STATE OF THE ART REPORT FOR IMPROVING STEM EDUCATION ACROSS EUROPEAN SCHOOLS

PROJECT ACRONYM:	STEM
PROJECT FULL TITLE:	Improving STEM Education across European Schools
PROJECT NO.:	2020-1-UK01-KA201-078810
FUNDING SCHEME:	Erasmus + KA201 – Strategic Partnerships
COORDINATOR:	AISR

Contents

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Improving STEM Education across European Schools

State of the art report on mapping the current situation regarding challenges of teaching during COVID19, current teaching methods, skills, competencies and best practices in STEM education. Moreover to develop STEM educational materials for STEM teachers to improve their digital skills, competencies and to help them with professional development.

Authors

Dr. Terence McIvor *Academy for International Science and Research, UK*
Zita Bertha *Academy for International Science and Research, UK*
Laura Curran *Academy for International Science and Research, UK*

Contributors

Deepika Nikam *Academy for International Science and Research, UK*

Acknowledgement

We would like to acknowledge the efforts and work of all project partners who contributed to the survey and provided valuable feedback on the results.

The state of the art report is available at: www……..

May 2021

Project title: *Improving STEM Education across European Schools*
Project number: *2020-1-UK01-KA201-078810*
Project lead: *Zita Bertha, Academy for International Science and Research, UK*

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Section 1 – Abstract

Introduction
The following State of the Art Report (SoAR) is based on a survey completed by STEM teachers across Europe as part of the Erasmus Plus Strategic Partnerships for school education project titled "Improving STEM Education Across European Schools (STEM)" project number 2020-1-UK01-KA201-078810.

Six project partners from the United Kingdom, Turkey, Italy, Romania, Belgium and Greece are taking part in this two year project. The survey is aimed at STEM teachers with students from an age range of 7-19 years old. Its purpose is to collect information about challenges of teaching, current teaching methods, skills, CLIL methods, competencies, digital skills, resources available and best practices in STEM education. Below is the summarised report. The aim is to draw on best practices, new initiatives, and usable tools for STEM educators.

This state of the art report reflects opportunities for the development of STEM teaching and digital education competences for STEM educators at the European level. It also identifies strategies and makes recommendations for progressing this important area of learning. It has to be noted that the data provided does not claim to be complete, neither presents an empirically grounded research, but it presents a snap-shot of STEM professional development opportunities. The project partners will develop lesson plans and e-learning modules for STEM teachers based on the recommendations.

About the survey
The total number of participants is 198, from teachers residing and teaching in the UK, Turkey, Italy, Romania, Belgium and Greece. The information is gathered through the teachers' emails, which will not be provided, due to GDPR regulations, instructed prior to sending of the survey.

AISR has developed this report based on the survey results and on statistical analysis.

The results were carefully gathered and analysed to provide the following information:

The main research topics that will be analysed are defined as follows:

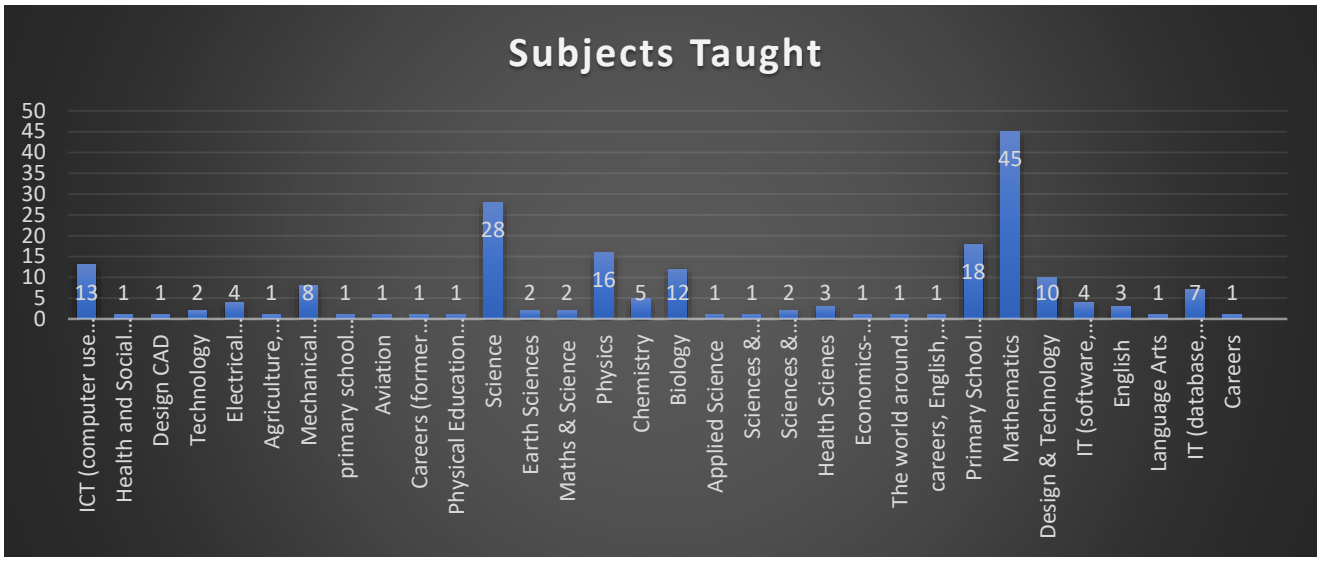
- the problems/constraints faced by teachers in classrooms regarding: the current perception and awareness of teachers on STEM education,
- STEM education by means of STEM activities, STEM lesson plans, materials, strategies, etc.
- the kind of support teachers need regarding knowledge;
- the kind of support teachers need regarding skills and competences;
- the kind of solutions teachers use in everyday situations which may be promoted as good practices.

Project Partners
Academy for International Science and Research (UK)
UC LIMBURG (Belgium)
21.YY Egitimciler Dernegi (Turkey)
VITALE TECNOLOGIE COMUNICAZIONE - VITECO SRL (Italy)
INSTITUTE OF ENTREPRENEURSHIP DEVELOPMENT (Greece)
Scoala Gimnaziala Gheorghe Magheru Caracal (Romania)

Section 2 – STEM Class Information

1. **Please provide information on your main STEM class that you teach.**

   The most common STEM class taught was Mathematics. Sciences including Physics and Biology were also frequently selected as a main STEM Class.



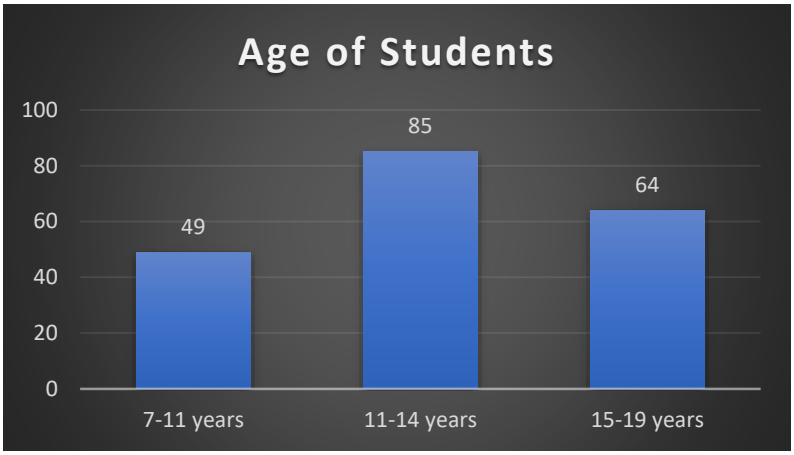
2. **If your subject was not listed in question 1. or you teach combined subjects, please state your answer here. If you teach medicine or veterinary related subjects, please state the level and the exact name of the course.**

   Listed below are the subjects taught outside of the subjects stated in Q1:

   - Astronomy
   - Aviation
   - Computer science
   - Combined science
   - BTEC Applied science (A level)
   - Construction
   - math, biology, earth science
   - Chemistry
   - Science and Technology
   - Home Economics, Hospitality, child care
   - Maths & Sciences
   - Support
   - Logical-mathematical primary school (Mathematics, Sciences, Technology)
   - Mathematics - Technology - STORIA - GEOGRAFIA
   - Sciences and Mathematics
   - Design CAD
   - Sciences-Mathematics-Technology

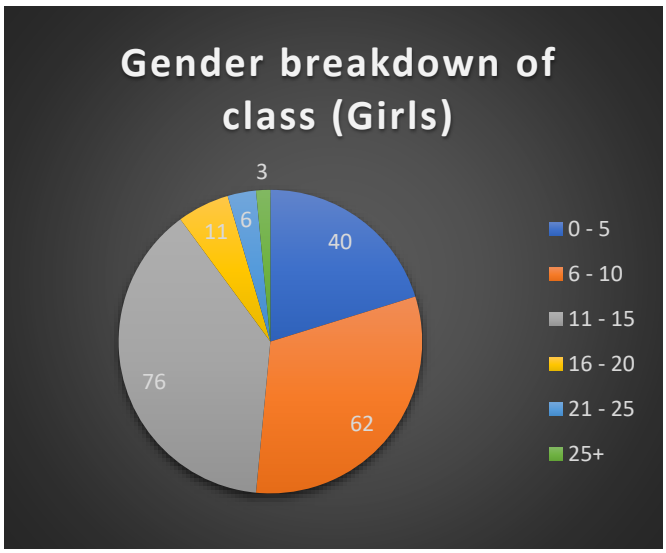
3. Age of students

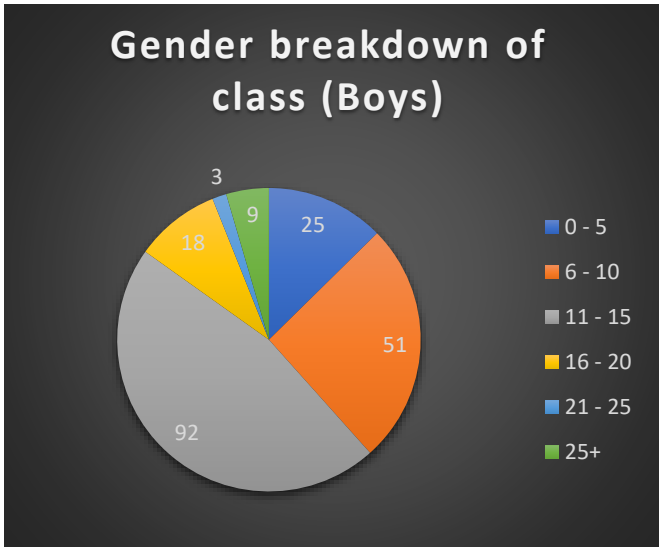
Out of the 198 responses, teachers who stated they teach more than 1 STEM subjects, the majority, 85 of them, teach 11 to 14 years old students:



4. Gender breakdown of class

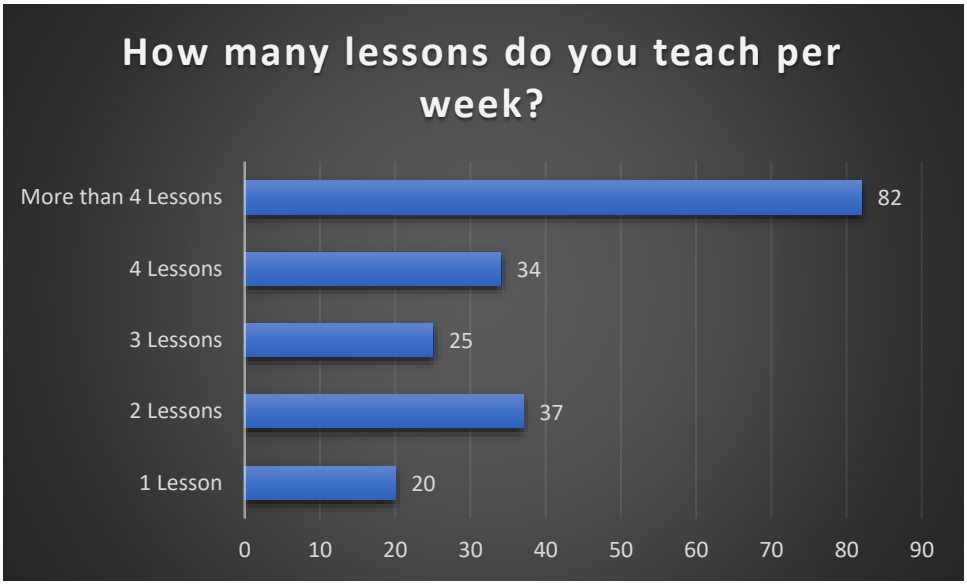
The following chart shows the gender and age breakdown of those STEM classes, which are taught by those 198 teachers, who stated they teach STEM subjects:





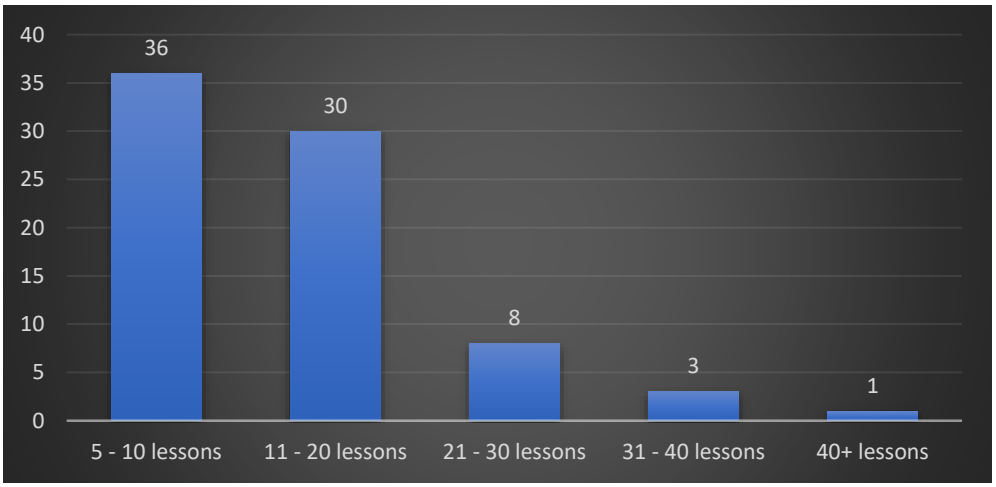
5. **How many lessons do you teach per week?**

The responses to this question show that the majority teach more than 4 lessons per week. 85 of the teachers responded as more than 4 lessons out of the 198 participants.



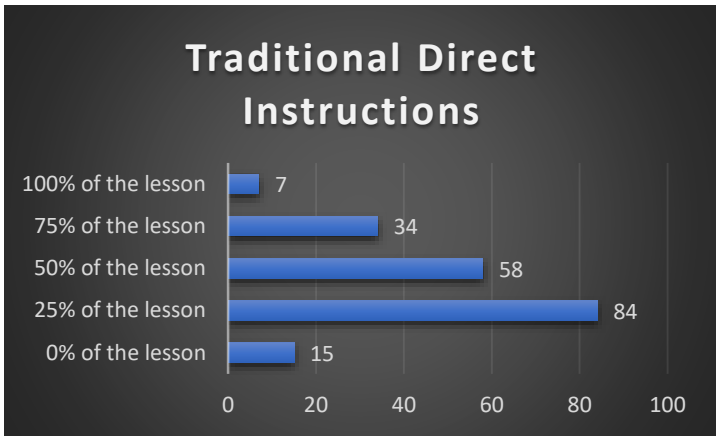
6. **If you teach more than 4 lessons per week please state the number below.**

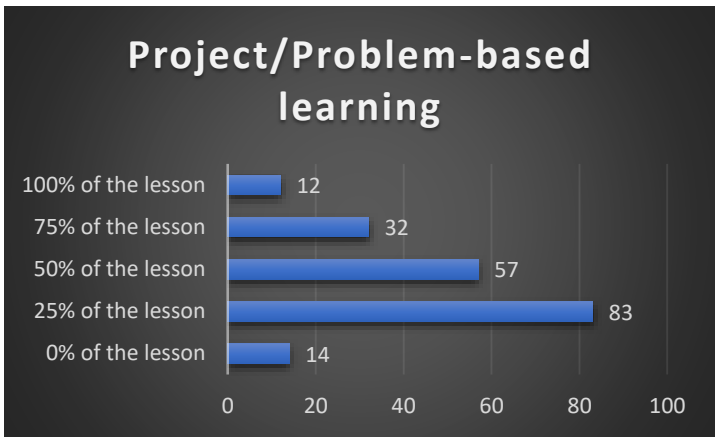
Out of the 78 responses it was shown that the majority of teachers teach 5-10 lessons per week. Lesson numbers upward of 21+ are less common.

