]
[Mathematics]
[Technology]
[Engineering]
1- A lot LESS than before
2- A little LESS than before
3- More or less the same (NO CHANGE)
4- A little MORE than before
5- A lot MORE than before

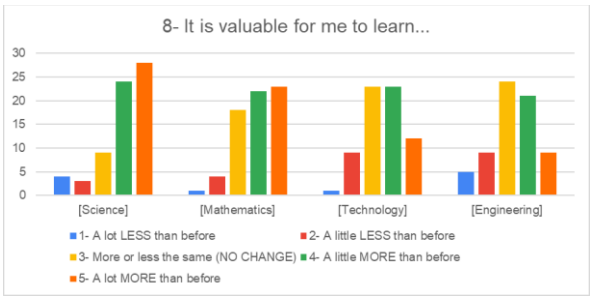

3- I am curious about...
35
30
25
20
15
10
5
0
[Science]
[Mathematics]
[Technology]
[Engineering]
1- A lot LESS than before
2- A little LESS than before
3- More or less the same (NO CHANGE)
4- A little MORE than before
5- A lot MORE than before

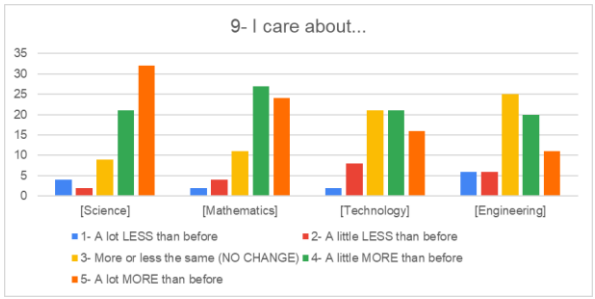

4- ...is difficult for me
40
35
30
25
20
15
10
5
0
[Science]
[Mathematics]
[Technology]
[Engineering]
1- A lot LESS than before
2- A little LESS than before
3- More or less the same (NO CHANGE)
4- A little MORE than before
5- A lot MORE than before

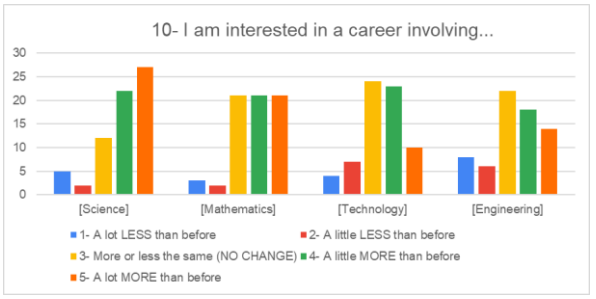

5- I am confident about my work in...
35
30
25
20
15
10
5
0
[Science]
[Mathematics]
[Technology]
[Engineering]
1- A lot LESS than before
2- A little LESS than before
3- More or less the same (NO CHANGE)
4- A little MORE than before
5- A lot MORE than before

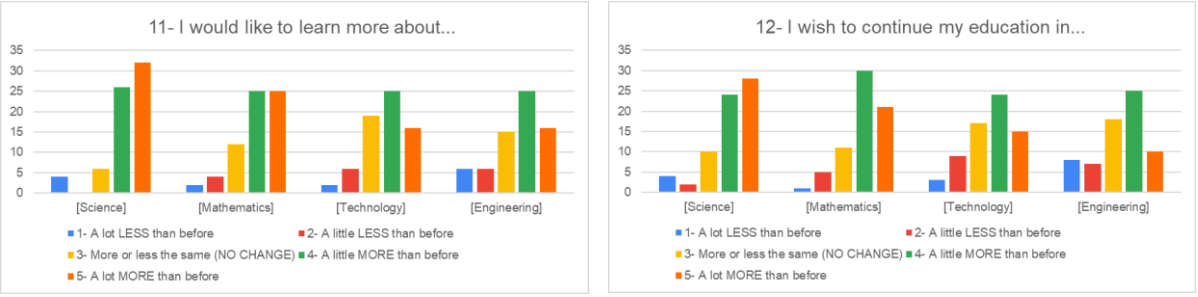

6- Assigned work in... easy for me
30
25
20
15
10
5
0
[Science]
[Mathematics]
[Technology]
[Engineering]
1- A lot LESS than before
2- A little LESS than before
3- More or less the same (NO CHANGE)
4- A little MORE than before
5- A lot MORE than before


7- ...is important to me
35
30
25
20
15
10
5
0
[Science]
[Mathematics]
[Technology]
[Engineering]
1- A lot LESS than before
2- A little LESS than before
3- More or less the same (NO CHANGE)
4- A little MORE than before
5- A lot MORE than before


8- It is valuable for me to learn...
30
25
20
15
10
5
0
[Science]
[Mathematics]
[Technology]
[Engineering]
1- A lot LESS than before
2- A little LESS than before
3- More or less the same (NO CHANGE)
4- A little MORE than before
5- A lot MORE than before


9- I care about...
35
30
25
20
15
10
5
0
[Science]
[Mathematics]
[Technology]
[Engineering]
1- A lot LESS than before
2- A little LESS than before
3- More or less the same (NO CHANGE)
4- A little MORE than before
5- A lot MORE than before


10- I am interested in a career involving...
30
25
20
15
10
5
0
[Science]
[Mathematics]
[Technology]
[Engineering]
1- A lot LESS than before
2- A little LESS than before
3- More or less the same (NO CHANGE)
4- A little MORE than before
5- A lot MORE than before



Graph 26. The students' responses to Change in Attitudes towards STEM survey

The findings in Graph 26 were evaluated for each item separately.

For the engineering subject, in 7 items, most of the students chose "no change", while in 5 items, most students chose "a little more than before".

For the mathematics subject, only in item 4- Mathematics is difficult for me, most of the students chose "no change", while in 2 items (8- It is valuable for me to learn mathematics, and 11- I would like to learn more about mathematics), more students chose the option "a lot more than before". It was interesting that for the item 10- I am interested in a career involving mathematics, the number of students who chose the option "no change", "a little more than before", and "a lot more than before" was equal (n=21). In 10 items, the students chose "a little more than before".

For the science subject, the only item that most of the students chose the option "a little LESS than before" was 4- Science is difficult for me. That is, the students still find science difficult after implementing the DAYLIGHTING RIVERS learning units. However, in 7 items, most of the students chose the option "a lot more than before". In 4 items (1- I like science, 2- I enjoy learning about science, 5- I am confident about my work in science, and 6- Assigned work in science is easy for me), the number of students who chose the option "a little more than before" was higher than other options.

For the technology subject, in 5 items (2, 4, 5, 6, and 10), the number of students who chose the option "no change" was higher than the number of students who chose the other options. In 2 items, which were 8- It is valuable for me to learn technology and 9- I care about technology, the number of students who chose the option "no change" was the same with the number of students who chose the option "a little more than before". In 5 items (1, 3, 7, 11, and 12), the number of students who chose the option "a little more than before" was higher than the number of students who chose the other options.

To have a better understanding of the students' responses to items in Change in Attitudes towards STEM survey, the statistical analysis of the responses were given in Table 4.

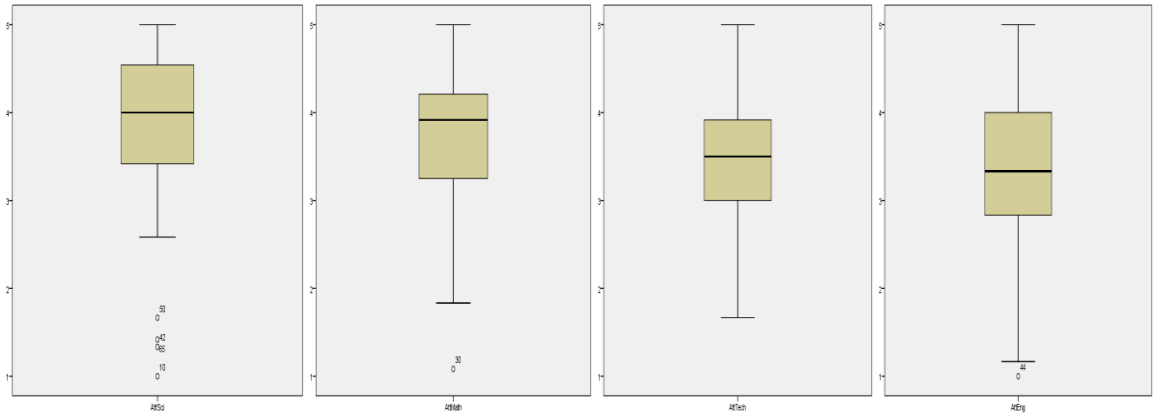
Table 4. The analysis of the students' responses to the Change in Attitudes towards STEM survey.

Change in Attitudes towards...	Mean	Sd	median	mode
[Science]	3.9	0.9	4.0	3.7
[Mathematics]	3.7	0.8	3.9	4.1
[Technology]	3.5	0.7	3.5	3.7
[Engineering]	3.3	0.9	3.3	4.0

The results in Table 4 indicate almost no change or very slight change (technology and engineering) and slight change (science and mathematics) to positive attitudes towards STEM disciplines.

In conclusion, the results showed that the implementation of even one educational module with high school students has students to perceive slightly positive changes in their attitudes towards STEM subjects and slightly higher levels of career decision self-efficacy.

The analysis of the change in attitudes towards STEM for each STEM subject resulted with the mean values given in Graph 27.



Graph 27. Change in attitudes towards STEM values (attitudes towards science, towards math, towards technology, and towards engineering)

According to graph 27, the students' perceived change in attitude towards each STEM subject is slightly towards a little more positive than before (μ=3.89, sd=.89 for science; μ=3.72, sd=.77 for math; μ=3.45, sd=.73 for technology; and μ=3.29, sd=.88 for engineering). Overall, the change in attitudes towards STEM is also slightly towards a little more positive than before (μ=3.59, sd=.56). In other words, students developed slightly more positive attitudes towards STEM subjects. The result can be interpreted as the positive impact of the educational modules developed in Daylighting Rivers project in contributing to the development of students' positive attitudes in STEM subjects.

4. Assessment of the learning process and competence and skills acquisition for European Schools Competition

"Daylighting Rivers" project successfully completed the European Competition for the best "Daylighting Rivers Design Project" presented in the form of a "Daylighting Rivers Location-Based Game". The competition was addressed to classes of secondary schools (students of age 11-19) and focused on challenging issues related to urban rivers – with a special emphasis on those rivers which have been covered over and may be candidates for "daylighting".

The competition was open to teams of secondary school students and teachers or other adults who would act as referents for the group. Participation was free of charge. Teachers or other supervisors were responsible for registering the group and submitting the competition entry.

As it indicated the project proposal, one of the aims was to collect data from students who joined to European School Competition to assess the learning process and competence and skills acquisition.

4.1. Methodology

4.1.1. Data Collection Tools

For Students:

Change in Attitudes towards STEM

The first questionnaire "Change in Attitudes towards STEM" was prepared to measure the changes in attitudes towards Science, Technology, Engineering and Mathematics (STEM) subjects after attending to the International Competition "Youth in Action for DAYLIGHTING RIVERS". The web link for online questionnaire can be found at http://bit.ly/39Cz82N

Change in Career Decision Self-Efficacy

The second questionnaire was "Change in Career Decision Self-Efficacy" scale that measures the way students perceive the changes in their ability to make educational and vocational decisions after attending to the International Competition "Youth in Action for DAYLIGHTING RIVERS". The web link for online questionnaire can be found at http://bit.ly/39yDjNj

For Teachers:

Change in Science Teaching Effectiveness

This instrument seeks to understand how the International Competition "Youth in Action for DAYLIGHTING RIVERS" has changed teachers' teaching preferences in the teaching of science subjects at a particular grade level. The web link for online questionnaire can be found at http://bit.ly/35L9JD8

Change in Science Teaching Efficacy Belief

This instrument is prepared to understand how the International Competition “Youth in Action for DAYLIGHTING RIVERS" has changed teachers’ science teaching efficacy beliefs. The web link for online questionnaire can be found at http://bit.ly/3nIu8yM

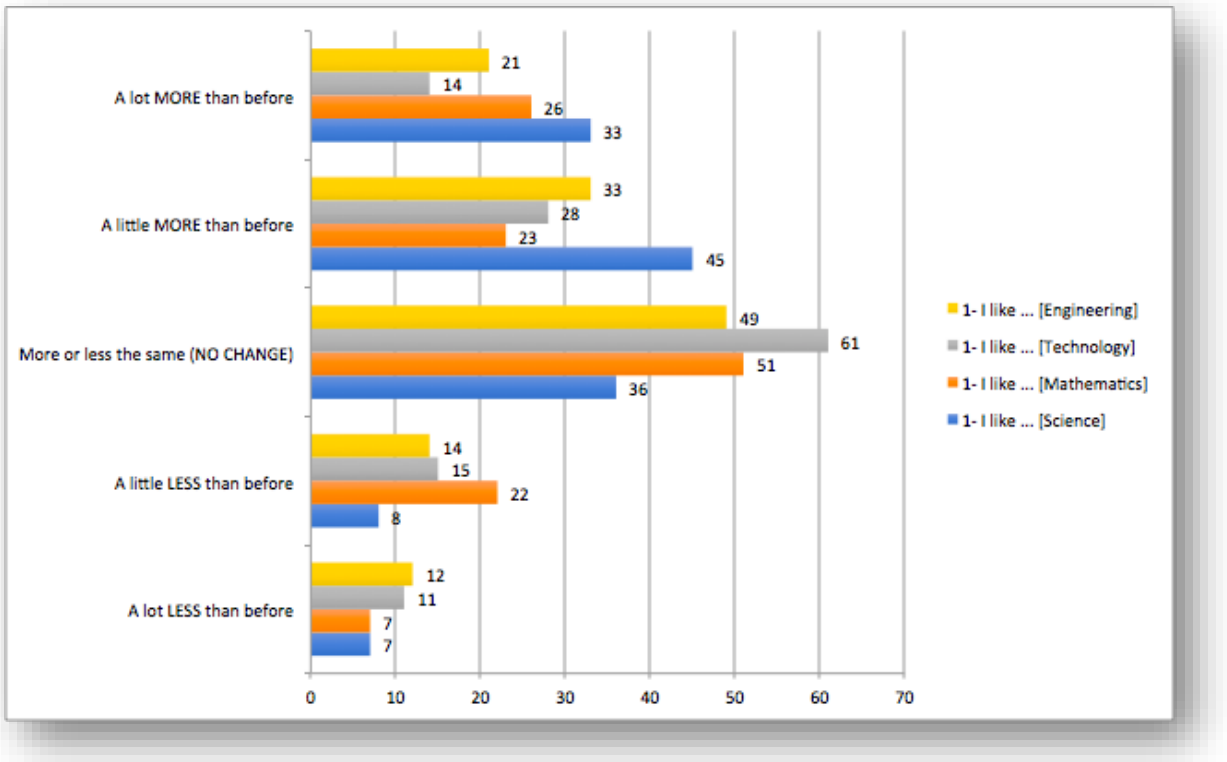
4.1.2. Participants

Totally 108 students from 5 schools send their data for evaluation. While 11 teachers filled out the Change in Science Teaching Effectiveness questionnaire, 12 teachers completed the Change in Science Teaching Efficacy Belief questionnaire.

4.2. Findings

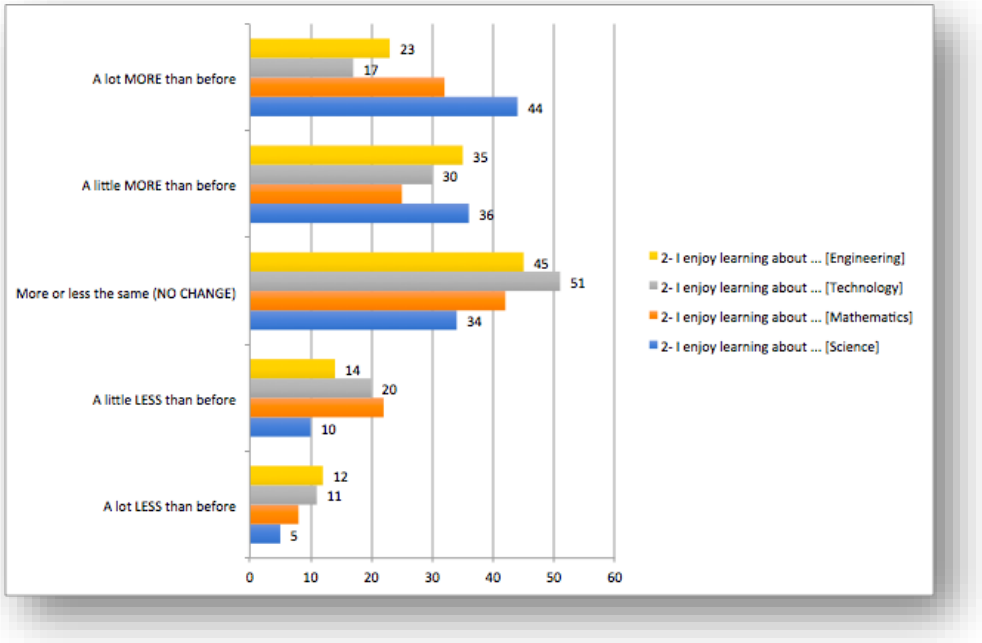
4.2.1. Findings for Change in Attitudes towards STEM (Students)

The data of the students participating in the project were analysed. The obtained analyses are presented below in graphics.



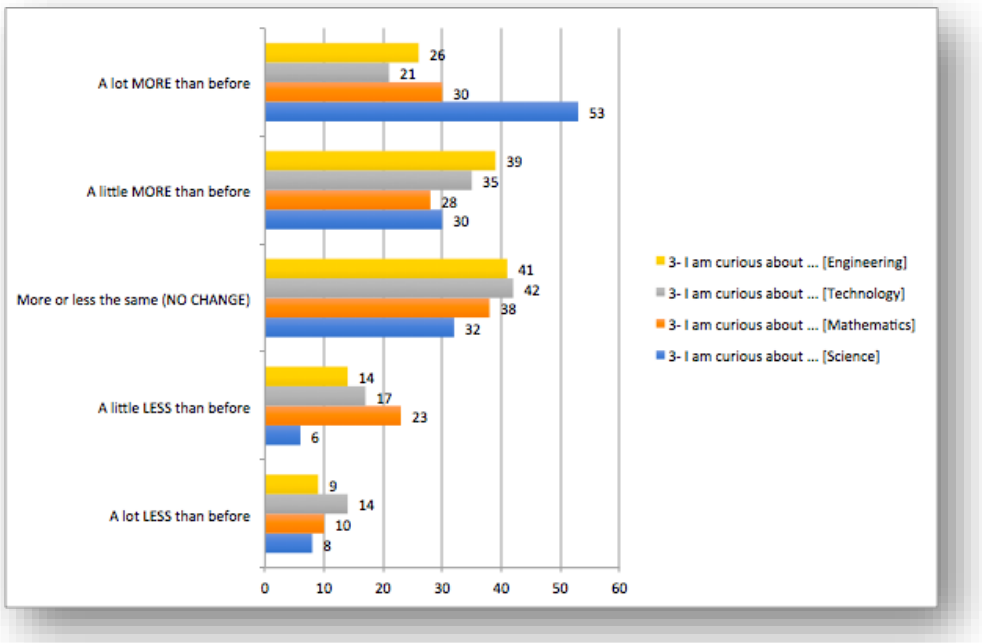
Graph 28. The number of students responded to the item “I like…. Science, Technology, Engineering and Mathematics”

When the graphic above is examined, it is seen that the attitudes of students in the field of science change positively. Positive attitudes in engineering, mathematics and technology follow it, respectively. However, it is seen that the number of students stating that attitudes towards technology did not change is 61, 51 for mathematics, 49 for engineering and 36 for science. It is seen that the number of students with less attitude is quite low.