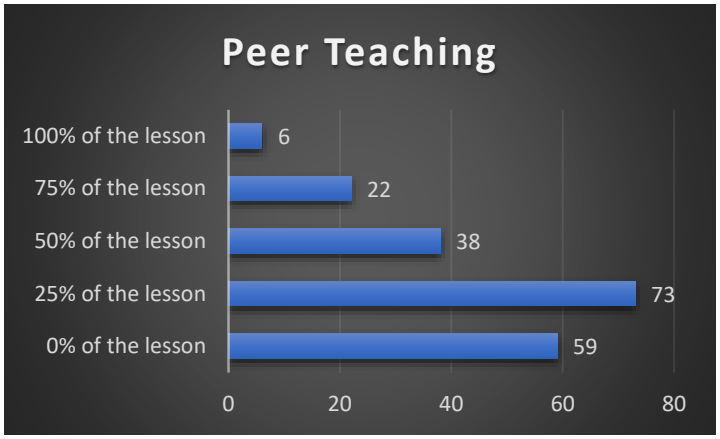


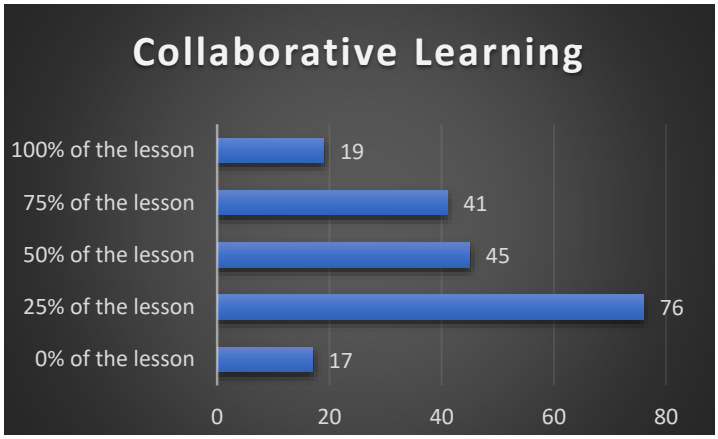
7. **Which of the following pedagogical approaches do you use in your STEM class? On average, how much time do you spend on them? Click as many as applies, the percentages refer to the average time you usually spend on a particular approach, thus these classroom methodologies are not additive, they are discrete and should not be amalgamated. As it is unlikely that in any one lesson a teacher would deploy all of the following methodologies**.

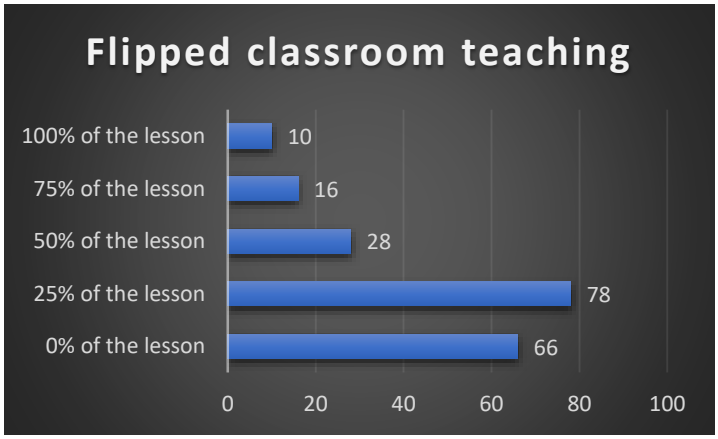
Most of the responses suggest that 25% of the time per lesson is spent in the following classroom methodologies shown in the headers of each graph.
Flipped classroom teaching and game-based learning have shown to be less popular methods of teaching, 33% of respondents do not use Flipped Classroom methodology and 29% do not use Game based learning and Peer Teaching at all.

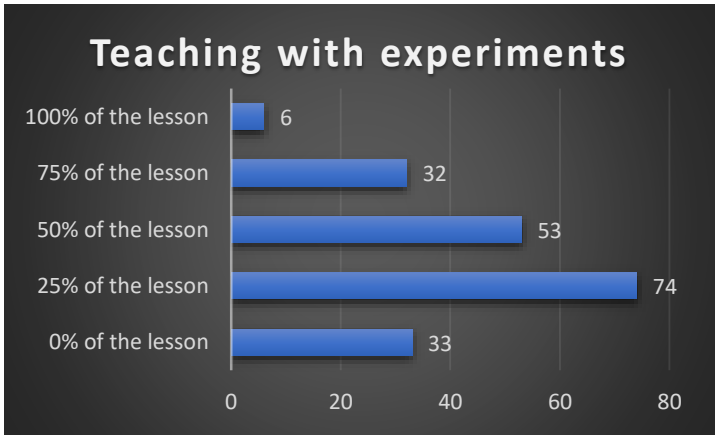












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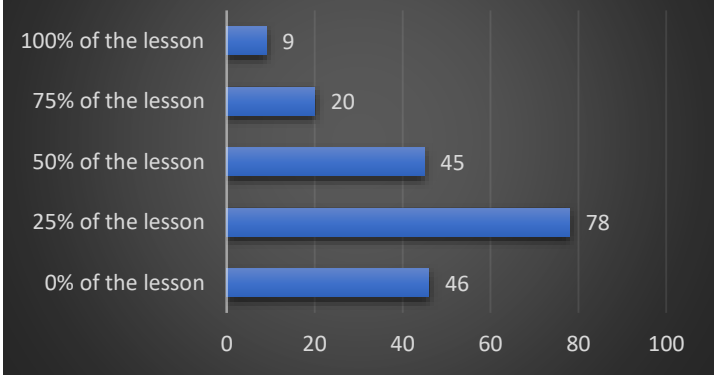
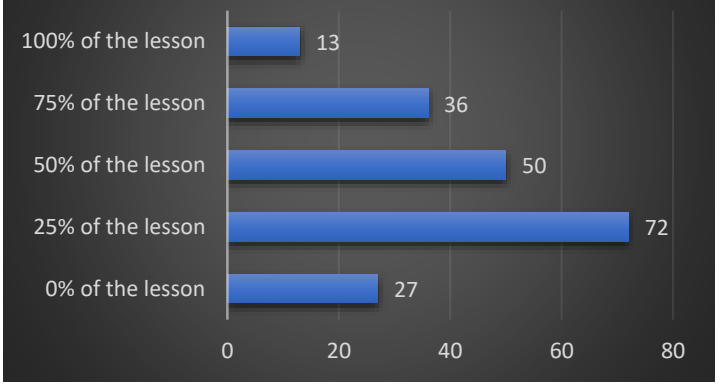
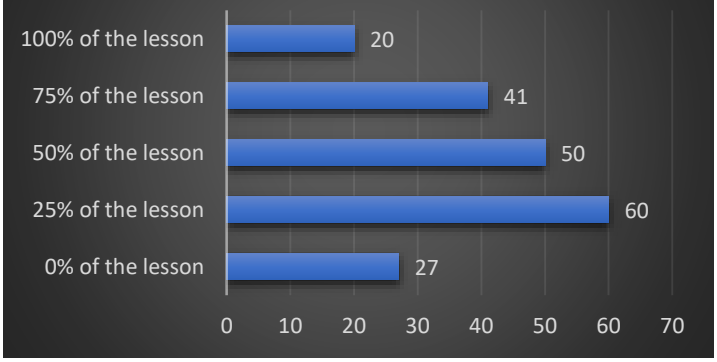
Inquiry-based learning



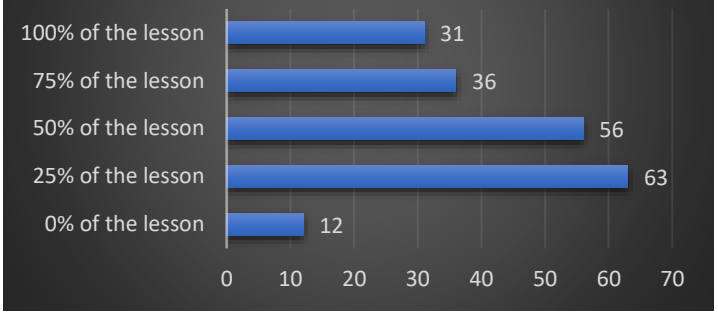
Differentiated Instruction



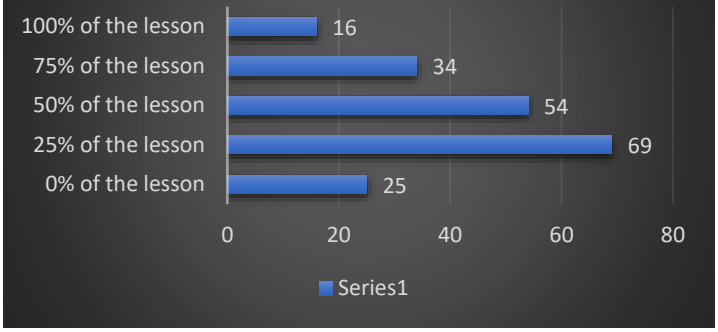
Integrated Learning



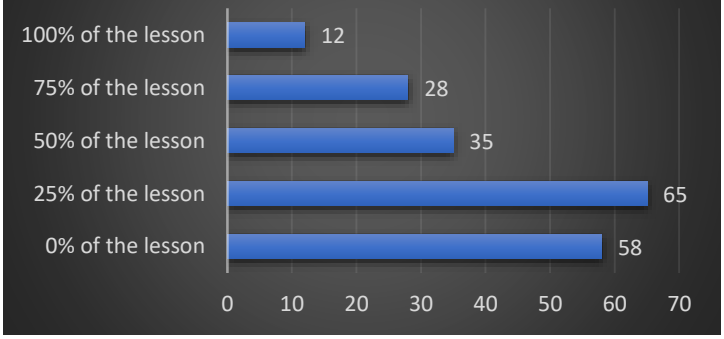
Formative Assessment (incl. self assessment)



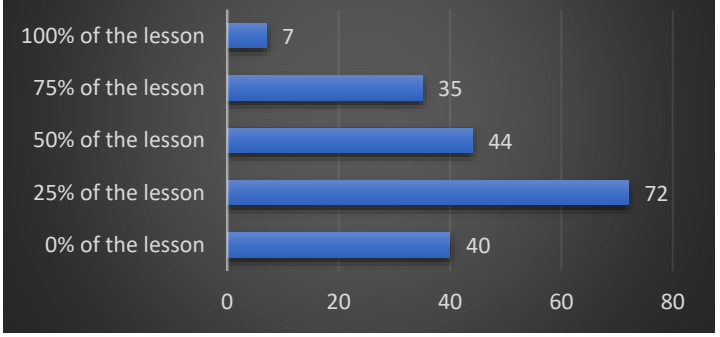
Summative Assessment



Game based learning



Personalised Learning



The responses regarding the use of problem based learning for 25% of the lesson was slightly higher as opposed to inquiry based learning. Inquiry based teaching is more demanding for the students as they have to decipher the problem from a case study and then solve the problem that they have found by analysing the said study. This is a multi-faceted approach and should be used for about 75% of the lesson as opposed to 25% which most of the participants stated. The reasons could be that teachers may not fully appreciate the difference between the various teaching methods.

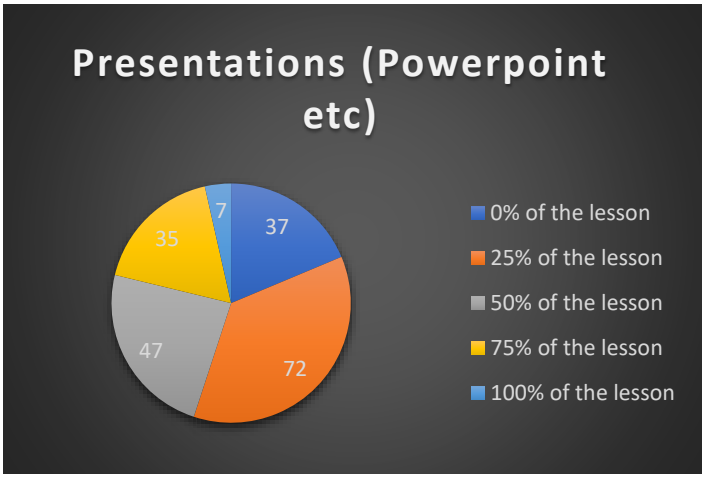
There is a further breakdown for each country in Annex II. Q.7. regarding Traditional Direct Instructions, as one of the most used teaching methodologies.

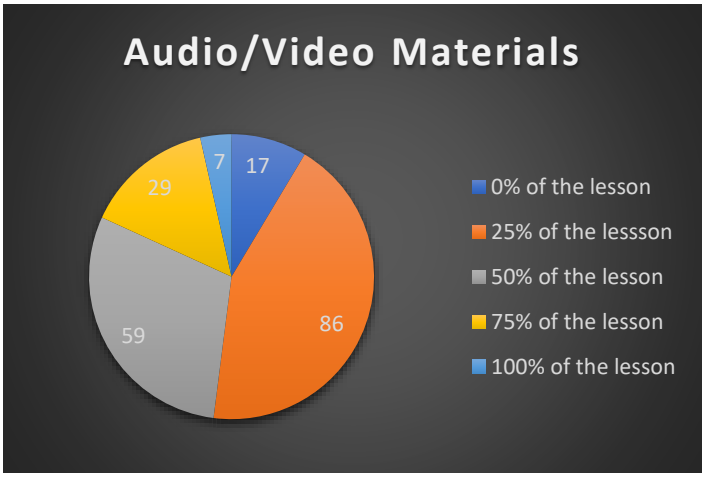
Project/problem based teaching methodology seemed to be the most popular type, and most of the teachers use it for 25% of the lesson. There is a further breakdown for each country in Annex II. Q. 7. Project/problem based teaching methodology.

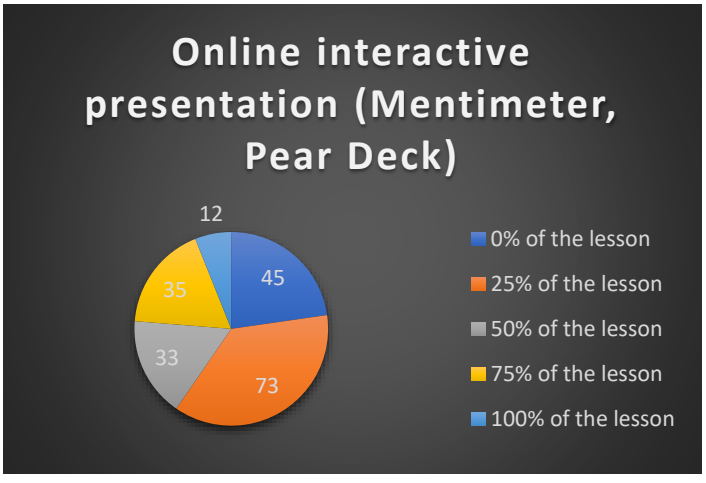
A similar breakdown can be found in Annex II. Q.7. regarding *Teaching with experiments*.