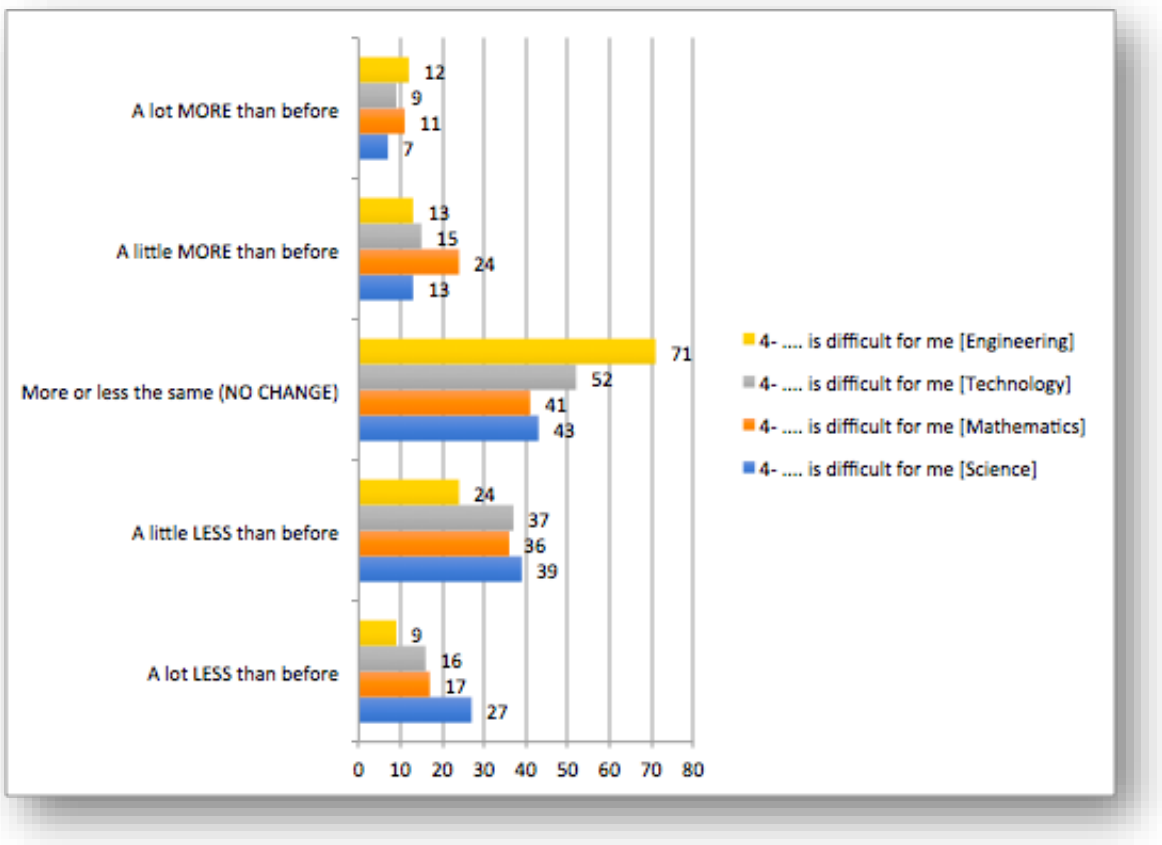
Graph 29. The number of students responded to the item "I enjoy learning about…. Science, Technology, Engineering and Mathematics"

When the graphic above is examined in detail, it is seen that the attitudes of students in the field of science change positively. Positive attitudes in engineering, mathematics and technology follow it respectively (58-56-47). However, it is seen that the number of students stating that attitudes towards technology did not change is 51, 42 for mathematics, 45 for engineering and 34 for science. It is seen that the number of students with less attitude is quite low.



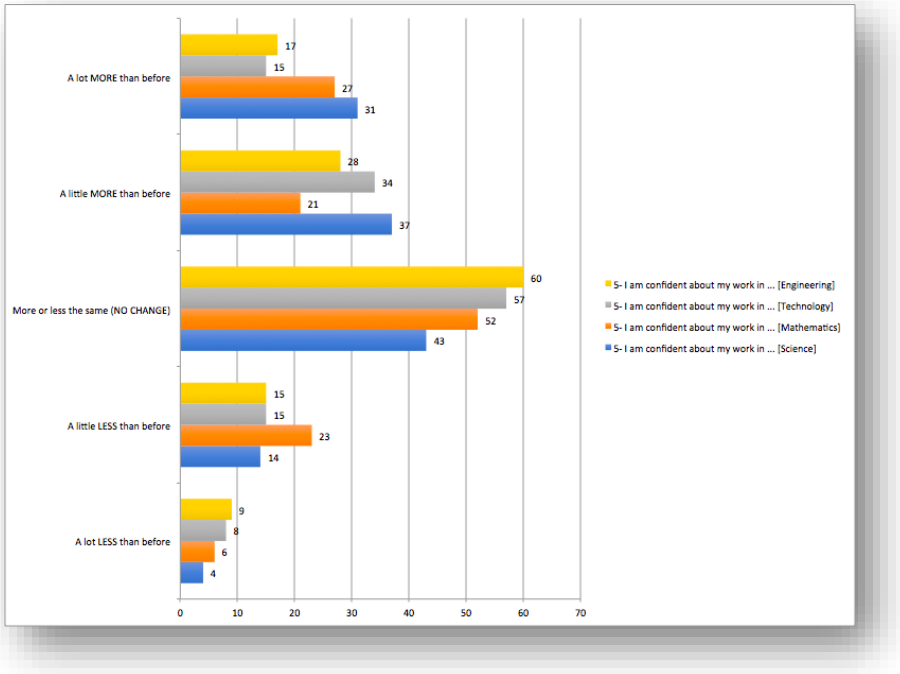
Graph 30. The number of students responded to the item "I am curious about…. Science, Technology, Engineering and Mathematics"

When the graphic above is examined in detail, it is seen that the attitudes of students in the field of science change positively (83). Positive attitudes in engineering, mathematics and technology follow it respectively (65-58-56). However, it is seen that the number of students stating that attitudes towards technology did not change is 42, 38 for mathematics, 41 for engineering and 32 for science. It is seen that the number of students with less attitude is quite low.



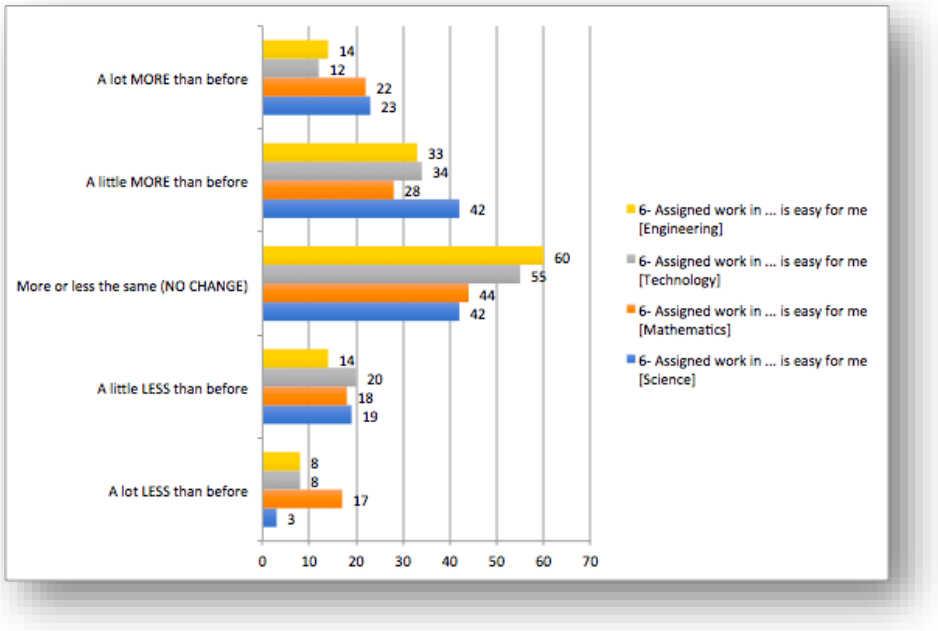
Graph 31. The number of students responded to the item "....is difficult for me (Science, Technology, Engineering and Mathematics)"

When the graphic above is examined in detail, it is seen that 20 students indicated that science is difficult for them a little / lot more than before. It is 25 for engineering, 35 for mathematics and 24 for technology. However, it is seen that the number of students stating that attitudes towards technology did not change is 71, 52 for mathematics, 71 for engineering and 43 for science.



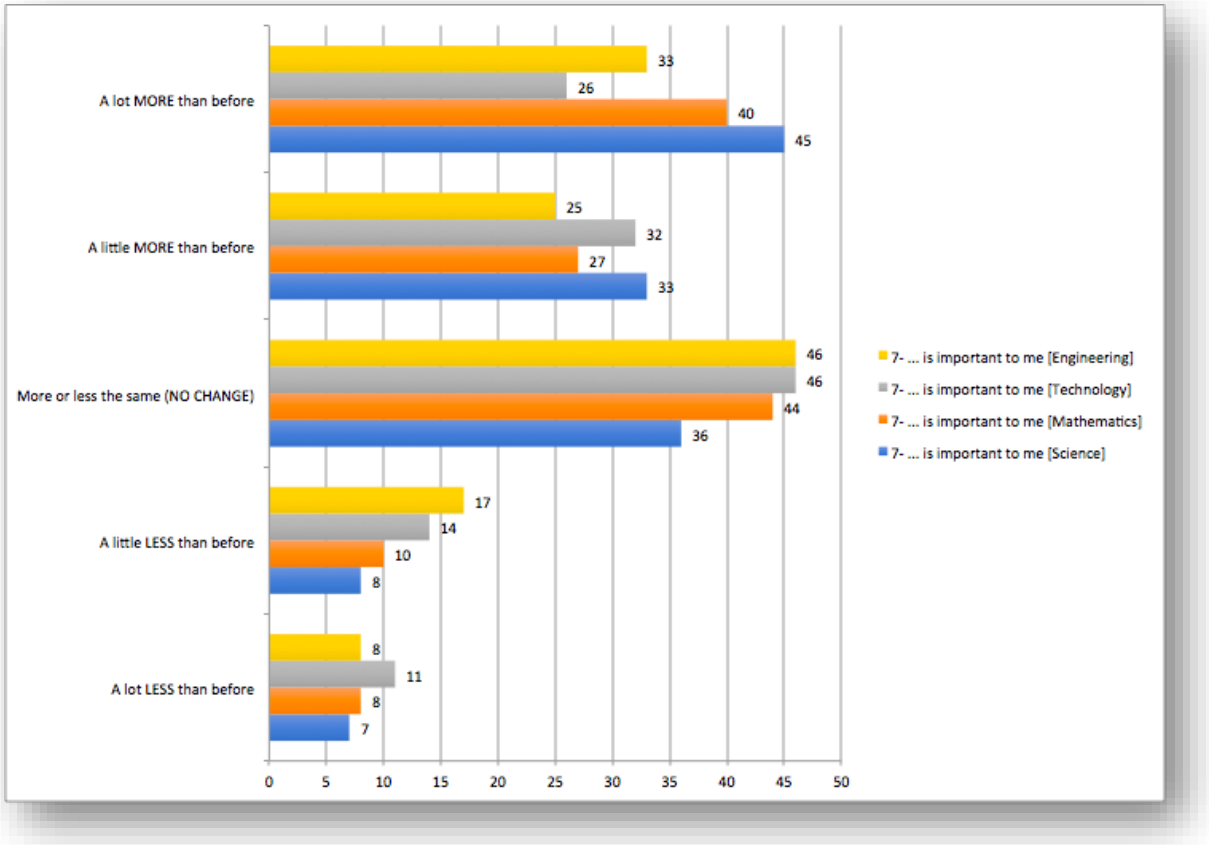
Graph 32. The number of students responded to the item "I am confident about my work in …. Science, Technology, Engineering and Mathematics"

When the graphic above is examined in detail, it is seen that the attitudes of students in the field of science change positively (68). Positive attitudes in engineering, mathematics and technology follow it respectively (45-48-49). However, it is seen that the number of students stating that attitudes towards technology did not change is 57, 52 for mathematics, 60 for engineering and 43 for science. It is seen that the number of students with less attitude is quite low.