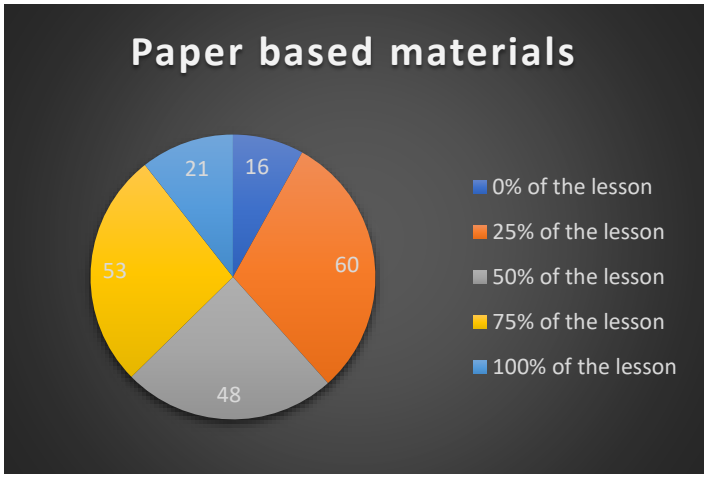
8. **Which learning resources do you use when teaching a face-to-face STEM class and to what extent do you use such resources?**

Out of the 198 responses to this question it shows that Robots and/or boards (e.g. aurdino, micro:bit) are the least used methods of learning resources with 113 of the teachers spending 0% of the lessons with this resource. The most popular methods of learning have shown to be Audio and Video and Web/Computer based simulation with an average of 40% of the teachers spending 25% of the lesson using these resources. There is a further breakdown for each country in Annex II. Q. 8. Audio/Video Materials and Web/Computer based simulation.









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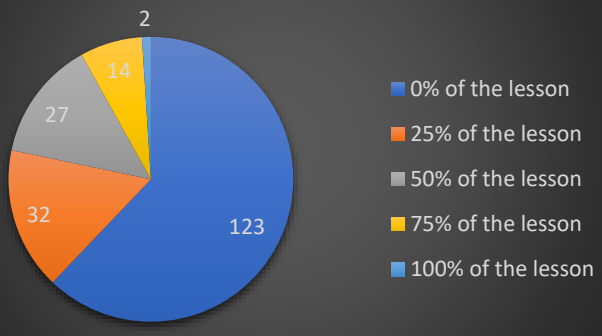
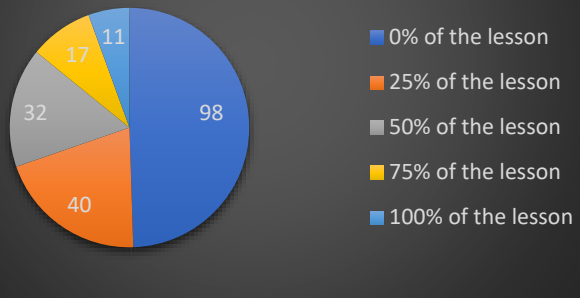
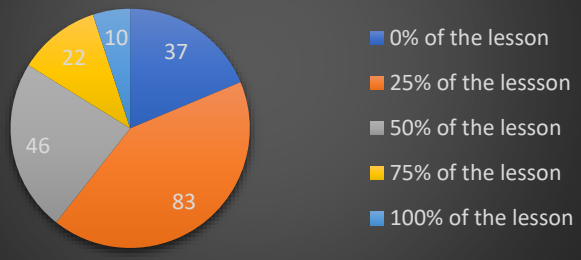
Sensors



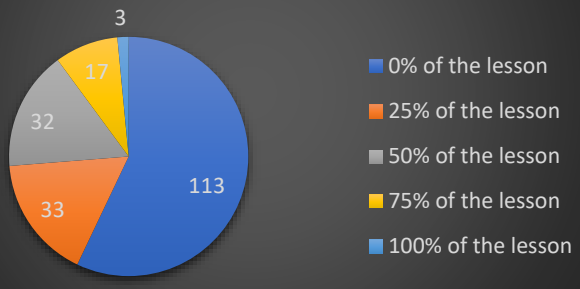
STEM specific software (eg: geogebra)



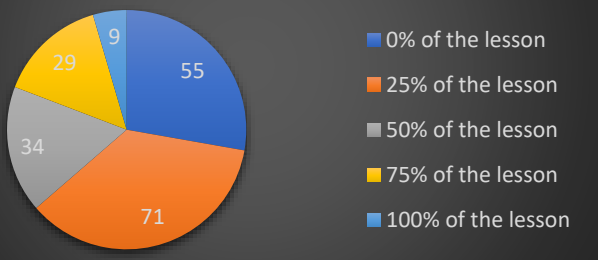
Web/Computer based simulation



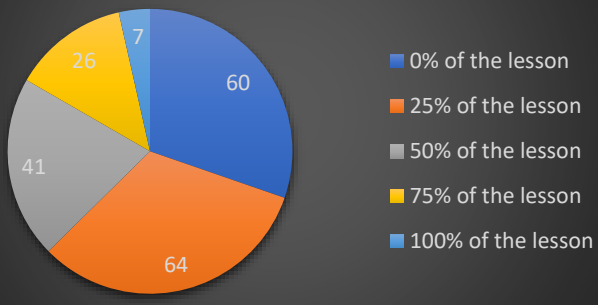
Robots and/or boards (eg: aurdino)



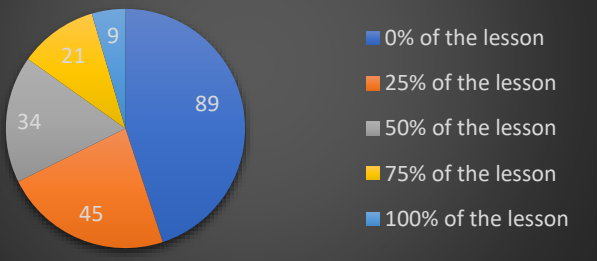
Resources for personalised learning



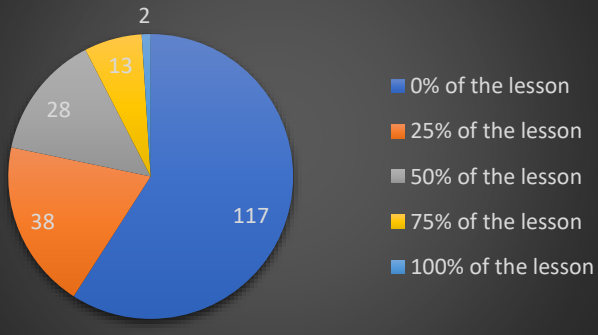
Lab Experiments

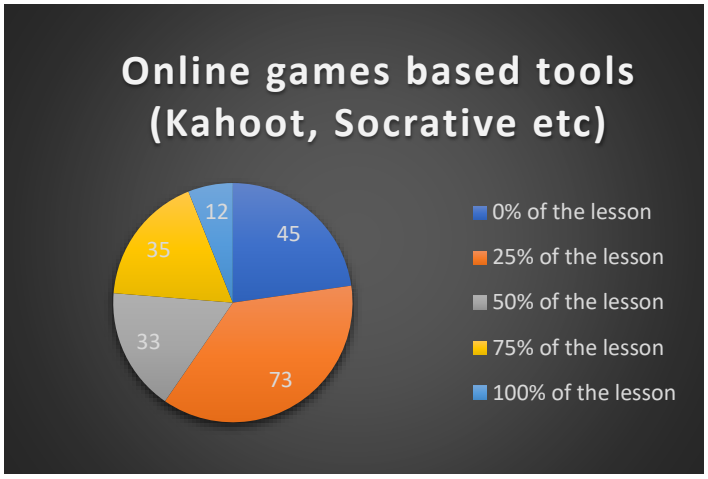


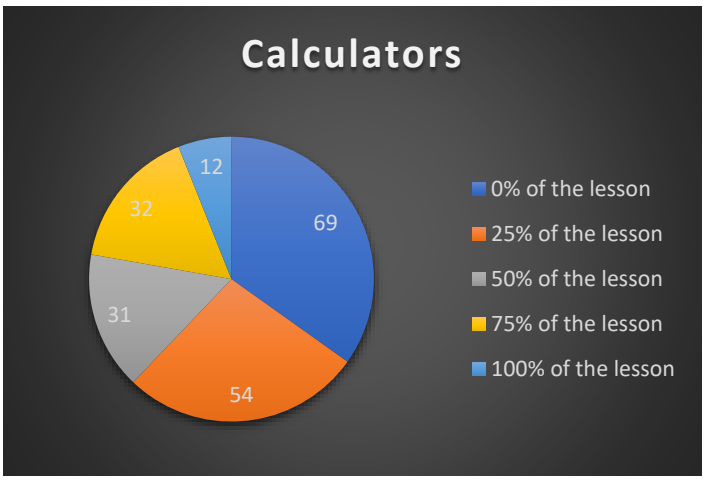
Resources for special needs learners

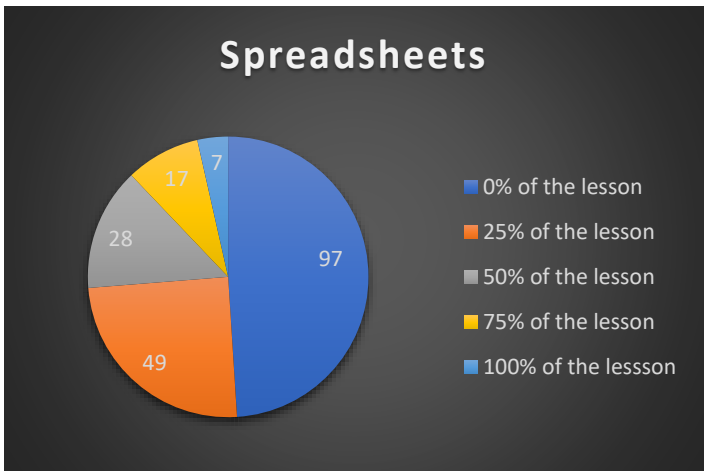


Graphing Calculators









28% of the responses state that they do not use any resources to implement personalised learning for example game-based learning systems, which allow students to learn at their own individual pace, and have fun while doing it. Personalised learning normally involves students in deciding their own learning process, which teaches the students vital skills that will serve them throughout their lives. For example:

- Sharing in goal-setting helps students develop **motivation and reliability**
- Engaging in self-assessment helps students develop **self-reflective abilities**
- Determining their best learning activities helps students develop **self-advocacy skills**

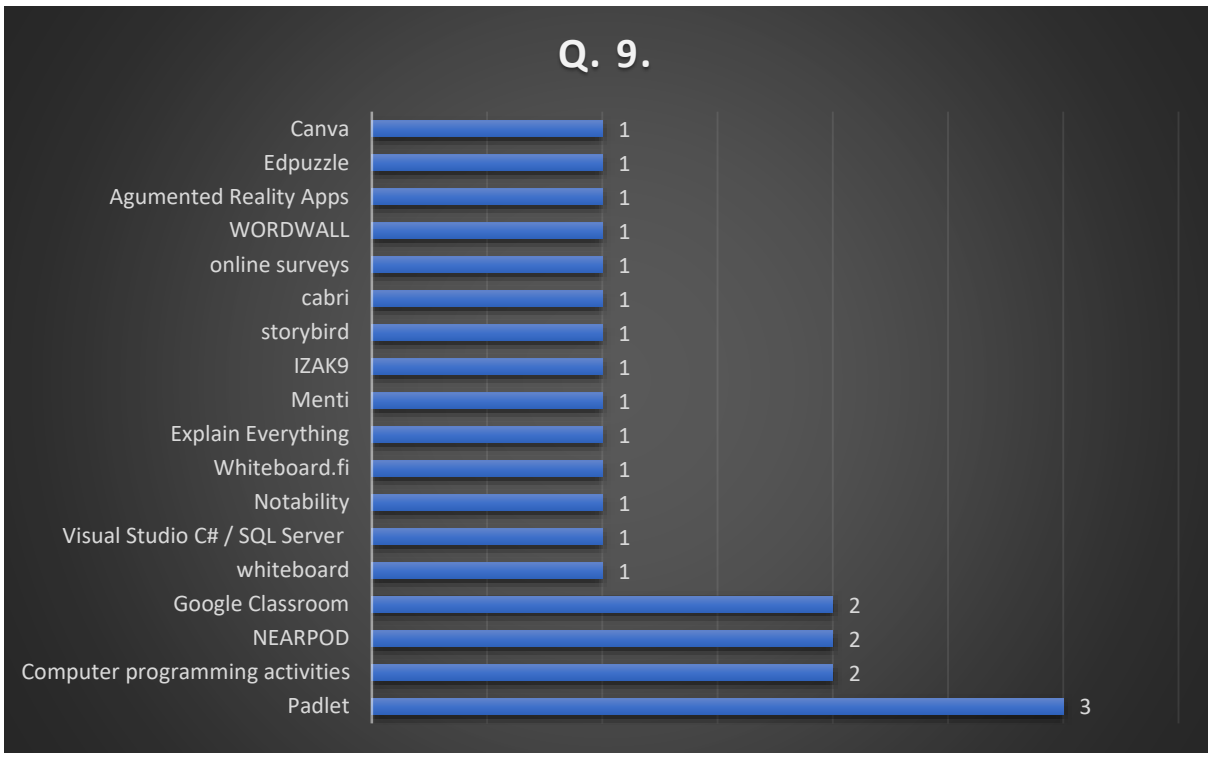
Based on research, students in a personalised learning environment improve their knowledge significantly. In one study by the Gates Foundation, using personalised learning to supplement math instruction substantially improved students' test scores. The average scores of students in the study went from far below the national average to exceeding the national average.

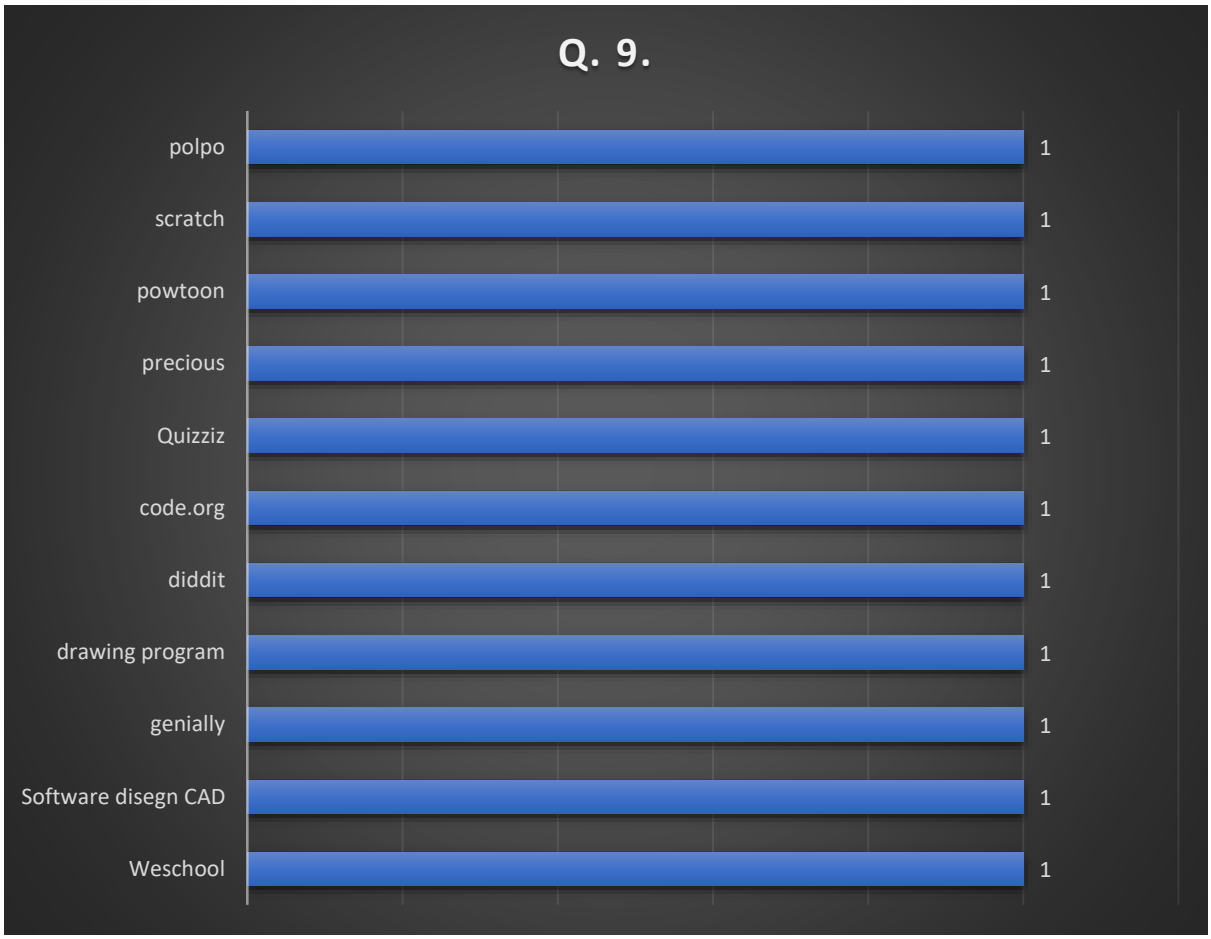
23% of responses stated that they do not use online game based tools such as kahoot or socrative. The positive impact of using Kahoot! in the classroom isn't limited to grades or test scores. A multitude of studies illustrated how Kahoot! improved classroom dynamics and created a safer, more positive learning environment.

Studies reported that classes using Kahoot!—especially those that used it often—saw **increased attendance, student participation, engagement, motivation,** as well as interaction between students and teachers and students and peers.

9. If you use any other resources or wish to elaborate on your resources, please use the box below

19 teachers out of the 198 stated the name of the resources they use. Padlet was the most mentioned tool, followed by Nearpod, Google Classroom and Computer programming activities.





10. **Which of the following learning resources do you use when teaching STEM lessons online, and to what extent do you use these resources? Click as many as applies, the percentages refer to the average time you usually spend on a particular resource, thus these classroom resources are not additive, they are discrete and should not be amalgamated. As it is unlikely that in any one lesson a teacher would deploy all of the following resources.**

Out of the 198 responses to this question it shows that Robots and/or boards and sensors are the least used methods of learning resources with over 70% of teachers stating they spend 0% of the lesson using Robots/boards. The most popular methods of learning has shown to be Audio and Video with 44% of teachers spengin a quarter of their lessons using this resource. There is a further breakdown for each country in Annex II. Q. 10. Audio/Video Materials, Robots/Boards and Online game based tools (Kahoot, Socrative etc.).

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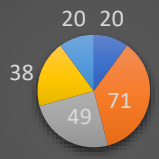
Presentations (Powerpoint etc.)

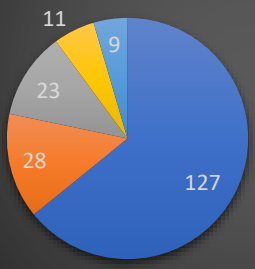


0% of the lesson
25% of the lesson
50% of the lesson
75% of the lesson
100% of the lesson

Audio/Video Materials

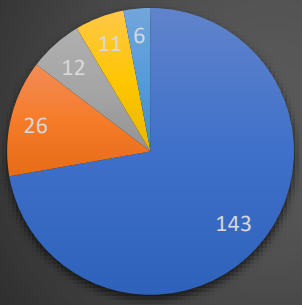
0% of the lesson
25% of the lesson
50% of the lesson
75% of the lesson
100% of the lesson

Robots and/or boards (eg: aurdino)



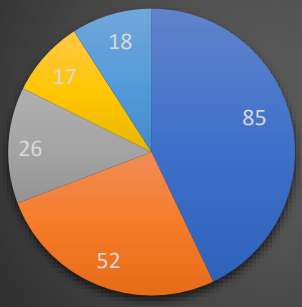
0% of the lesson
25% of the lesson
50% of the lesson
75% of the lesson
100% of the lesson

Sensors



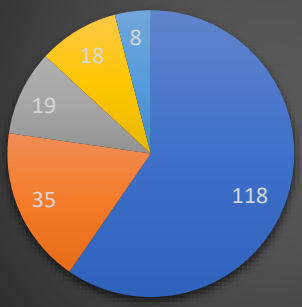
0% of the lesson
25% of the lesson
50% of the lesson
75% of the lesson
100% of the lesson

Calculators



0% of the lesson
25% of the lesson
50% of the lesson
75% of the lesson
100% of the lesson

Graphing Calculators



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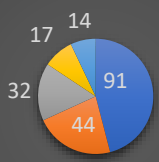
STEM specific software (eg: geogebra)



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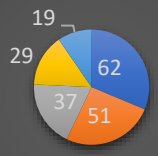
Online games based tools (Kahoot, Socrative etc)



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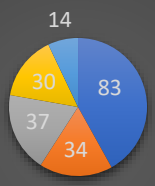
online interactive presentation (Mentimeter, Pear Deck etc)



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Resources for special needs learners

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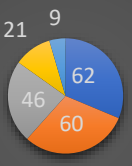
Resources for personalised learning



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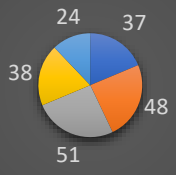
Online collaborative tools (Padlet, One Note, Google Docs/Forms etc)



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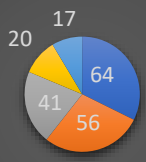
Ready made lessons available online



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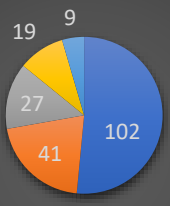
Spreadsheets



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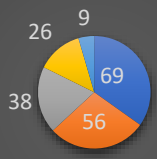
Web/computer based stimulation



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100% of the lesson

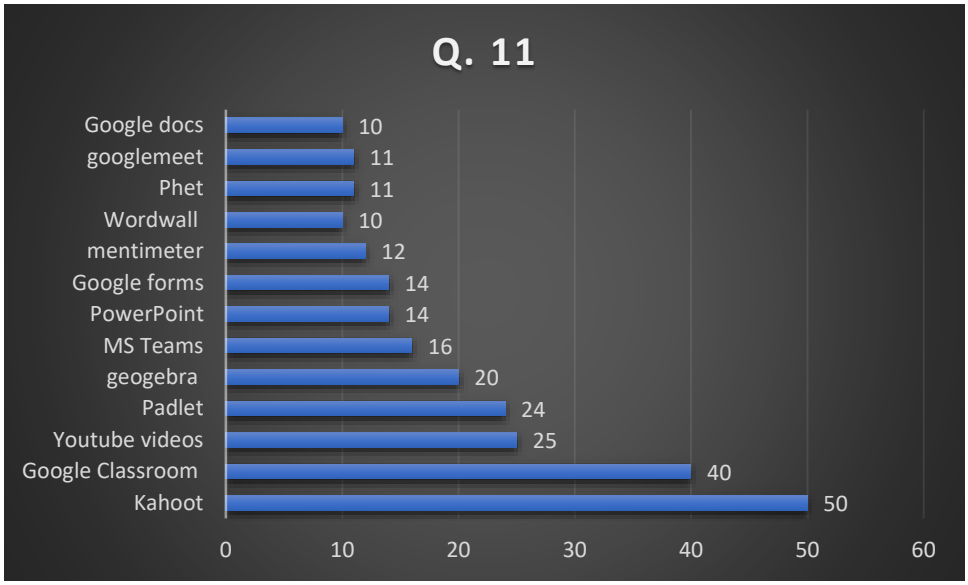
25% of the teachers do not use any interactive presentations such as peardeck while teaching online and 29% do not use any online game based tools such as kahoot. 16% of the teachers stated that they do not use any online collaborative tools such as google forms or OneNote.
The number of teachers who do not use robots/boards grew fom 57% to 64% compared to face-to-face and online learning. This could be caused by budget issues in terms of studens are not provided with robots/boards during the pandemic while learning from home.

69% of teachers used lab experiements when teaching face-to-face, which was not possible to deliver during the pandemic due to school closures. It was expected to find more teachers engaging with online simulations, however, the 81% of teachers who used online simulations when teaching face-to-face dropped to 65% when teaching online.

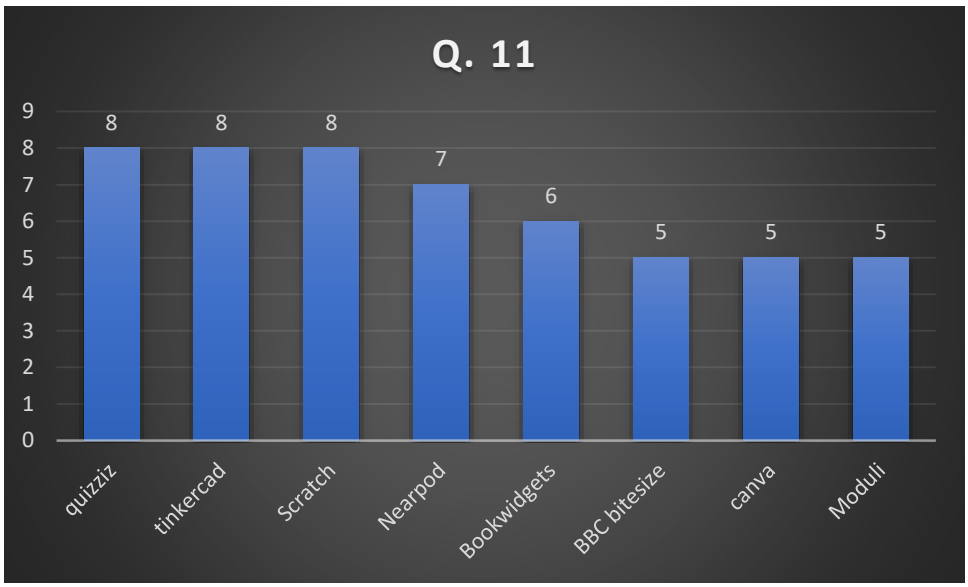
35% of teachers do not use any ready made lessons available online and the majority of the respondents (30%) who implement such resources into their lessons, stated that they only use them for 25% of the class.

11. Please list 3 of your favourite online tools/apps/platforms that you use in your STEM class:

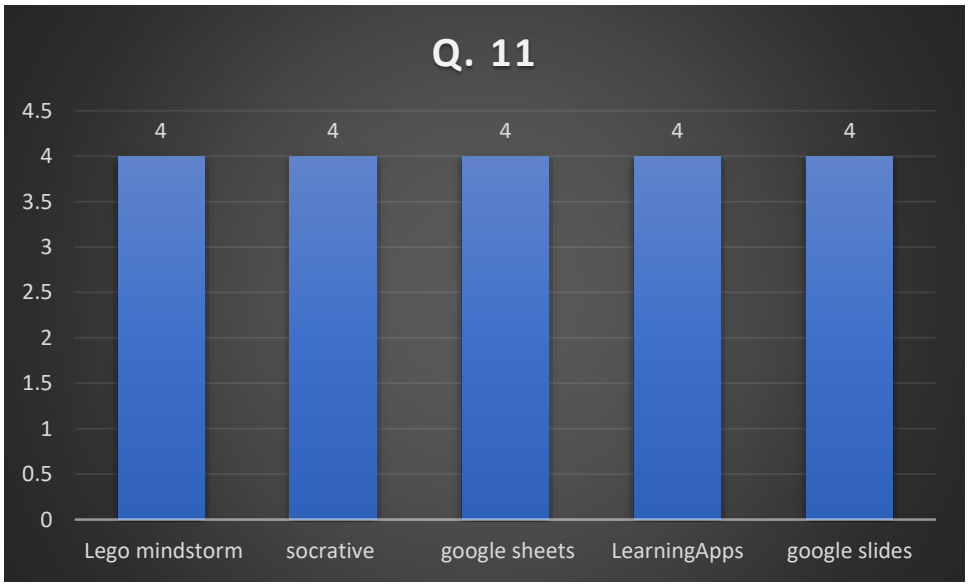
The following chart represents the most popular online tools/apps/platforms that are used in 187 of the responders' STEM classes:

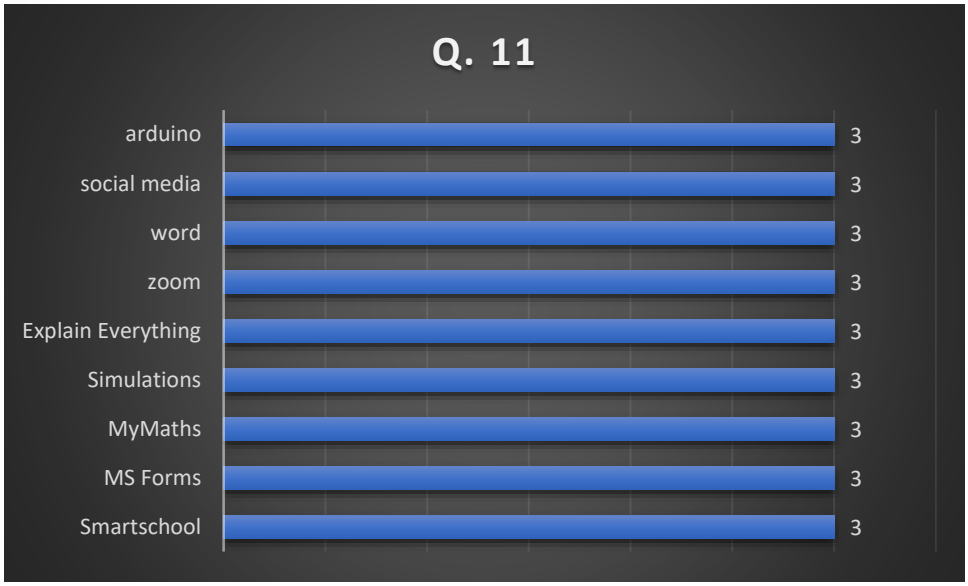


Between 5 and 8 teachers stated that they use the following online tools:



Between 2 and 4 teachers stated that they use the following online tools:

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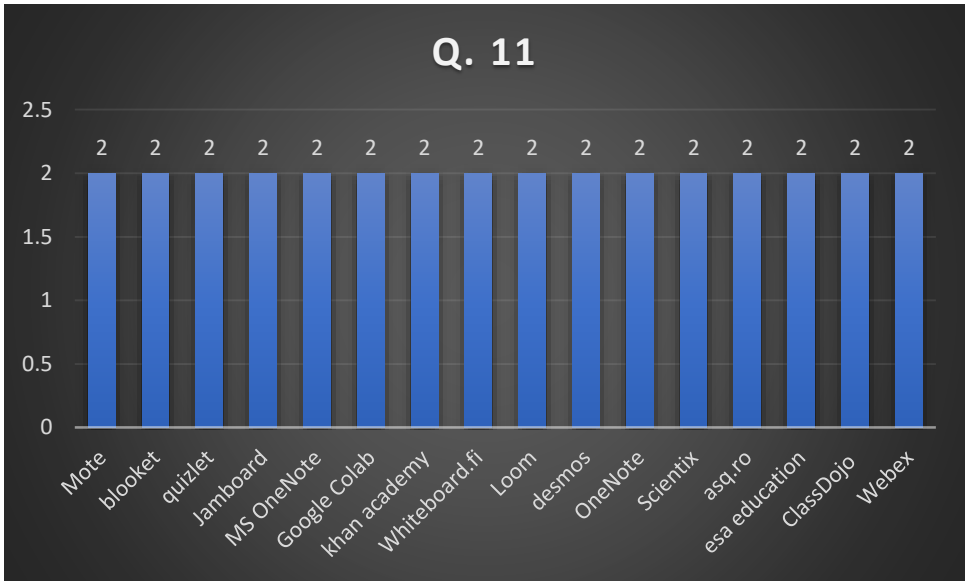
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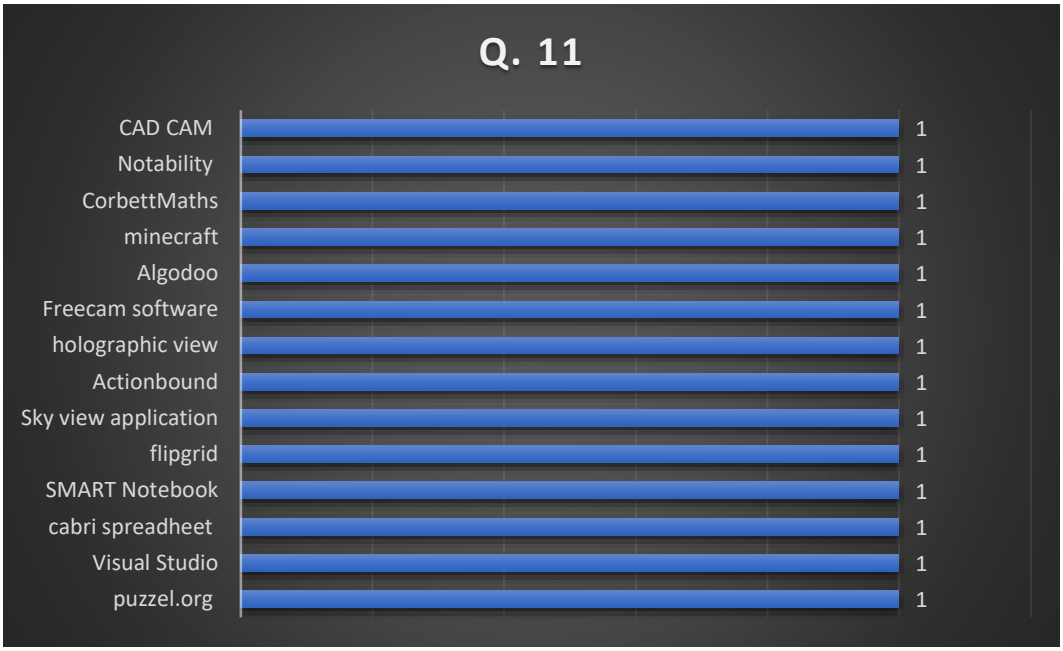
quizlet
Jamboard
MS OneNote
Google Colab
khan academy
Whiteboard.fi
Loom
desmos
OneNote
Scientix
asq.ro
esa education
ClassDojo
Webex

Another 126 online tools were mentioned only once. The following chart shows a selection of these online tools:

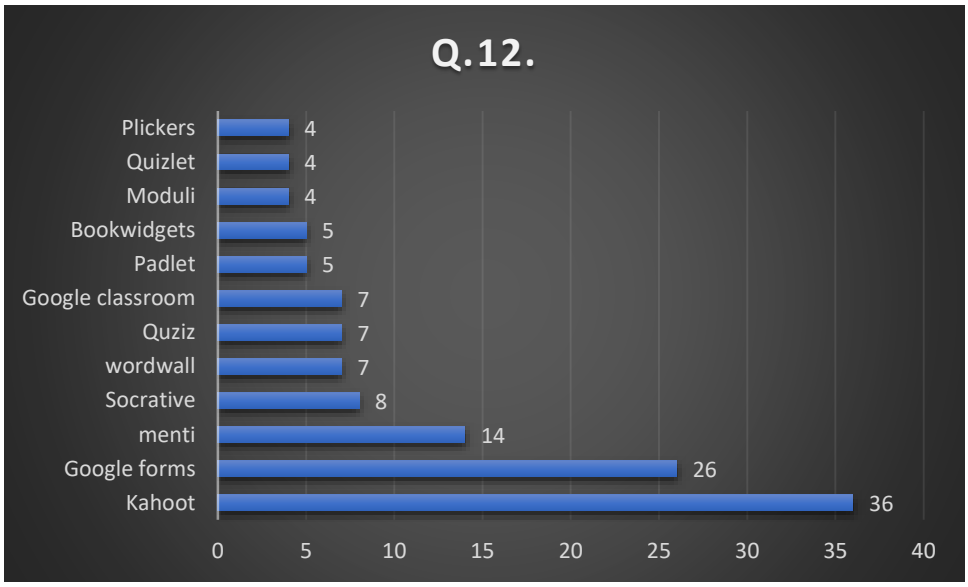


Other tools include:

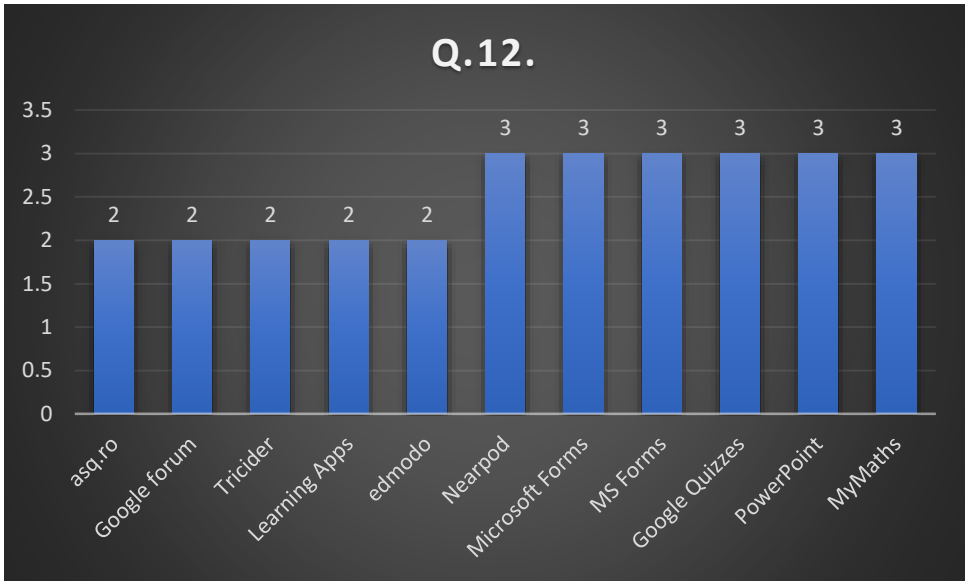
- puzzel.org
- Visual Studio
- cabri spreadsheet
- SMART Notebook
- flipgrid Sky view application
- Actionbound
- holographic view
- Freecam software
- Algodoo
- CorbettMaths
- Notability
- CAD CAM etc.

12. Please list 3 of your favourite online summative e-assessment tools/apps. If not applicable, please type N/A:

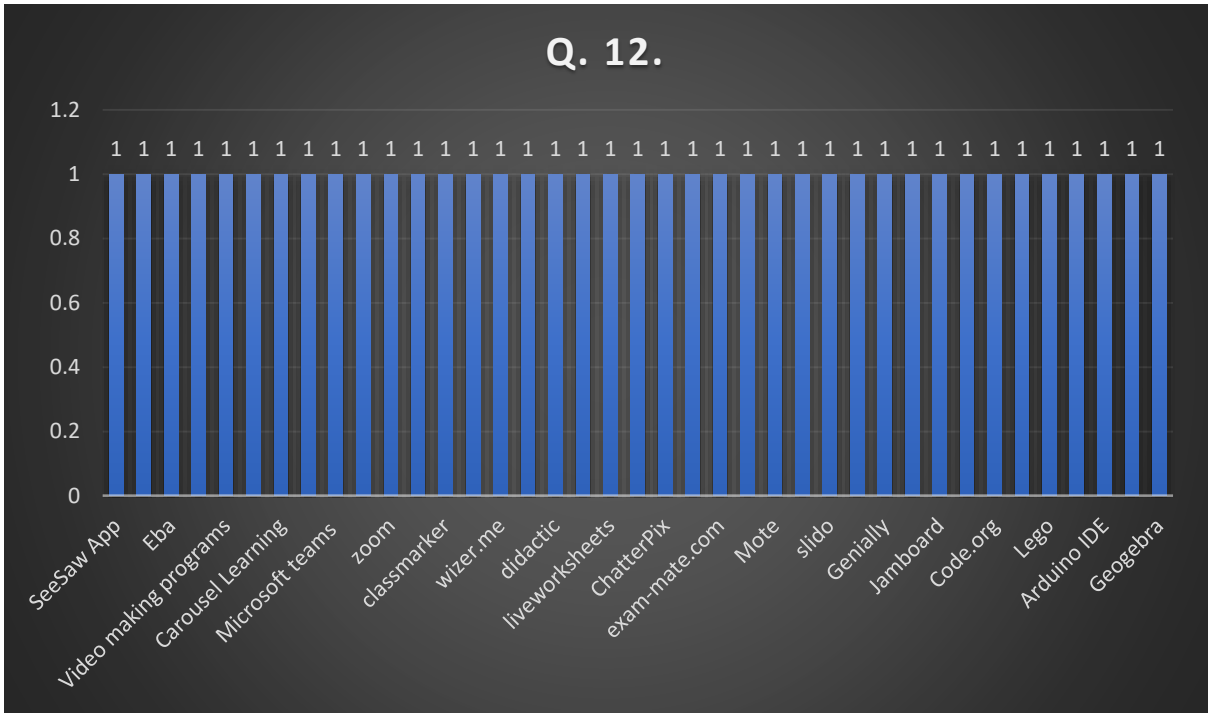
The following chart represents the most popular online summative e-assessment tools/apps mentioned by 104 teachers:



Between 2 and 3 teachers stated that they use the following online assessment tools:



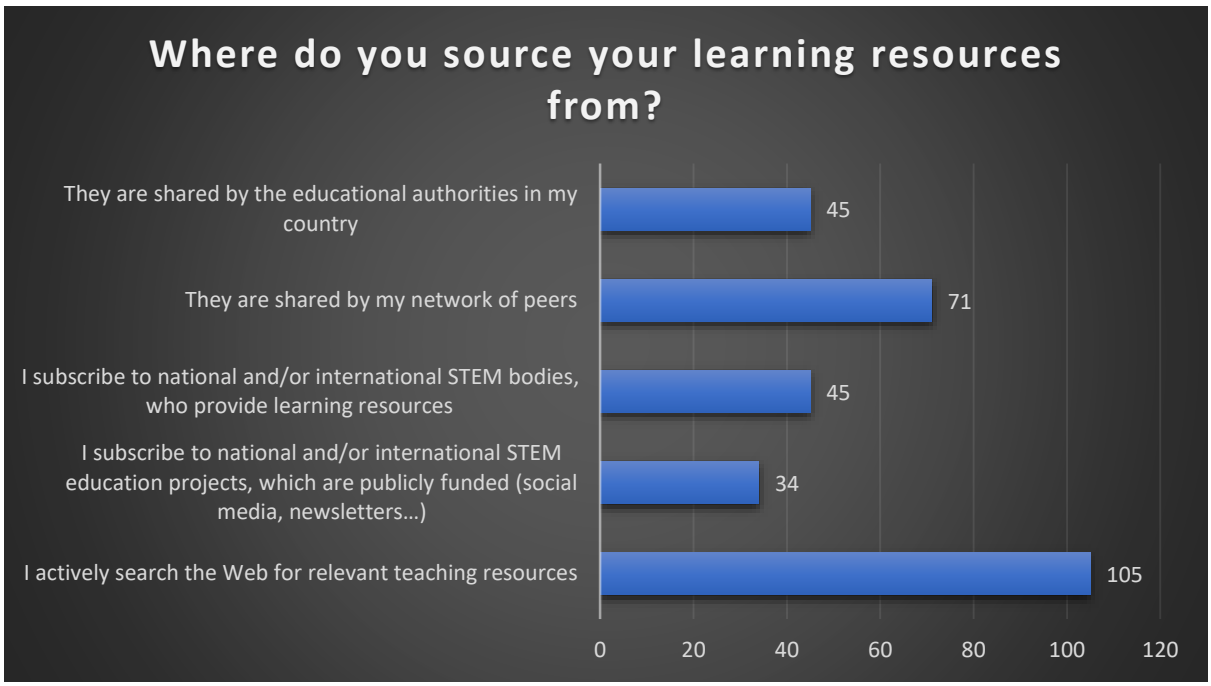
Another 39 online assessment tools were mentioned only once. The following chart shows a selection of these online tools:



Section 3 – Your STEM Teaching

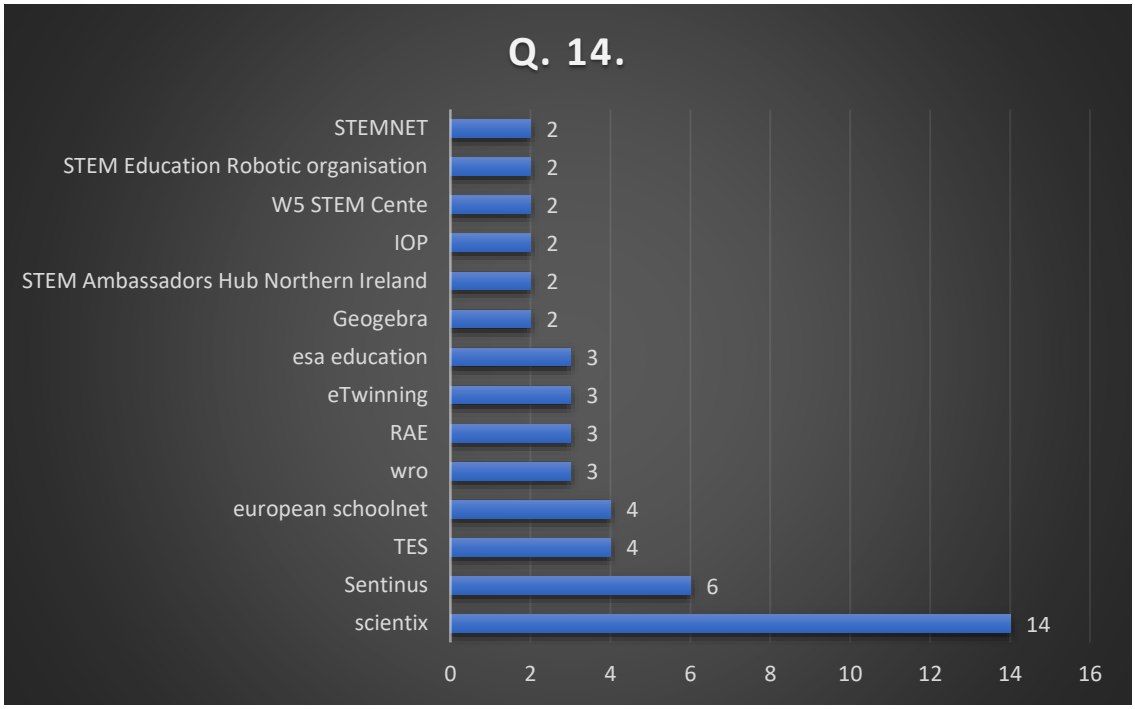
13. Where do you source your learning resources from?

The most commonly used source that responders used was actively searching the web for relevant teaching resources followed by sourcing materials from a network of peers. From the feedback we received there seems to be a scarcity of learning resources for the schools with 23% saying that learning resources are shared by their education authority and 53% are actively searching the web.