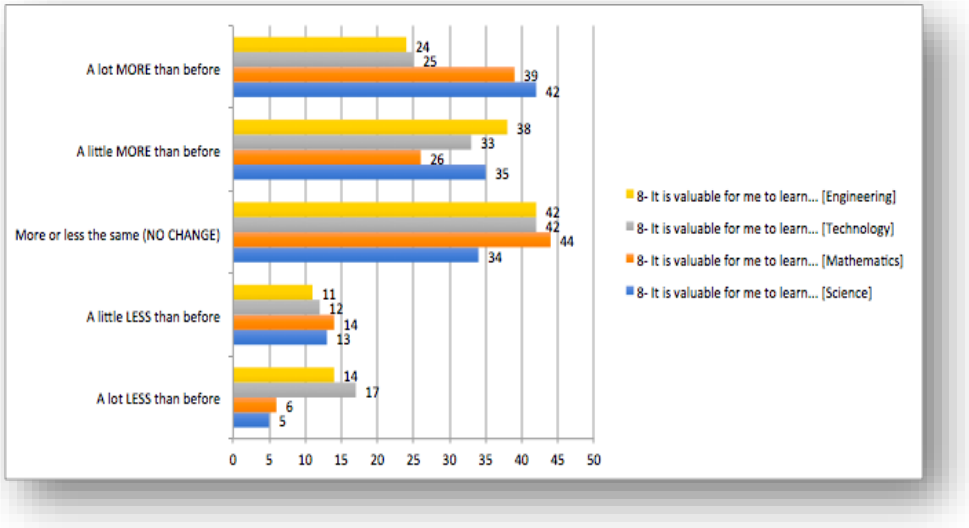
Graph 33. The number of students responded to the item "Assigned work in …. (Science, Technology, Engineering and Mathematics) is easy for me".

When the graphic above is examined in detail, it is seen that the attitudes of students in the field of science change positively (65). Positive attitudes in engineering, mathematics and technology follow it respectively (47-50-46). However, it is seen that the number of students stating that attitudes towards technology did not change is 55, 44 for mathematics, 60 for engineering and 42 for science. It is seen that the number of students with less attitude is quite low.



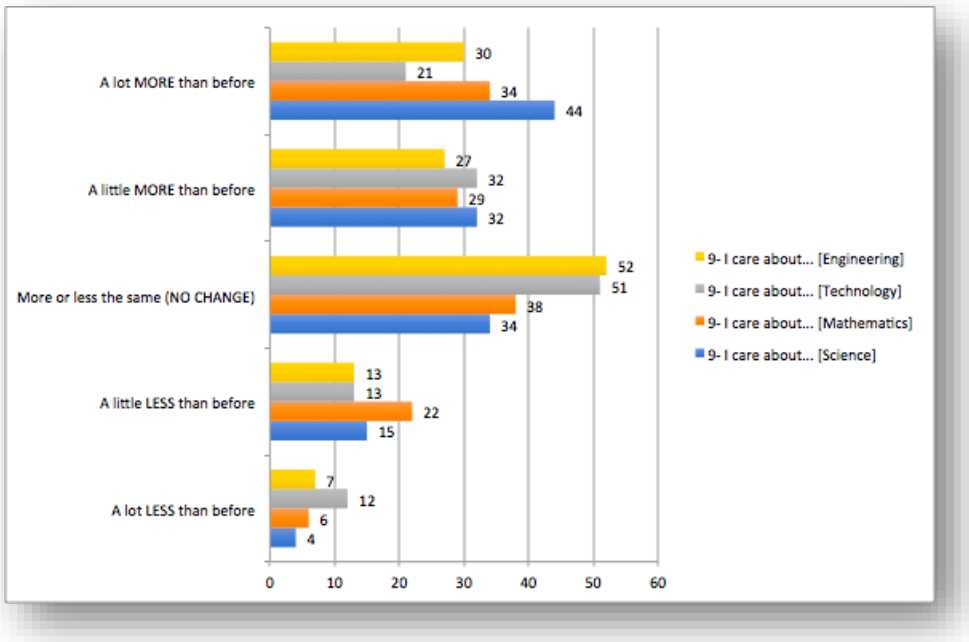
Graph 34. The number of students responded to the item "…. Is important to me (Science, Technology, Engineering and Mathematics) is easy for me".

When the graphic above is examined in detail, it is seen that the attitudes of students in the field of science change positively (78). Positive attitudes in engineering, mathematics and technology follow it respectively (58-58-67). However, it is seen that the number of students stating that attitudes towards technology did not change is 46, 44 for mathematics, 46 for engineering and 36 for science. It is seen that the number of students with less attitude is quite low.



Graph 35. The number of students responded to the item "It is valuable for me to learn... (Science, Technology, Engineering and Mathematics)"

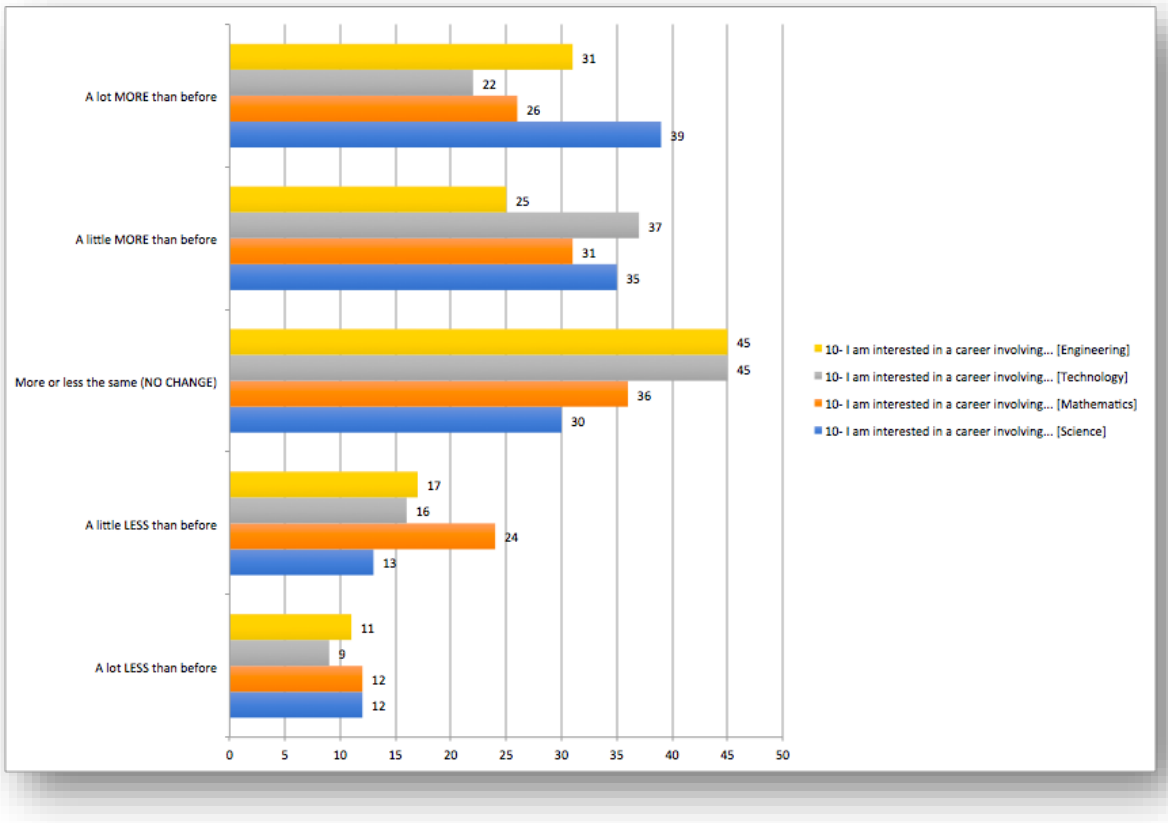
When the graphic above is examined in detail, it is seen that the attitudes of students in the field of science change positively (77). Positive attitudes in engineering, technology and mathematics follow it respectively (62-58-65). However, it is seen that the number of students stating that attitudes towards technology did not change is 42, 44 for mathematics, 42 for engineering and 34 for science. It is seen that the number of students with less attitude is quite low.



Graph 36. The number of students responded to the item "I care about…. (Science, Technology, Engineering and Mathematics)"

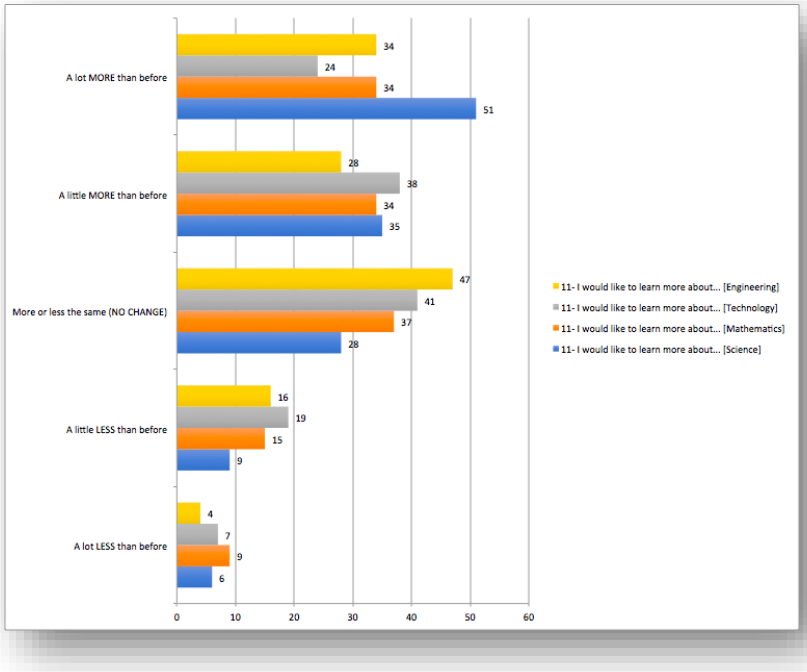
When the graphic above is examined in detail, it is seen that the attitudes of students in the field of science change positively (76). Positive attitudes in engineering, technology and mathematics follow

it respectively (57-53-63). However, it is seen that the number of students stating that attitudes towards technology did not change is 51, 38 for mathematics, 52 for engineering and 34 for science. It is seen that the number of students with less attitude is quite low.