14. Which national and/or international STEM Education projects resources do you subscribe to? If not applicable, please type N/A:

65 people responded out of the 198 survey participants. The following chart shows the various STEM Education project resources the responders subscribe to:



Another 54 resources were mentioned:

- First Tech Robotics Competition
- Royal Society Partnerships
- STEM PD Community of Practice
- STEM Teacher İnstitutes
- Teachit Science
- CCEA STEMWORKS
- CAS
- Isaac CS
- BP
- FCL
- NASA
- Jet Laboratory
- ISS
- Maytal from CreateCodeLoad
- ESERO
- RED
- Educația on line
- Tinkercade
- desmos
- symbolab
- STEM Learning
- Phet
- mozaweb.
- spongelab
- sciencebuddies
- ASE
- National Pace Academy
- Raspberry Pi
- Stem UK
- STEPS
- Neon Futures
- NI Teachers group
- Climate change
- Integrated Stem teaching for primary school
- Junior Achievement
- Nessuno
- Redazione digitale
- Steam powered family
- Progettare il Futuro
- Safer Internet Stories
- Brightlab
- klascement
- technopolis
- T2 campus
- lerend netwerk techniek
- iSTEM project
- iMuscica
- Newsletters
- E-learning EKPA
- Organization of Educational Robotics, Science, Technology and Mathematics
- Frontiers
- Science on Stage
- Amgen teach

CAS – Computing at School

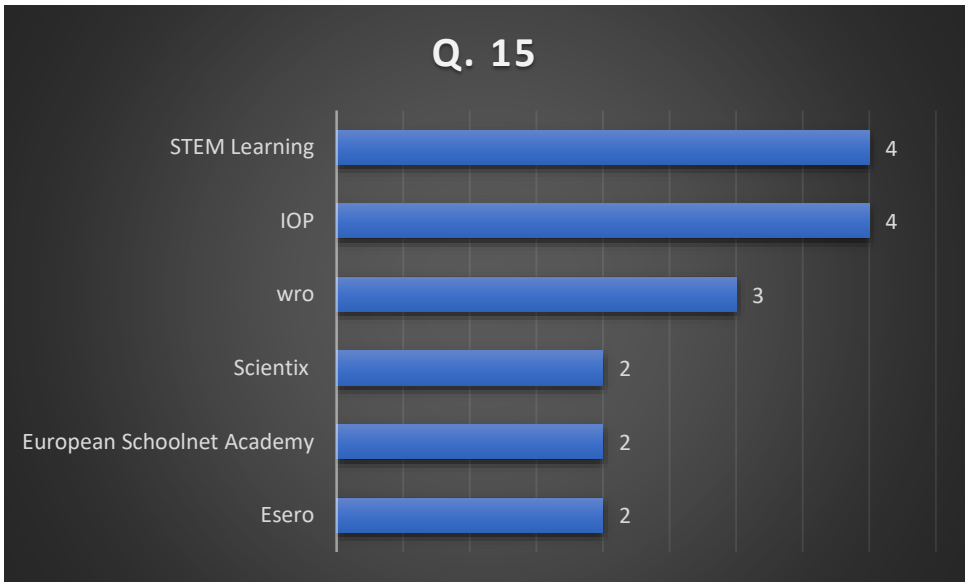
ESERO – European Space Education Resource Office

FCL – Future Classroom Lab

ASE – Association for Science Education

15. Which national and/or international STEM bodies do you subscribe to? If not applicable, please type N/A:

52 responses received out of the 198. The following chart shows the most popular STEM bodies responders subscribe to:



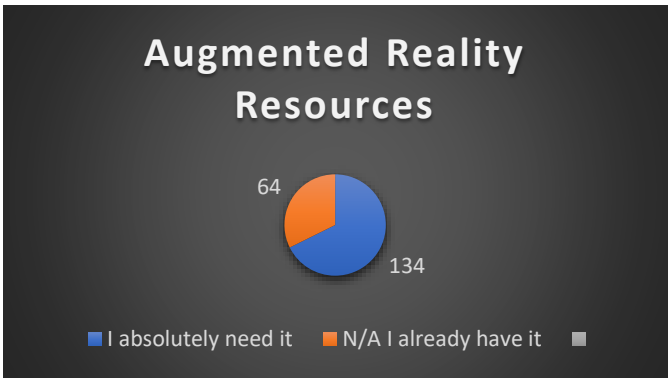
Another 31 STEM bodies were mentioned by the 52 responders once:

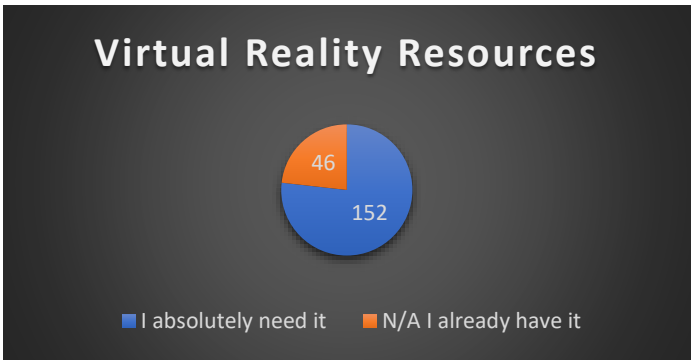
- Nasa STEM
- MoNE curriculum
- ASE
- National Space Academy
- Computer Science Teacher Association of Ireland
- Association for Science Education
- Technology and Design Home Learning
- Turkish STEM educators association
- W5 STEM Center
- Royal Society
- Stem oğretmen enstitüleri
- RSC
- CAS
- Nessuno
- INDIRE
- Techniek is fun
- Veel nemo, technopolis, stem, micropia, instructzbles
- T2 campus
- the yposthrizetai
- phet
- mozaweb.
- spongelab
- sciencebuddies
- STEM Education Robotic body
- BP
- CITB
- IET
- SSMR
- asq
- Resource software mathematics

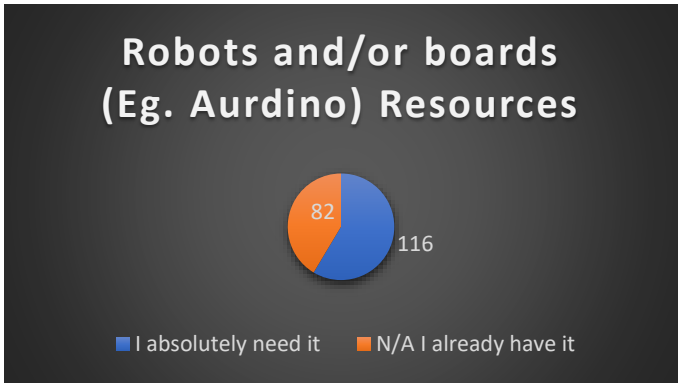
ASE – Association for Science Education
RSC – Royal Society of Chemistry
CAS – Computing At School
SSMR - Mathematical Sciences Society of Romania
BP
CITB
IET – Institution of Engineering and Technology
ASQ
IOP – Institute of Physics

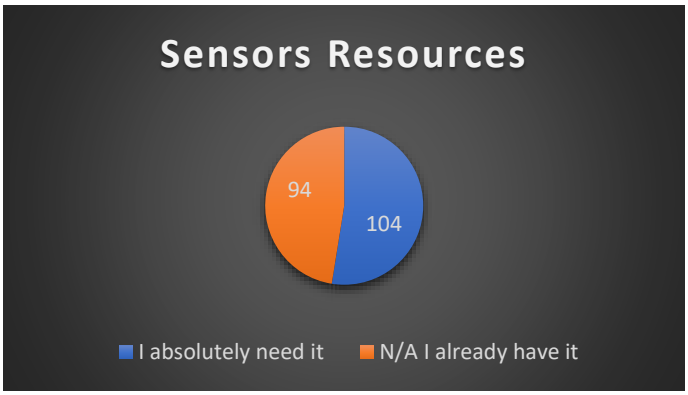
16. Which learning resources would you like to use, but do not have at your disposal?

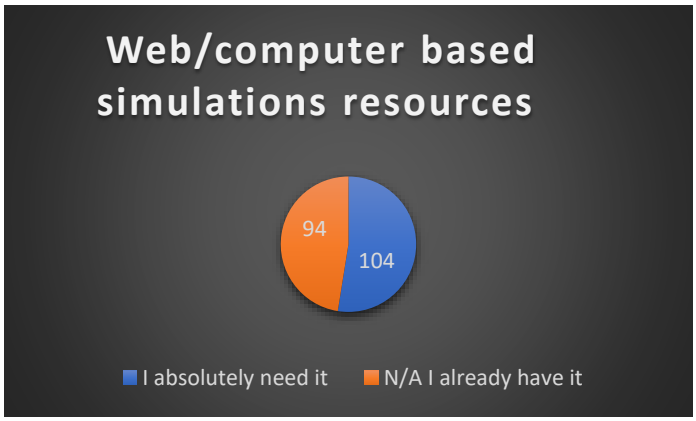
It was found that the most commonly requested learning resources needed was in relation to Virtual Reality resources with 77% of the responders stating that they absolutely need it. Resources for special needs learning was also highly requested with 67% of teachers stating that they absolutely need it.

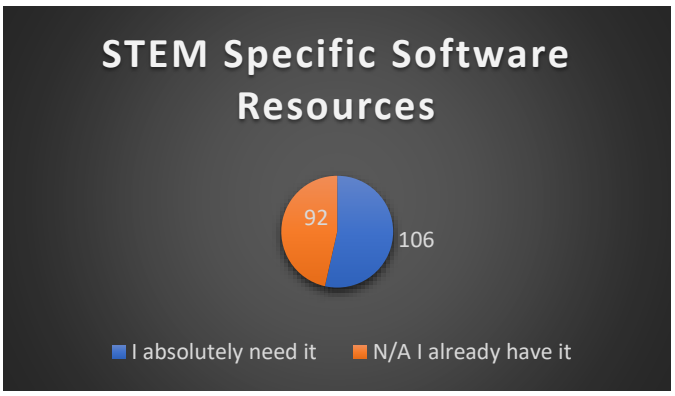


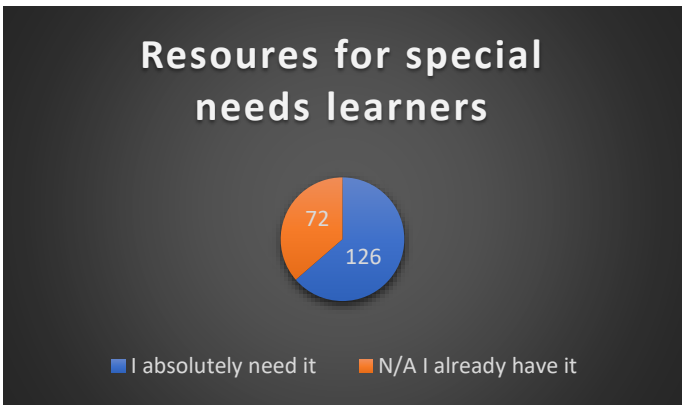












Between 52% and 77% of responders stated that they absolutely need AR, VR, sensors, simulations, STEM specific software and resources for personalised learning and special needs learners.

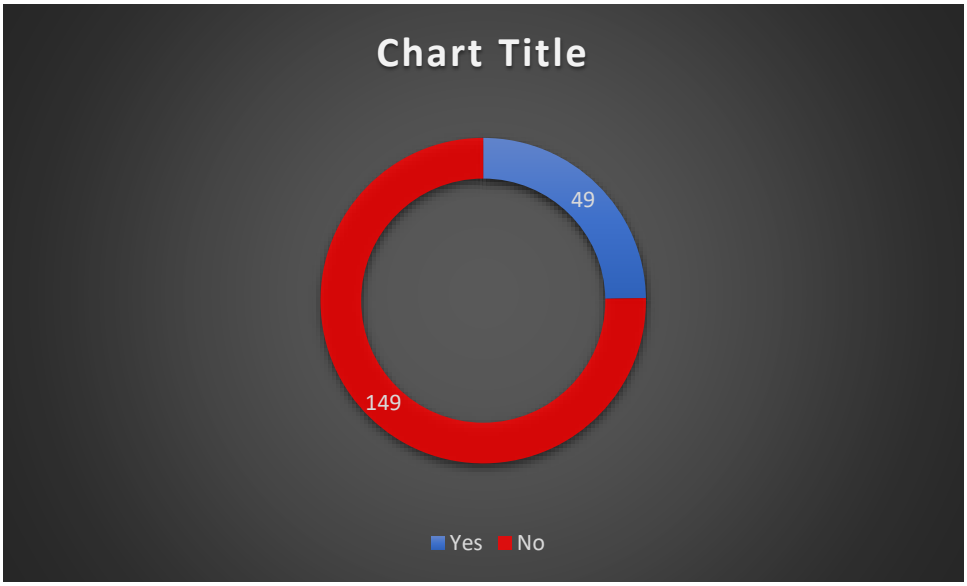
17. If you wish to use other resources which were not mentioned above, please state your answer here.

6 responses were received out of the 198:

- Easy to use resources
- Maths resources which are easier to edit online, specific software to enable entering answers appropriately like powers, equations, etc.
- CleverTouch Boards
- Nessuna
- Other specific STEM software in addition to Geogebra + Resources / guides / tutorials to teach analogue STEM experiences + guides for specific experiences in the field of analogue and digital coding
- Laser cutter

18. Do you also teach careers lessons? Where you inform students about STEM careers, help them with CV writing and mock interviews.

75% of the responders do not teach careers lessons.



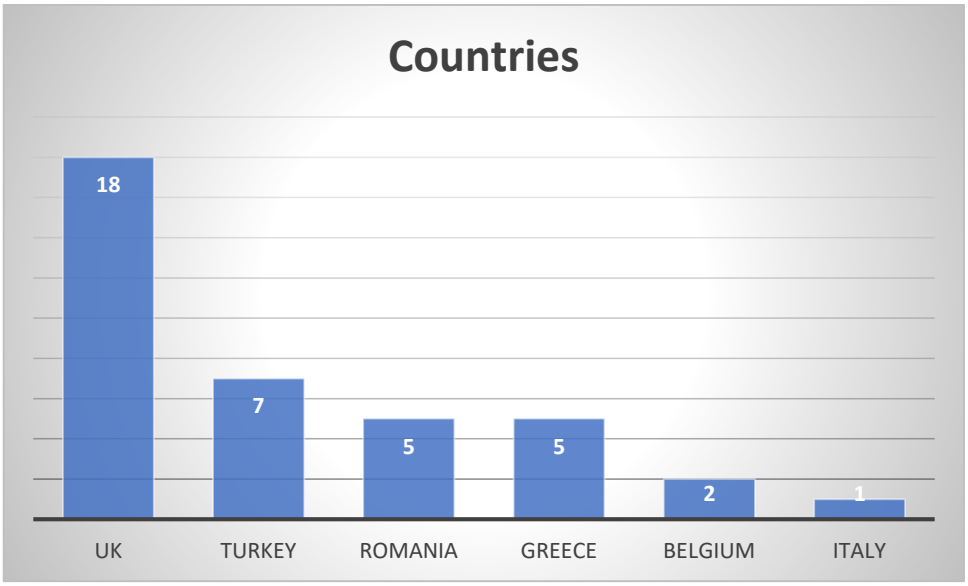
19. If you answered yes to question 18, please state the topics that you include in your careers lessons:

38 responses were received out of the 49 who stated that they teach STEM careers:

- Construction and stem
- Our school is conducting a career project to encourage students for choosing their career path
- space
- Occupations
- Information on how to research careers, CV writing, mock interviews, talks, UCAS application
- Career pathways
- they are tailored to each pupil and their interests
- UCAS
- Stem career pathways and Labour Market Information (LMI)
- STEM carriers
- I have organised the following, STEM Careers Networking Events, Mock Interviews, CV Prep etc. This year we have also introduced themed weeks and acknowledge past pupils success through weeks such as National Apprenticeship Week, Tomorrow's Engineers Week etc.
- Astronomy
- Subjects which Chemistry links directly to and also those less directly connected
- STEM LMI, GROWTH SECTORS IN NI ECONOMY, IT CAREERS, ENGINEERING and ENGINEERING FOR FEMALES, STEM CASE STUDIES IN NI INDUSTRY - STEM HEROES, STEM ENTREPRENEURS, CAREERS USING MATHS/SCIENCE, CAREERS IN FOOD. STEM SCHOLARSHIPS.
- Aviation, engineering careers
- Oxbridge / Where different subjects would lead you
- Science careers
- Each topic we teach, we will link to a career
- Giving them tools to research careers at various stages of their school career, individual guidance interviews, organised talks from professionals, universities, etc, help with university applications, CVs, interview preparation, mock interviews, finance
- Physics and Science
- All relevant aspects of Careers, STEM, Job Applications, Places of Work etc
- Career paths, career research, external speakers, industrial visits
- job opportunities in STEM
- Subject choices for careers, qualifications required for FHE and specific occupations
- astronomy and astrophysics, environmental career, NASA and ESA careers
- CV, Discuss about future career
- Computer Science
- At this level it is making them aware of opportunities available / careers open to them through the study of this subject. Highlighting entry requirements for progressing to Higher education and making them aware of Work experience /opportunities.

- abilities, competences, chances, life-long learning
- New and future careers presentations, skills needed, educational path
- Career opportunities, cover letter, personnel selection techniques and adequate CV
- Gaining experience and previous service in apprenticeship
- To see difficulties of the industry
- Greater students' enjoyment of online tools, interest in technology
- strengthening students 'skills, more confidence in teachers' teaching.
- Students through the education know many interesting fields, develop their critical ability and are equipped with skills that will help them in many different areas in the future
- Study choice lessons to 3rd years, voice calls video
- Resume writing
- presentation methods, interview tips, search for organizations
- CV writing, interview, europass, training
- Information about the mathematics schools that exist in Greece but also prospects for work after studies
- Engineering and job opportunities
- future career opportunities

The following chart shows the number of responders from each country:



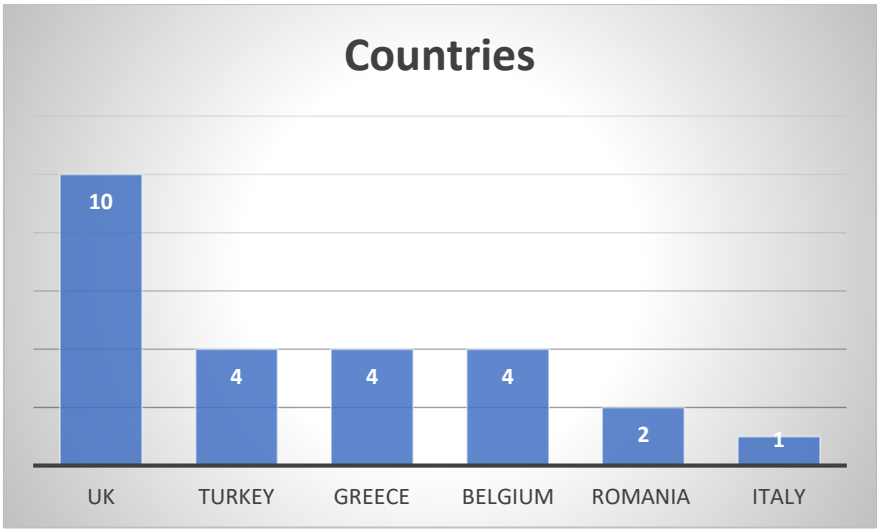
20. If your school is currently working with industry partners, what advantages has this brought to skills development and student learning? If not applicable, please type N/A:

25 responses were received out of the 195, therefore 13% of the responders have links with the industry:

- STEM career awareness is the most important part of this ecosystem. It was very useful.
- it provided work experience tailored to our pupils and able to deal with their needs
- Teaching items that are industrial and cannot be accessed in school

- The Year 10 and 12 Visit to Industry day allows pupils to gain an insight to the range of careers available within STEM.
  Work based learning projects such as the bus shelter project with a local engineering company has allowed pupils to design a bus shelter and they will follow the manufacturing process through to the end. A local engineering company has also sponsored BTEC Engineering afterschool which has allowed 10 pupils to achieve this qualification.
  Funding from the Royal Society Partnership Grant has allowed Year 10 pupils to complete a research project and will design and make a solar lantern for pupils in Zambia. We have also linked with NIE Network's for this project to allow pupils to understand the benefits of solar power and the roles within NIE Networks.
- Professional awareness and development of employability skills
- Working with industry has encouraged real world learning and problem solving challenges, teamwork through sponsored competition and visits and taster events from Year 9. Pupils are more aware of career opportunities in Engineering and Construction.
- Experiences, practical shortcuts
- Practical grounding, work-based relevance
- Huge advantages. Really anchors the real life connections to what they are learning. Great for CVs / UCAS as well.
- It is very good for giving pupils a real understanding of what skills they need and how education links to the workplace.
- Industry links to real world projects
- Huge advantage. Before Covid, We had just introduced a programme of industry based learning for Post 16 in a Mechanical engineering field. Students were taught Solidworks and Hydraulic design by engineers from a local company - Telestack Ltd.
- Improve their 21st century skills
- Authentic contexts, better view of connection amongst STEM subjects
- To see difficulties of the industry
- strengthening students 'skills, more confidence in teachers' teaching.
- Students through the education know many interesting fields, develop their critical ability and are equipped with skills that will help them in many different areas in the future
- Acquisition of professional skills that can be readily used

The 25 responses came from the following countries:



21. How confident do you feel when you are developing STEM Lesson Plans?

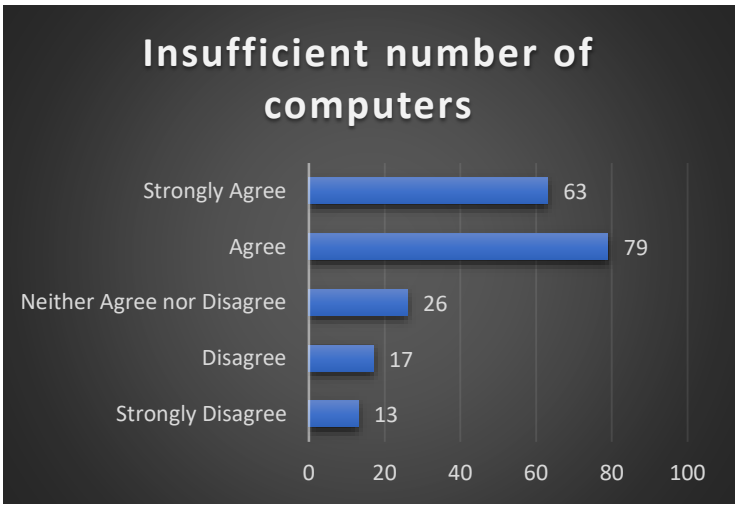
26% of responders are very confident when developing STEM Lesson plans, while 66% stated that they are confident and somewhat confident and 8% are unconfident and not confident at all.

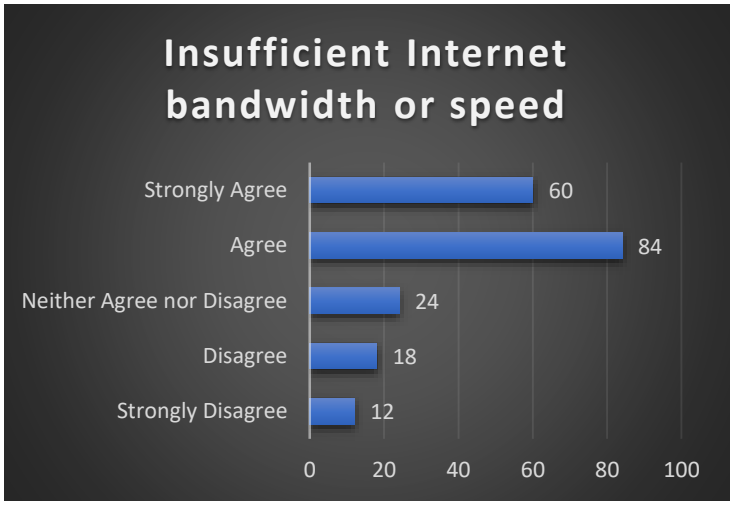
Section 4 – Obstacles to implementing effective STEM teaching

22. Is your STEM teaching affected by the following?

Out of the 198 responses it was shown that the majority agreed that their STEM teaching is affected by the following issues:

- Insufficient bandwidth
- Insufficient number of computers
- Budget constraints in accessing adequate content/material for teaching
- Pressure to prepare students for exams





Co-funded by the
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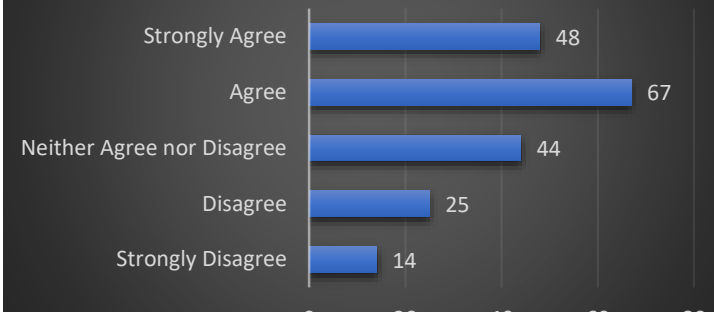
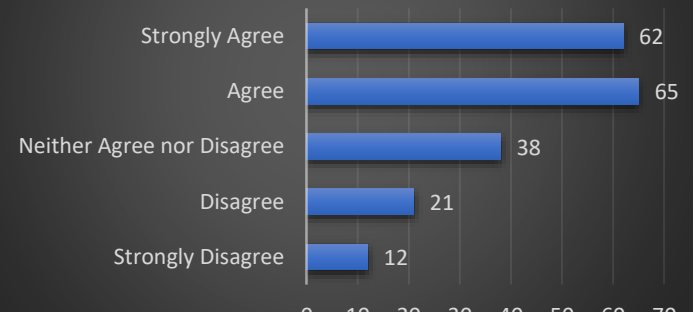
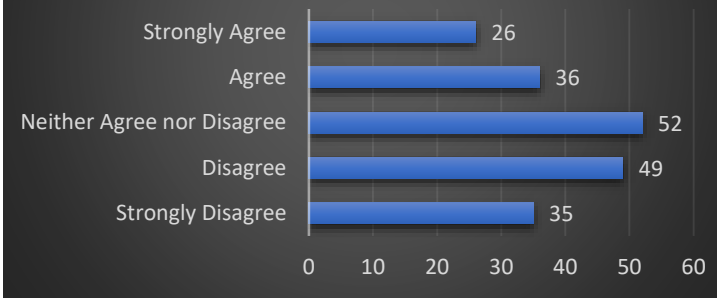
Insufficient number of interactive whiteboards



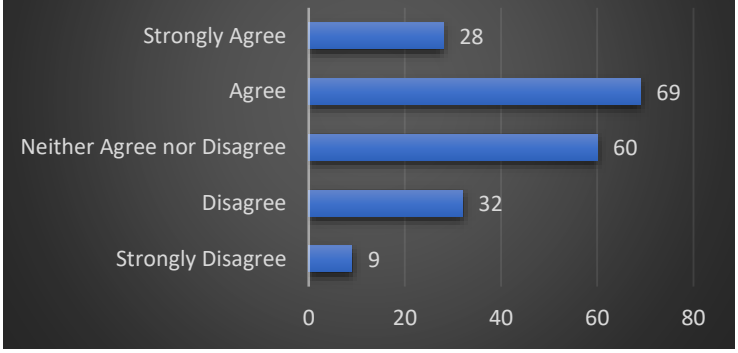
School computers out of date and/or needing repair



Using ICT in teaching and learning is not a goal in our school

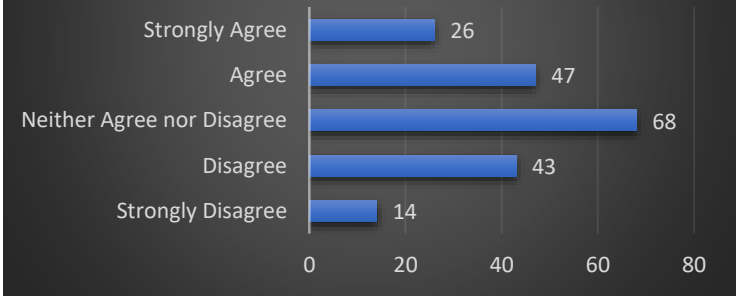


Lack of adequate training of teachers



Insufficient technical support for teachers

Insufficient cross-curricular support from my school colleagues



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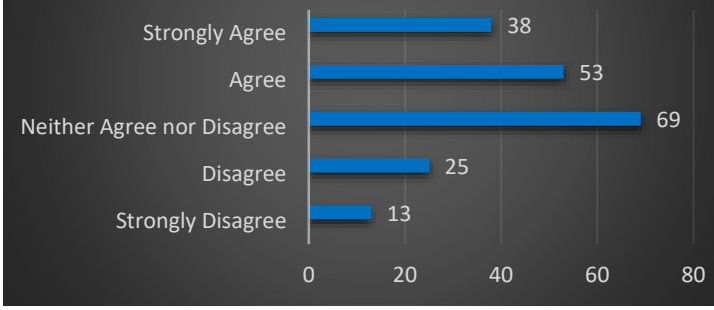
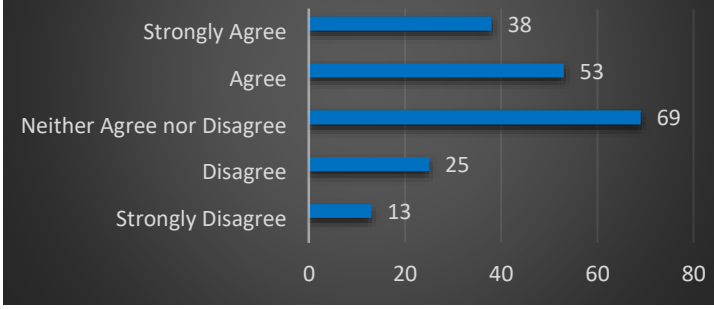
Lack of STEM content in national language

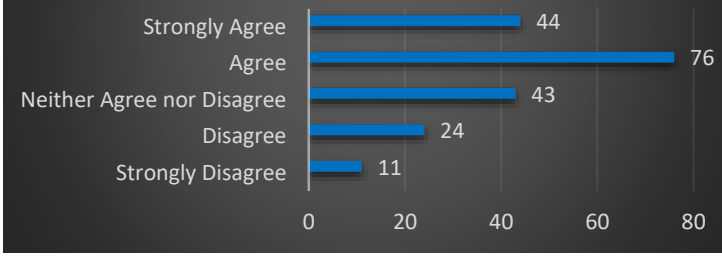


Lack of STEM content in national language

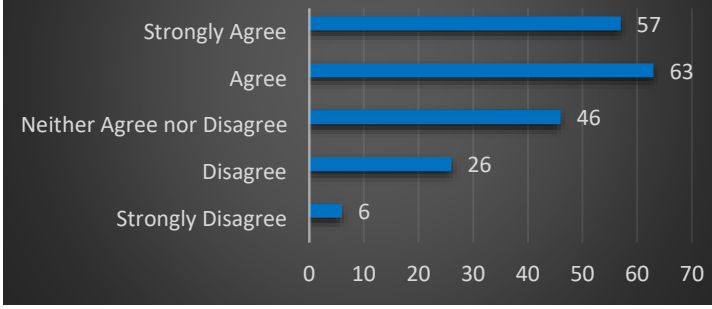


Budget constraints in accessing adequate content/material for teaching

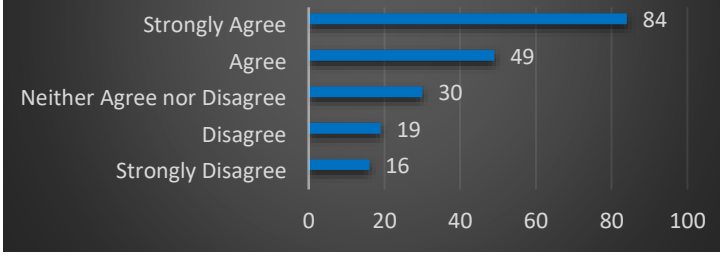
Lack of pedagogical models on how to teach STEM in an attractive way



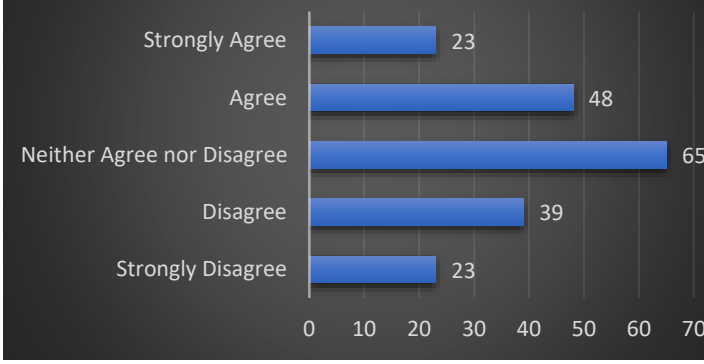
School time organisation (fixed lesson time, etc.)