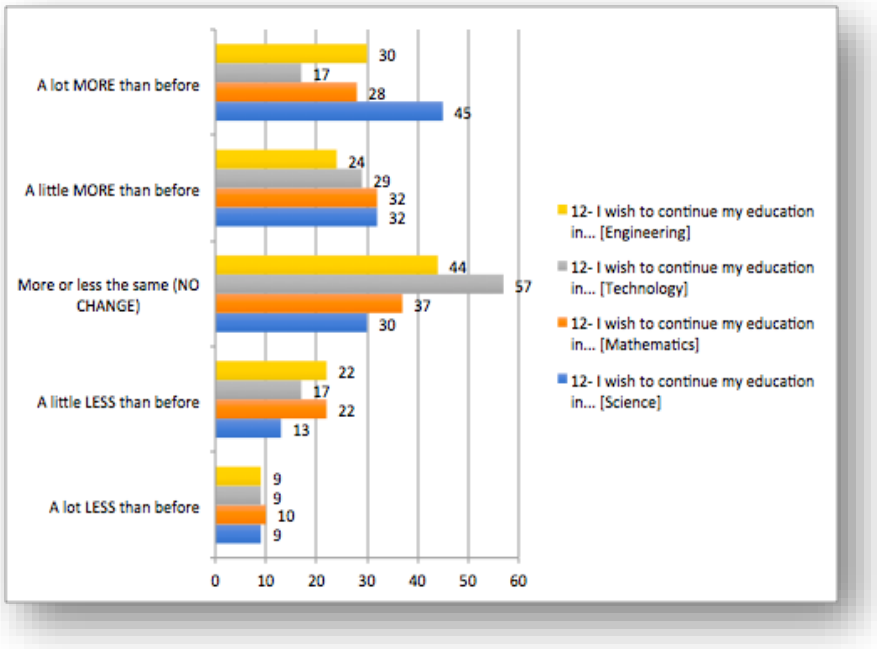
Graph 37. The number of students responded to the item "I am interested in a career involving…. (Science, Technology, Engineering and Mathematics)"

When the graphic above is examined in detail, it is seen that the attitudes of students in the field of science change positively (74). Positive attitudes in engineering, technology and mathematics follow it respectively (56-59-57). However, it is seen that the number of students stating that attitudes towards technology did not change is 45, 36 for mathematics, 45 for engineering and 30 for science. It is seen that the number of students with less attitude is quite low.



Graph 38. The number of students responded to the item "I would like to learn more about…. (Science, Technology, Engineering and Mathematics)"

When the graphic above is examined in detail, it is seen that the attitudes of students in the field of science change positively (86). Positive attitudes in engineering, technology and mathematics follow it respectively (62-62-68). However, it is seen that the number of students stating that attitudes towards technology did not change is 41, 37 for mathematics, 47 for engineering and 28 for science. It is seen that the number of students with less attitude is quite low.



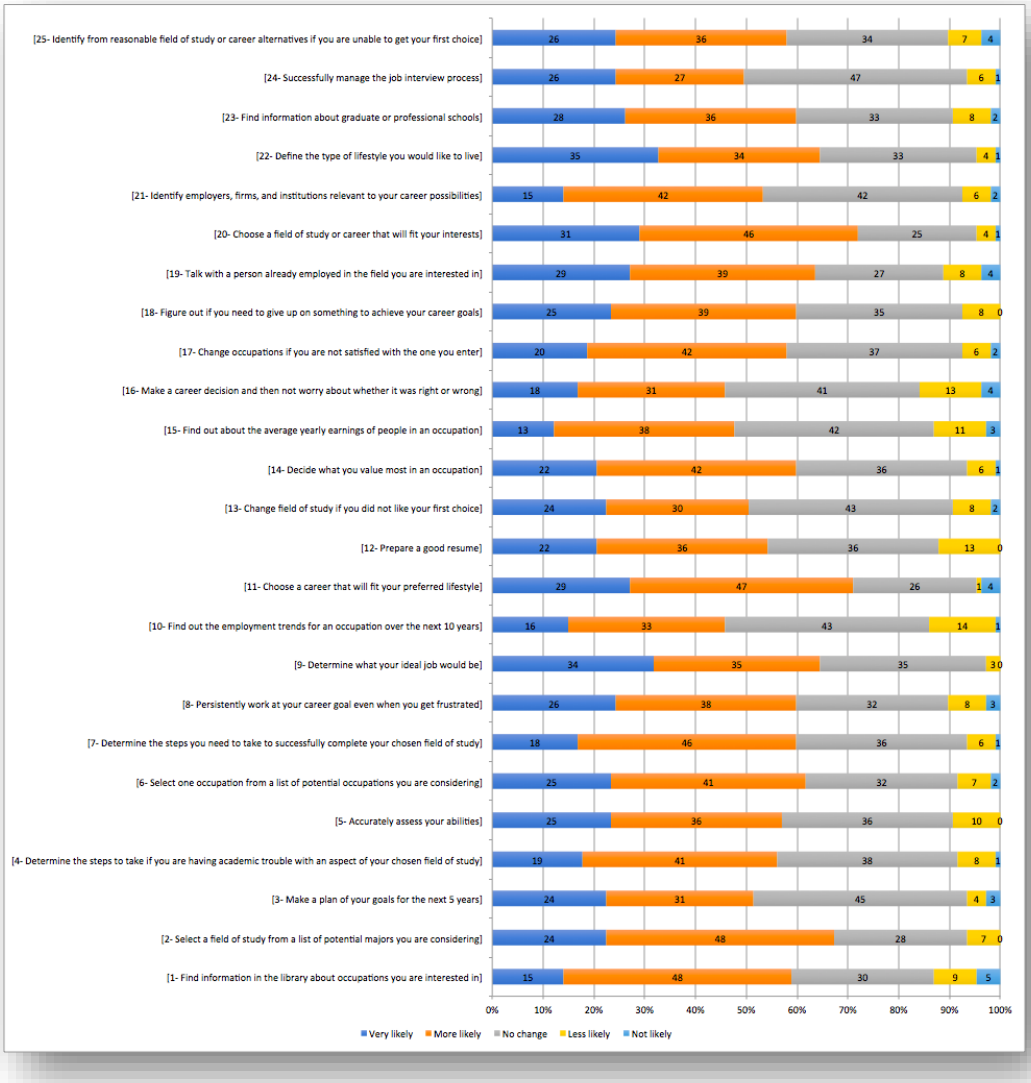
Graph 39. The number of students responded to the item "I wish to continue my education…. (Science, Technology, Engineering and Mathematics)"

When the graphic above is examined in detail, it is seen that the attitudes of students in the field of science change positively (77). Positive attitudes in engineering, technology and mathematics follow it respectively (54-46-60). However, it is seen that the number of students stating that attitudes towards technology did not change is 57, 37 for mathematics, 44 for engineering and 30 for science. It is seen that the number of students with less attitude is quite low.

4.2.2. Findings for Change in Career Decision Self-Efficacy (Students)

The students were asked to respond to the question "After participating in the International Competition "Youth in Action for DAYLIGHTING RIVERS", do you think that you have been more able to…". The data of the students participating in the project were analysed. The obtained analyses are presented below in graphics.

When Graph 40 is analysed in detail, it was found that students mostly expressed positive opinions (More likely + Very likely) about the following items regarding their future career:



Graph 40. Students responses for the questionnaire "Change in Career Decision Self-Efficacy".

Item #20: “20- Choose a field of study or career that will fit your interests” (77 Students)
Item #11: “11- Choose a career that will fit your preferred lifestyle” (76 Students)
Item #2: “2- Select a field of study from a list of potential majors you are considering” (72 Students)
Item #9: “Determine what your ideal job would be” (69 Students)
Item #22: “Define the type of lifestyle you would like to live” (69 Students)

In some items, the students stated that their views did not change in the following items after participating in the competition:

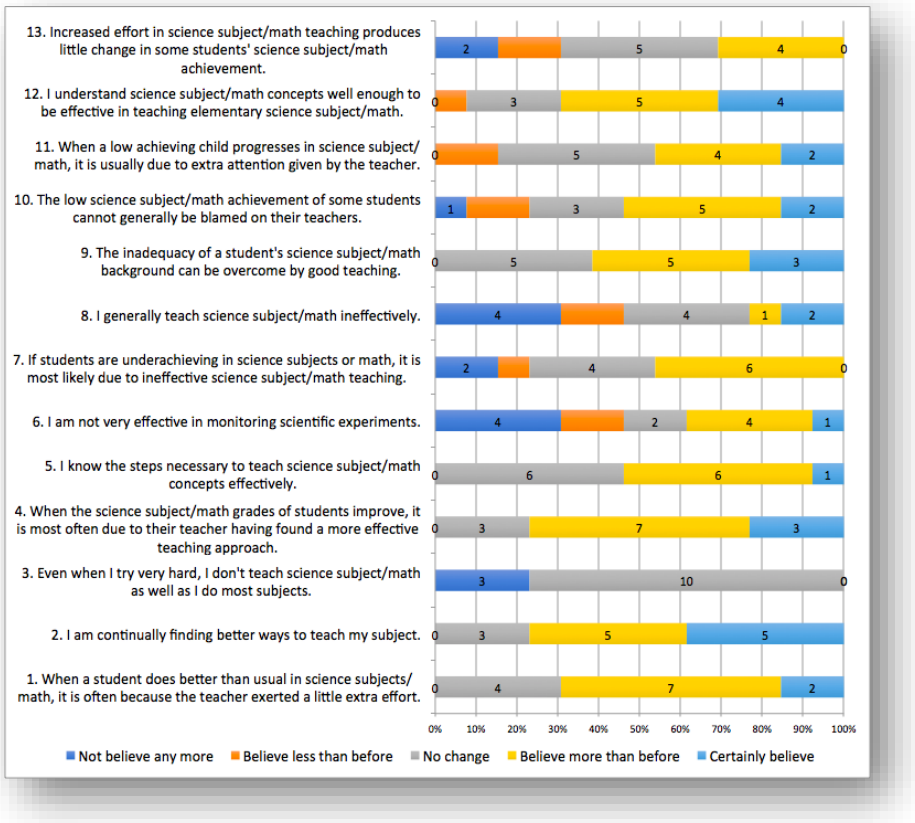
Item #3: “Make a plan of your goals for the next 5 years” (45 Students)
Item #10: “Find out the employment trends for an occupation over the next 10 years” (43 Students)
Item #13: “Change field of study if you did not like your first choice” (43 Students)
Item #24: “Successfully manage the job interview process” (47 Students)

More statistical information can be found at Graph 40.

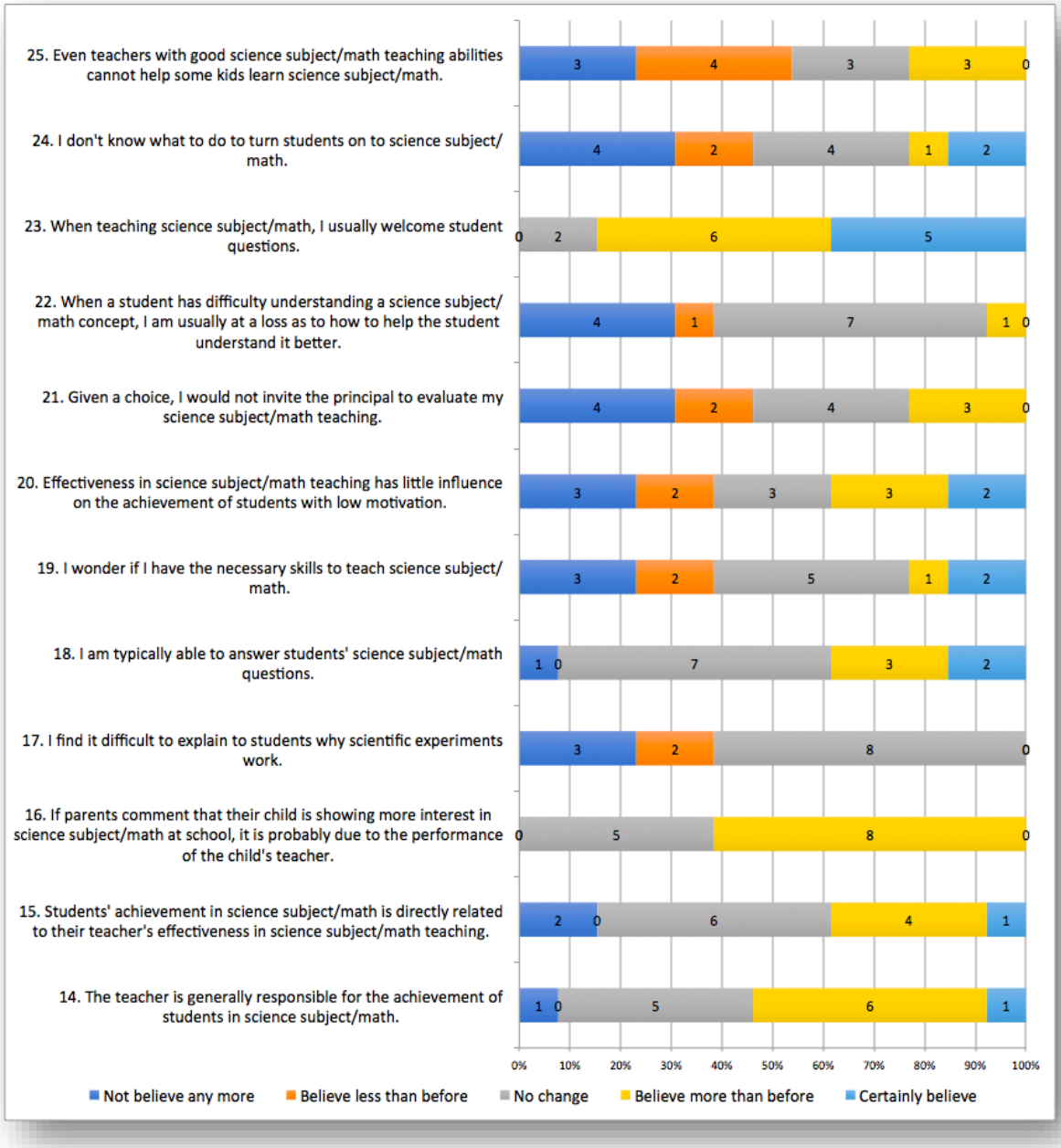
4.2.3. Findings for Change in Science Teaching Efficacy Belief (Teachers)

Teachers were asked to indicate their teaching beliefs, compared to their approach before participating in the International Competition “Youth in Action for DAYLIGHTING RIVERS".

The statistical analyses were presented at Graph 42 and 43.



Graph 41. First 13 Items and Statistical Analysis of Data Related to Change in Science Teaching Efficacy Belief



Graph 42. Items# 14-17 and Statistical Analysis of Data Related to Change in Science Teaching Efficacy Belief

13 Teachers joined the European School Competition with their students. Their teaching fields are presented at Table 5 below:

Table 5. The teaching majors of the participating teachers

Teaching Field	Number of Teachers (N)	Percentage (%)
Biology	2	15.38
Science	2	15.38
Mathematics	4	30.76
Chemistry	1	7.69
Computer Science	1	7.69

History	2	15.38
Sociology	1	7.69
Total	13	

When Graph 42 and 43 are analysed in detail, it was found that teachers mostly expressed positive opinions (Believe more than before + certainly believe) about the following items regarding their teaching belief after competition:

Item #1: When a student does better than usual in science subjects/math, it is often because the teacher exerted a little extra effort (9 Teachers).
Item #2: I am continually finding better ways to teach my subject (10 Teachers).
Item #4: When the science subject/math grades of students improve, it is most often due to their teacher having found a more effective teaching approach (10 Teachers).
Item #12: I understand science subject/math concepts well enough to be effective in teaching elementary science subjects/math (9 Teachers).
Item #23: When teaching science subjects/math, I usually welcome student questions (10 Teachers).

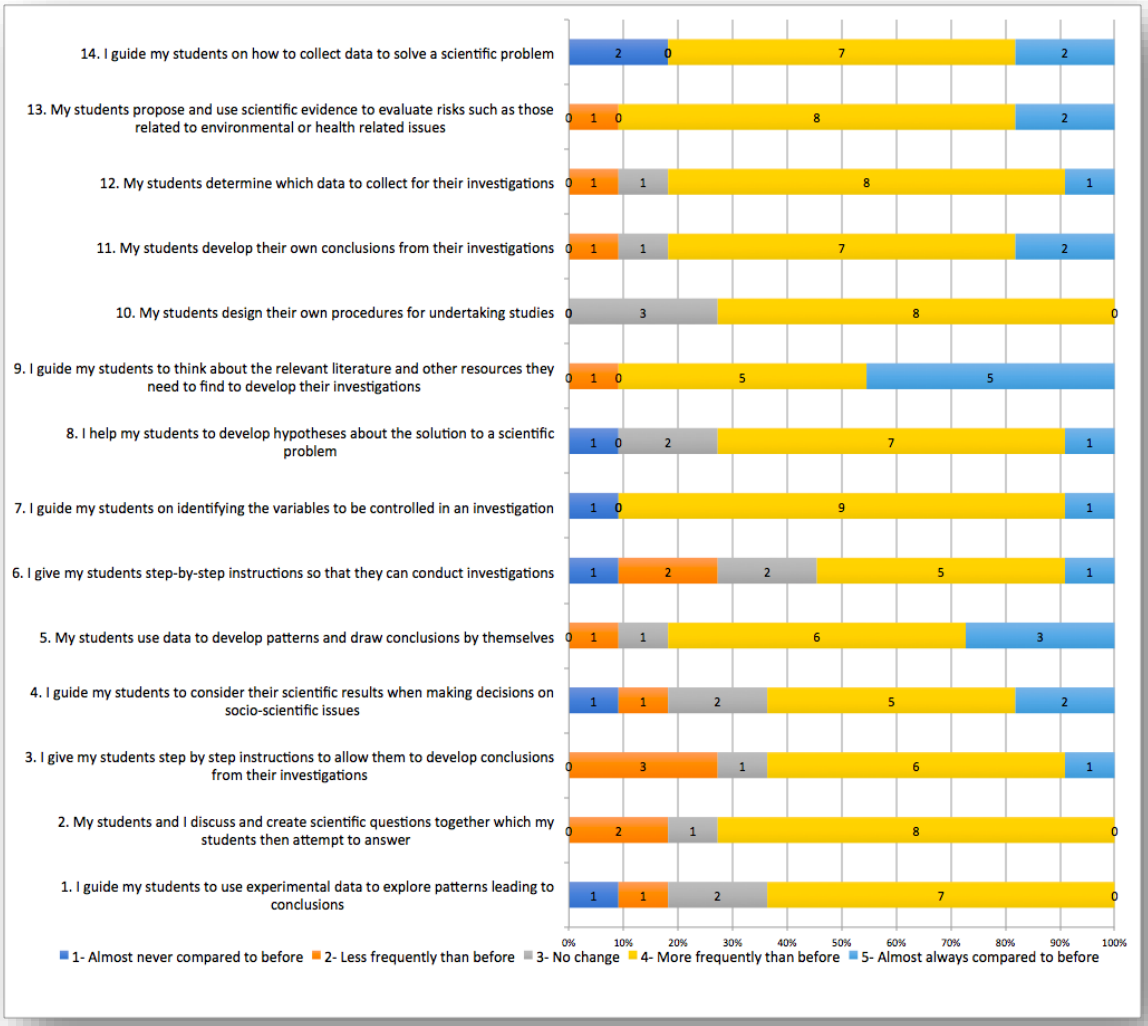
More statistical information can be found at Graph 42 and 43.

4.2.4. Findings for Change in Science Teaching Effectiveness (Teachers)

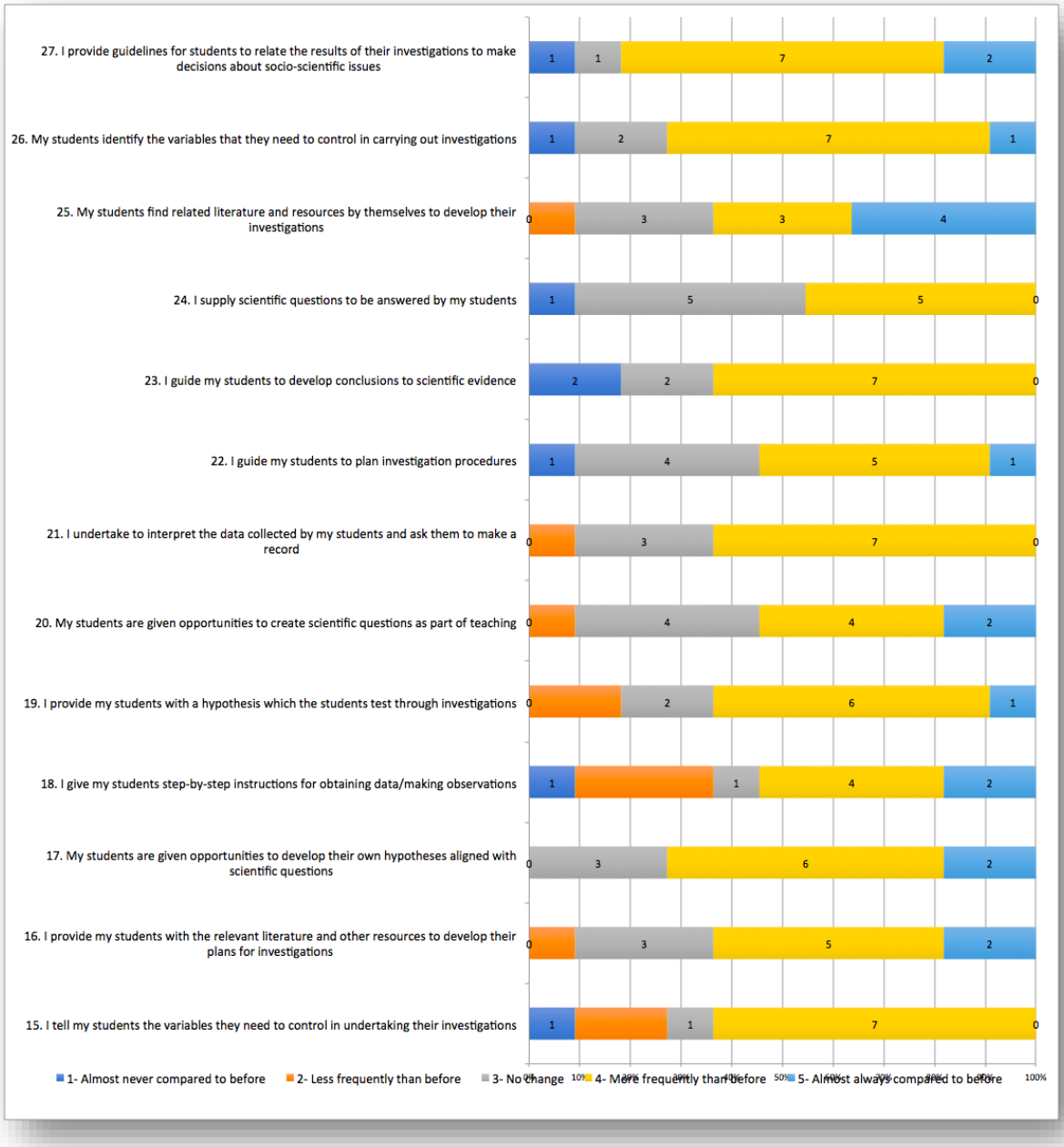
This instrument seeks to understand how the International Competition "Youth in Action for DAYLIGHTING RIVERS" has changed teachers' teaching preferences in the teaching of science subjects at a particular grade level. The statistical analyses were presented at Graph 44 and 45. 11 Teachers participated in this study.
When Graph 44 and 45 are analysed in detail, it was found that teachers mostly expressed positive opinions (more frequently than before + Almost always compared to before) about the following items regarding their science teaching effectiveness after competition:

Item #7: I guide my students on identifying the variables to be controlled in an investigation (10 Teachers).
Item #9: I guide my students to think about the relevant literature and other resources they need to find to develop their investigations (10 Teachers).
Item #13: My students propose and use scientific evidence to evaluate risks such as those related to environmental or health related issues (10 Teachers).
Item #5: My students use data to develop patterns and draw conclusions by themselves (9 Teachers).
Item #11: My students develop their own conclusions from their investigations (9 Teachers).
Item #14: I guide my students on how to collect data to solve a scientific problem (9 Teachers).
Item #27: I provide guidelines for students to relate the results of their investigations to make decisions about socio-scientific issues (9 Teachers).

More statistical information can be found at Graph 44 and 45.



Graph 43. First 14 Items and Statistical Analysis of Data Related to Change in Science Teaching Effectiveness



Graph 44. Items# 15-17 and Statistical Analysis of Data Related to Change in Science Teaching Effectiveness

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Appendices

Evaluating Learning Units- Teacher Interview Form

Dear teachers/members of Daylighting Rivers (DR) project,

This form is prepared for you to evaluate the feasibility and suitability of the learning units. Learning units are the teaching-learning sequences which involve learning activities in five steps, namely Orientation, Conceptualization, Investigation, Conclusion and Discussion.

Please read each description and evaluation criterion carefully, and response in as much detail as possible.

Thank you in advance for your valuable comments.

The title of the Learning Unit:

Please select the sections of the learning unit available for evaluation:

	Brief Description		Objectives
	Introduction or Orientation		Conceptualization
	Investigation		Conclusion
	Discussion		

Please select the options that apply to the title of the learning unit. The title...

□ is attractive and rises curiosity
□ reflects the content of the learning unit

Brief Description

Brief description is the general introduction to the learning unit. The holistic picture of the learning unit should be provided here with an introduction to the key concepts and the big idea of the learning unit.

Does the brief description clearly and accurately describe the content of the learning unit?

□ 1-No, it does not □ 2 □ 3 □ 4 □ 5- Yes, perfectly it does

Please explain your response and write your suggestions below.

Do the objectives correctly and adequately address the content and skills that students will have at the end of the learning unit?

□ 1-No, they do not □ 2 □ 3 □ 4 □ 5- Yes, they do

Please explain your response and write your suggestions below.

Learning Unit

Please rate the level of challenge the learning unit has for implementation between...

1- The learning unit is not challenging at all for this age group.

10- The learning unit is too challenging for implementation with this age group.

Please explain your response and write your suggestions below.

Please rate the cost of implementation for the learning unit between…

1- The learning unit has almost no cost of implementation.

10- The learning unit requires too much expense for implementation.

Please explain your response and write your suggestions below.

Please rate the level of commitment required for implementing the learning unit between...

1- It requires little or very low commitment to implement the learning unit.

10- It requires too much commitment to implement the learning unit.

Please explain your response and write your suggestions below.

Transversal Learning

Transversal Learning opportunities are those that 1) recognize the learners as core participants, encourage their active engagement and develop in them an understanding of their own activity as learners, 2) are founded on the social nature of learning and actively encourages well-organised co-operative learning, 3) help teachers become highly attuned to the learners' motivations and the key role of emotions in achievement, 4) are acutely sensitive to the individual differences among the learners, including their prior knowledge, 5) devise programs that demand hard work and challenge from all but without excessive overload, 6) operate with clarity of expectations using assessment strategies consistent with these expectations with a strong emphasis on formative feedback to support learning, and 7) strongly promote horizontal connectedness across areas of knowledge and subjects as well as to the community and the wider world.

Please rate the effectiveness of the learning unit for transversal learning between

1- The learning unit does not have transversal learning opportunities at all.

10- The learning unit has adequate number of transversal learning opportunities.

Please explain your response and write your suggestions below.

Competences and Skills

Please check the boxes next to the competence and skill if you think the learning unit will help your students have this competence or skill at the completion of the learning unit. You may refer to http://www.p21.org/our-work/p21-framework for the description of the competences and skills listed below.

I think that at the completion of this learning unit, my students will have more of the Learning and Innovation skills, such as…

□ Creativity □ Innovation □ Critical Thinking

□ Problem Solving □ Communication □ Collaboration

I think that at the completion of this learning unit, my students will have more of the Information, Media, and Technology Skills, such as…

□ Information Literacy □ Media Literacy

□ ICT (Information and Communication Technologies) Literacy

I think that at the completion of this learning unit, my students will have more of the Life and Career Skills, such as…

□ Flexibility and Adaptability □ Initiative and Self-direction

□ Social and Cross-Cultural Skills □ Productivity and Accountability

□ Leadership and Responsibility

Please explain your response and write your suggestions below.

Evaluating Learning Units- Student Interview Form

Dear students,

This form is prepared for you to evaluate the learning units for the project "Daylighting Rivers". Learning units are the teaching-learning sequences which involve learning activities in five steps, namely Orientation, Conceptualization, Investigation, Conclusion and Discussion.

We ask you for your opinion regarding how exciting each learning unit is for you. Therefore, there is no right or wrong answer. We appreciate and value your comments and make the learning units more fun and educative based on your suggestions. So, please read each description and evaluation criterion carefully, and write what you think of each learning unit freely and as much detail as possible.

Thank you in advance for your valuable comments.

The title of the Learning Unit:

Please select the options that apply to the title of the learning unit. The title...

□ is attractive and rises curiosity
□ reflects the content of the learning unit

Brief Description

Brief description is the general introduction to the learning unit. The holistic picture of the learning unit should be provided here with an introduction to the key concepts and the big idea of the learning unit.

Does the brief description clearly and accurately describe the content of the learning unit?

□ 1-No, it does not □ 2 □ 3 □ 4 □ 5- Yes, perfectly it does

Please explain your response and write your suggestions below.

Do the objectives correctly and adequately address the content and skills that you would like to have at the end of the learning unit?

□ 1-No, they do not □ 2 □ 3 □ 4 □ 5- Yes, they do

Please explain your response and write your suggestions below.

Learning Unit

Please rate how much challenge do you think the learning unit has for implementation between...

1- The learning unit is not challenging at all for this age group.

10- The learning unit is too challenging for implementation with this age group.

Please explain your response and write your suggestions below.

Please rate the level of commitment required for completing the learning unit between...

1- It requires little or very low commitment to implement the learning unit.

10- It requires too much commitment to implement the learning unit.

Please explain your response and write your suggestions below.

Learning Opportunities

Please check the boxes next to statements that apply for this learning unit. "Do you feel like if the learning unit..." or "You would like a learning unit that..."The learning unit does not have transversal learning opportunities at all.

- ☐ recognizes the learners as core participants and encourage active engagement.
- ☐ actively encourages well-organised co-operative learning.
- ☐ helps teachers become highly attuned to the learners' motivations and the key role of emotions in achievement.
- ☐ is acutely sensitive to the individual differences among the learners, including their prior knowledge.
- ☐ includes activities that demand hard work and challenge but without excessive overload.
- ☐ the assessment strategies are clear with a strong emphasis on feedback to support learning.
- ☐ strongly promotes connections across areas of knowledge and subjects as well as to the community and the wider world.

Please explain your response and write your suggestions below.

Competences and Skills

Please check the boxes next to the competence and skill if you think the learning unit will help you have this competence or skill at the completion of the learning unit.

I think that at the completion of this learning unit, I will have more of the Learning and Innovation skills, such as…

□ Creativity □ Innovation □ Critical Thinking

□ Problem Solving □ Communication □ Collaboration

I think that at the completion of this learning unit, I will have more of the Information, Media, and Technology Skills, such as…

□ Information Literacy □ Media Literacy

□ ICT (Information and Communication Technologies) Literacy

I think that at the completion of this learning unit, I will have more of the Life and Career Skills, such as…

□ Flexibility and Adaptability □ Initiative and Self-direction

□ Social and Cross-Cultural Skills □ Productivity and Accountability

□ Leadership and Responsibility

Please explain your response and write your suggestions below.

Change in Science Teaching Efficacy Belief

Dear teacher,

This instrument is prepared to understand how the International Competition “Youth in Action for DAYLIGHTING RIVERS"/ implementing DAYLIGHTING RIVERS project learning units has changed if any, your science teaching efficacy beliefs. The instrument contains a number of statements. Please evaluate each statement considering the degree to which you agree or disagree with the statement (SD=strongly disagree; D = Disagree; UN = Uncertain; A = Agree; SA=strongly agree).

Please be aware that there are no right or wrong answers. Also, note that the following information will be kept strictly confidential and that providing us with your personal data is voluntary.

Thank you for your participation.

Daylighting Rivers Team

Your school is... *

Your teaching major is... *

Please select the response that best describes the change, if any, related to your teaching beliefs now, compared to your approach before participating in the International Competition “Youth in Action for DAYLIGHTING RIVERS". *

	Not believe any more	**Believe less than before**	**No change**	**Believe more than before**	**Certainly believe**
1. When a student does better than usual in science subjects/math, it is often because the teacher exerted a little extra effort.					
2. I am continually finding better ways to teach my subject.					
3. Even when I try very hard, I don't teach science subject/math as well as I do most subjects.					
4. When the science subject/math grades of students improve, it is most often due to their teacher having found a more effective teaching approach.					
5. I know the steps necessary to teach science subject/math concepts effectively.					
6. I am not very effective in monitoring scientific experiments.					
7. If students are underachieving in science subjects or math, it is most likely due to ineffective science subject/math teaching.					
8. I generally teach science subject/math ineffectively.					
9. The inadequacy of a student's science subject/math					

background can be overcome by good teaching.					
10. The low science subject/math achievement of some students cannot generally be blamed on their teachers.					
11. When a low achieving child progresses in science subject/math, it is usually due to extra attention given by the teacher.					
12. I understand science subject/math concepts well enough to be effective in teaching elementary science subject/math.					
13. Increased effort in science subject/math teaching produces little change in some students' science subject/math achievement.					
14. The teacher is generally responsible for the achievement of students in science subject/math.					
15. Students' achievement in science subject/math is directly related to their teacher's effectiveness in science subject/math teaching.					
16. If parents comment that their child is showing more interest in science subject/math at school, it is probably due to the performance of the child's teacher.					
17. I find it difficult to explain to students why scientific experiments work.					
18. I am typically able to answer students' science subject/math questions.					
19. I wonder if I have the necessary skills to teach science subject/math.					
20. Effectiveness in science subject/math teaching has little influence on the achievement of students with low motivation.					
21. Given a choice, I would not invite the principal to evaluate my science subject/math teaching.					
22. When a student has difficulty understanding a science subject/math concept, I am usually at a loss as to how to help the student understand it better.					
23. When teaching science subject/math, I usually welcome student questions.					
24. I don't know what to do to turn students on to science subject/math.					
25. Even teachers with good science subject/math teaching abilities cannot help some kids learn science subject/math.					

Change in Science Teaching Effectiveness

Dear teacher,

This instrument seeks to understand how the International Competition "Youth in Action for DAYLIGHTING RIVERS"/ implementing DAYLIGHTING RIVERS project learning units has changed if any, your teaching preferences in the teaching of science subjects at a particular grade level. The instrument contains a number of statements. You will be asked what you think about these statements. Please evaluate each statement considering the degree to which it applies to your teaching (Almost never to Almost always).

Please be aware that there are no right or wrong answers. Your opinion is what we are looking for.

Also, note that the following information will be kept strictly confidential and that providing us with your personal data is voluntary.

Thank you for your participation.

Daylighting Rivers Team

Your school is... *

Your teaching major is... *

	1- Almost never compared to	2- Less frequently than before	3- No change	4- More frequently than	5- Almost always compared to
1. I guide my students to use experimental data to explore patterns leading to conclusions					
2. My students and I discuss and create scientific questions together which my students then attempt to answer					
3. I give my students step by step instructions to allow them to develop conclusions from their investigations					
4. I guide my students to consider their scientific results when making decisions on socio-scientific issues					
5. My students use data to develop patterns and draw conclusions by themselves					
6. I give my students step-by-step instructions so that they can conduct investigations					
7. I guide my students on identifying the variables to be controlled in an investigation					
8. I help my students to develop hypotheses about the solution to a scientific problem					
9. I guide my students to think about the relevant					

literature and other resources they need to find to develop their investigations					
10. My students design their own procedures for undertaking studies					
11. My students develop their own conclusions from their investigations					
12. My students determine which data to collect for their investigations					
13. My students propose and use scientific evidence to evaluate risks such as those related to environmental or health related issues					
14. I guide my students on how to collect data to solve a scientific problem					
15. I tell my students the variables they need to control in undertaking their investigations					
16. I provide my students with the relevant literature and other resources to develop their plans for investigations					
17. My students are given opportunities to develop their own hypotheses aligned with scientific questions					
18. I give my students step-by-step instructions for obtaining data/making observations					
19. I provide my students with a hypothesis which the students test through investigations					
20. My students are given opportunities to create scientific questions as part of teaching					
21. I undertake to interpret the data collected by my students and ask them to make a record					
22. I guide my students to plan investigation procedures					
23. I guide my students to develop conclusions to scientific evidence					
24. I supply scientific questions to be answered by my students					
25. My students find related literature and resources by themselves to develop their investigations					
26. My students identify the variables that they need to control in carrying out investigations					
27. I provide guidelines for students to relate the results of their investigations to make decisions about socio-scientific issues					

Change in Attitudes towards STEM

Dear student,

This questionnaire is prepared to measure the changes, if any, in your attitudes towards Science, Technology, Engineering and Mathematics (STEM) subjects after attending to International Competition "Youth in Action for DAYLIGHTING RIVERS"/ participation in DAYLIGHTING RIVERS learning units. The questionnaire contains a number of statements. You will be asked to evaluate each statement for any change that might have occurred in your attitude.

Please be aware that there are no right or wrong answers. We are interested in your perception.

Also, note that the following information will be kept strictly confidential and that providing us with your personal data is voluntary.

Thank you for your participation.

Daylighting Rivers Team

Your school is... *

Interest in the Subject

Please think about the statements below regarding your interest in each subject before the start of International Competition "Youth in Action for DAYLIGHTING RIVERS" and provide a rating of how your interest in the subject has changed now. Please mark the option which you think best applies to the change you experienced.
P.S. To the dotted lines, the subject (science or mathematics or technology or engineering) comes.

		1- A lot LESS than before	2- A little LESS than before	3- More or less the same (NO	4- A little MORE than before	5- A lot MORE than before
1- I like…	Science					
	Mathematics					
	Technology					
	Engineering					
2- I enjoy learning about…	Science					
	Mathematics					
	Technology					
	Engineering					
3- I am curious about ...	Science					
	Mathematics					
	Technology					
	Engineering					

Perceived Ability

Please think about the statements below regarding your ability in each subject before the start of International Competition "Youth in Action for DAYLIGHTING RIVERS" and provide a rating of how your ability has changed now. Please mark the option which you think best applies to the change you experienced.

		1- A lot LESS than before	2- A little LESS than before	3- More or less the same (NO CHANGE)	4- A little MORE than before	5- A lot MORE than before
4- .... is difficult for me	Science					
	Mathematics					
	Technology					
	Engineering					
5- I am confident about my work in ...	Science					
	Mathematics					
	Technology					
	Engineering					
6- Assigned work in ... is easy for me	Science					
	Mathematics					
	Technology					
	Engineering					

Value

Please think about the statements below regarding your ability in each subject before the start of International Competition "Youth in Action for DAYLIGHTING RIVERS" and provide a rating of how your ability has changed now. Please mark the option which you think best applies to the change you experienced.

		1- A lot LESS than before	2- A little LESS than before	3- More or less the same (NO CHANGE)	4- A little MORE than before	5- A lot MORE than before
7- ... is important to me	Science					
	Mathematics					
	Technology					
	Engineering					
8- It is valuable for me to learn...	Science					
	Mathematics					
	Technology					
	Engineering					
9- I care about...	Science					

	Mathematics					
	Technology					
	Engineering					

Long-term Interest

Please think about the statements below regarding your long-term interest in each subject before the start of International Competition "Youth in Action for DAYLIGHTING RIVERS" and provide a rating of how long-term interest has changed now. Please mark the option which you think best applies to the change you experienced.

		1- A lot LESS than before	2- A little LESS than before	3- More or less the same (NO CHANGE)	4- A little MORE than before	5- A lot MORE than before
10- I am interested in a career involving...	Science					
	Mathematics					
	Technology					
	Engineering					
11- I would like to learn more about...	Science					
	Mathematics					
	Technology					
	Engineering					
12- I wish to continue my education in...	Science					
	Mathematics					
	Technology					
	Engineering					

Change in Career Decision Self-Efficacy

Dear student,

The Change in Career Decision Self-Efficacy scale is a measure of the way you perceive the changes, if any, in your ability to make educational and vocational decisions after attending to International Competition "Youth in Action for DAYLIGHTING RIVERS"/ participating in DAYLIGHTING RIVERS learning units. The scale contains a number of statements. Please evaluate each statement considering the degree to which you agree or disagree with the statement (1- disagree at all; 5- fully agree).

Please be aware that there are no right or wrong answers. We are interested in your perception.

Also, note that the following information will be kept strictly confidential and that providing us with your personal data is voluntary.

Thank you for your participation.

Daylighting Rivers Team

Your school is... *

	1- Not likely	2- Less likely	3- No change	4- More likely	5- Very likely
1- Find information in the library about occupations you are interested in					
2- Select a field of study from a list of potential majors you are considering					
3- Make a plan of your goals for the next 5 years					
4- Determine the steps to take if you are having academic trouble with an aspect of your chosen field of study					
5- Accurately assess your abilities					
6- Select one occupation from a list of potential occupations you are considering					
7- Determine the steps you need to take to successfully complete your chosen field of study					
8- Persistently work at your career goal even when you get frustrated					
9- Determine what your ideal job would be					
10- Find out the employment trends for an occupation over the next 10 years					
11- Choose a career that will fit your preferred lifestyle					
12- Prepare a good resume					

13- Change field of study if you did not like your first choice					
14- Decide what you value most in an occupation					
15- Find out about the average yearly earnings of people in an occupation					
16- Make a career decision and then not worry about whether it was right or wrong					
17- Change occupations if you are not satisfied with the one you enter					
18- Figure out if you need to give up on something to achieve your career goals					
19- Talk with a person already employed in the field you are interested in					
20- Choose a field of study or career that will fit your interests					
21- Identify employers, firms, and institutions relevant to your career possibilities					
22- Define the type of lifestyle you would like to live					
23- Find information about graduate or professional schools					
24- Successfully manage the job interview process					
25- Identify from reasonable field of study or career alternatives if you are unable to get your first choice					