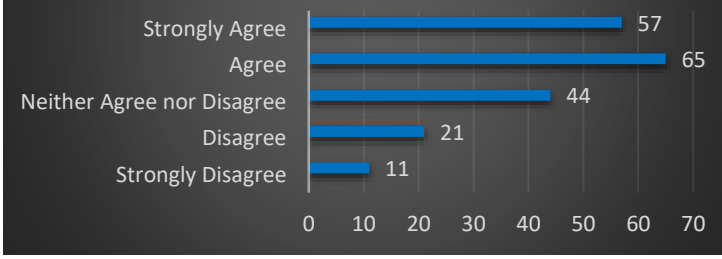
Pressure to prepare students for exams and tests



Lack of interest of teachers

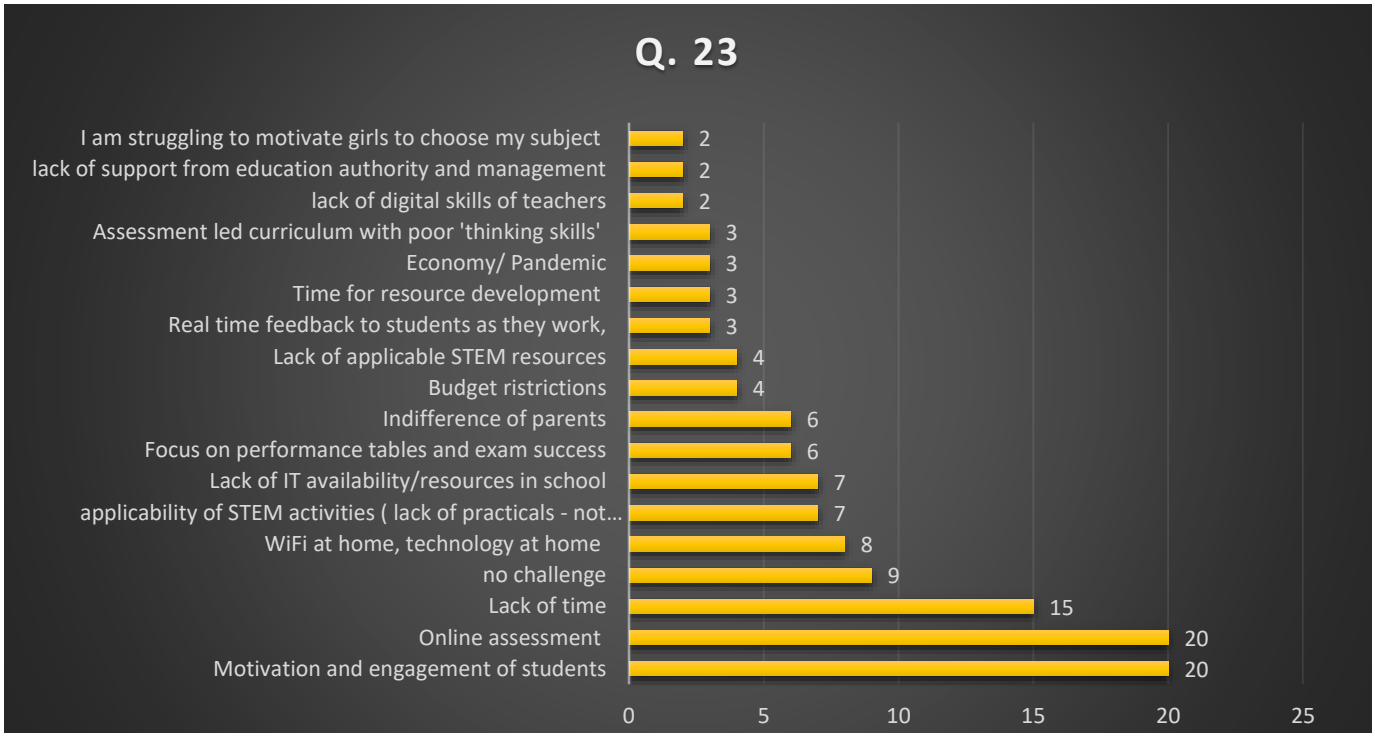


School space organisation (classroom size and furniture, etc)



23. What other challenges do you face and what are their indicators? For example: I am struggling with online assessment and its indicator is that my students' performance is declining.

123 teachers responded with the following challenges:

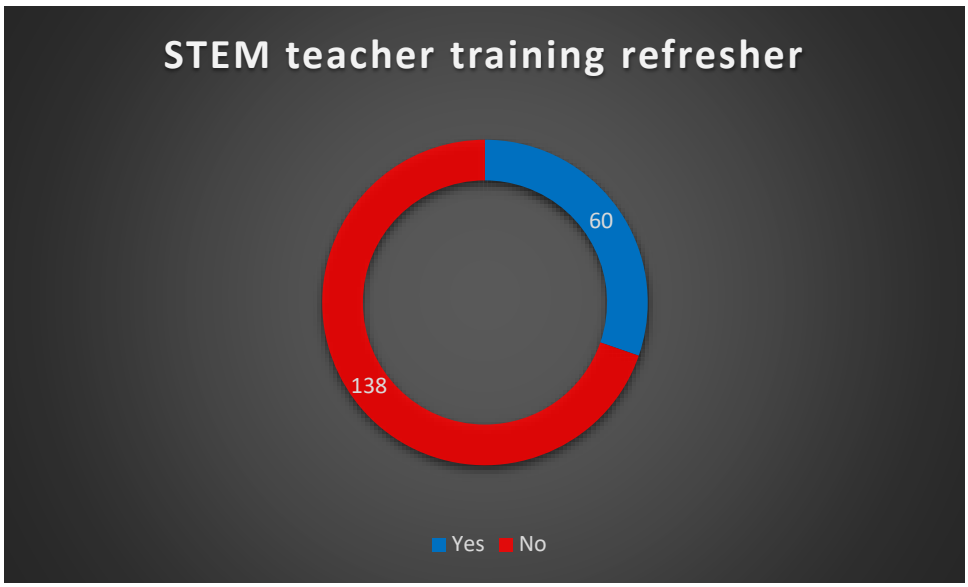


It is evident from the responses that most of the teachers struggle with student motivation and engagement while distance teaching and also with online assessment.

Section 5 – Teacher Training/CPD

24. Are STEMM teacher training refresher courses conducted on a regular basis?

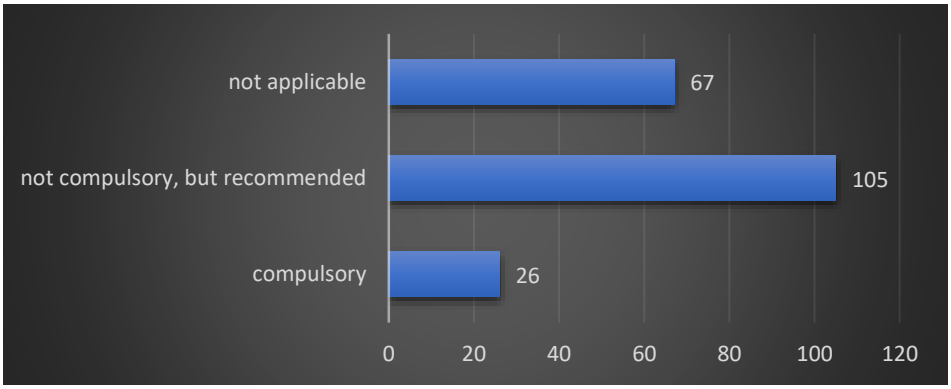
70% of responders stated that there is no refresher STEMM teacher training conducted on a regular bases:



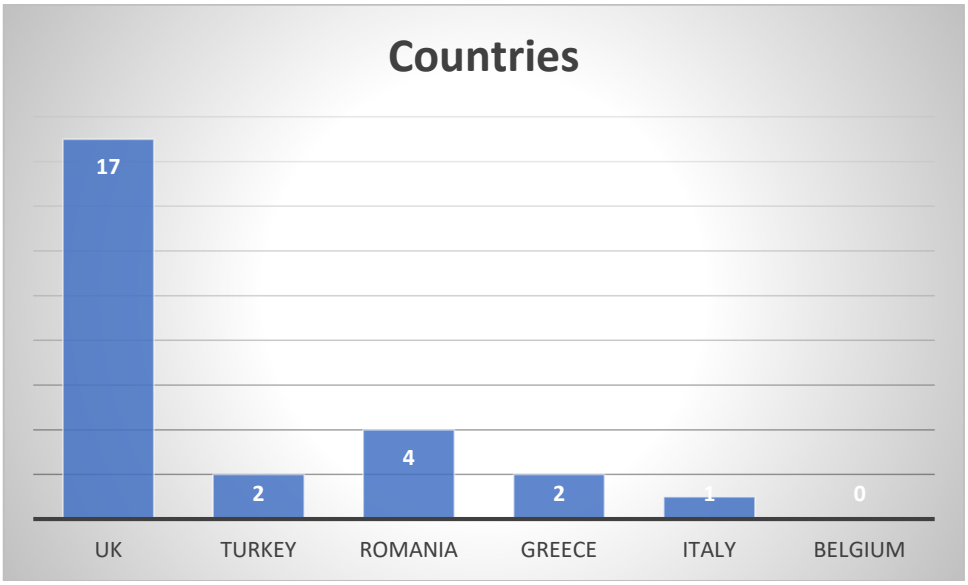
There is further breakdown for each country in Annex II. Q.24 Are STEMM teacher training refresher courses conducted on a regular basis?

25. If you answered No to question 24, does a competent authority (education department, school principal) in your country make it compulsory to participate in CPD (professional development) activities every year?

13% of the 198 responders stated that participating in CPD (professional development) activities on a yearly bases is compulsory, while 87% stated that such activities are either not compulsory but recommended and not applicable.



The chart below shows the number of respondents from each country regarding the compulsory CPD:



26. In the past two school years, have you undertaken professional development? Please also indicate the mode of delivery and the time spent on the training.

Out of those respondents who have undertaken professional development, the majority of them participated in online training as opposed to face-to-face, in a ratio of 5:1, while some participants took part in both modes of training, online and face-to-face.

43 - 44% of respondents did not undertake professional development in the following fields:

- Introductory ICT training (word, spreadsheet etc.)
- Advanced ICT training (complex databases, virtual learning environments etc.)
- Equipment-specific training (interactive whiteboard, laptop, etc.)
- Courses on the pedagogical use of ICT in teaching and learning
- Subject-specific training on learning applications (tutorials, simulations, etc.)
- Personal learning about innovative STEM teaching in your own time

49 - 61% of respondents did not undertake professional development in the following fields:

- Advanced web focused courses (creating websites, video conferencing etc.)
- The use of Social media in the classroom
- Other professional development opportunities related to innovative STEM teaching
- Cooperation with industry for the contextualisation of STEM teaching (joint development of learning resources, placement in industry etc.)

The bar representing the “other” category includes both face-to-face and online training. There is a further breakdown for each country in Annex II. Q26 regarding the two most popular training: “Introductory ICT training” and “Personal learning about innovative STEM learning in your own time”.

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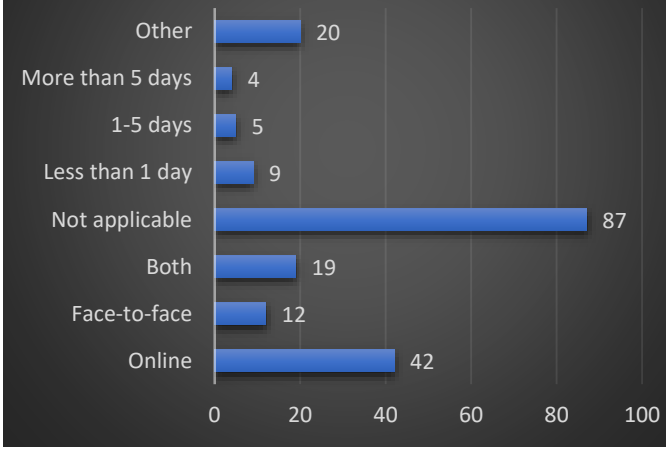
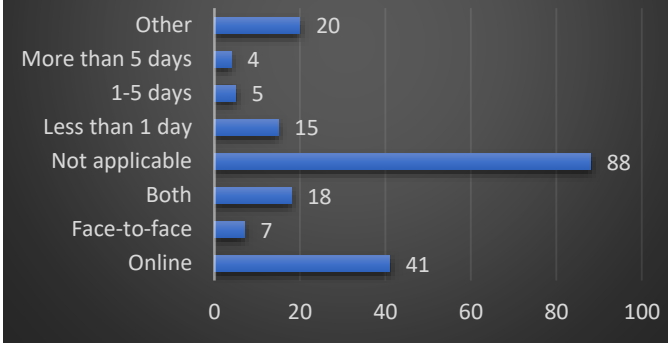
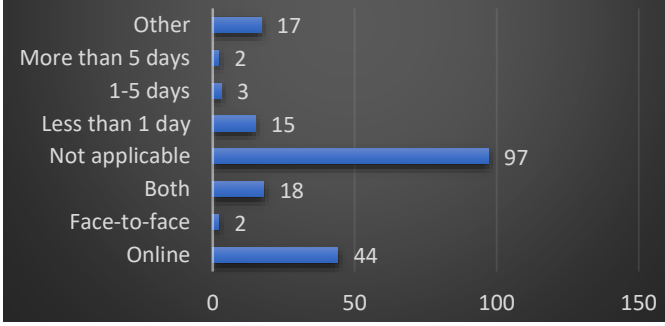
Introductory ICT training (word, spreadsheet etc.)



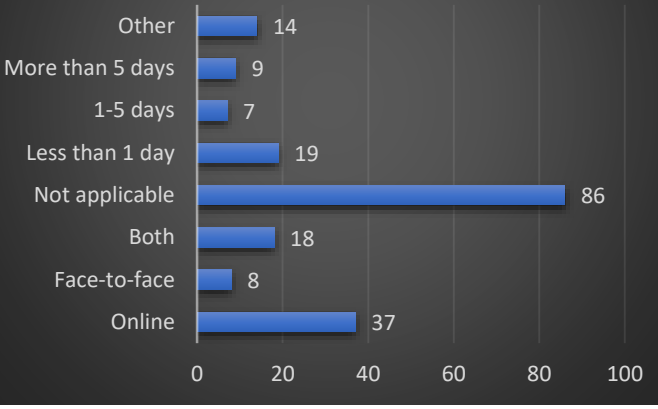
Advanced ICT training (complex databases, virtual learning environments etc.)



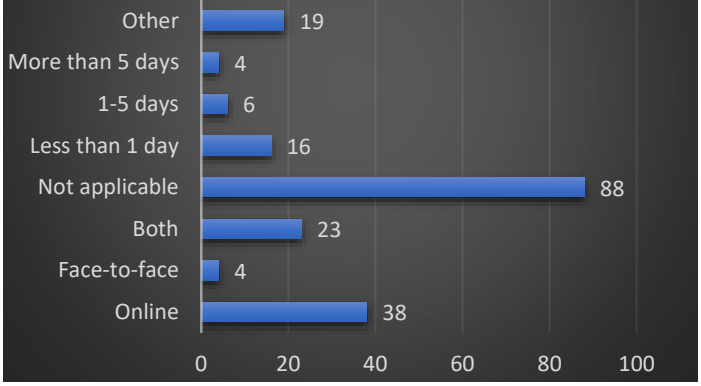
Advanced web focused courses (creating websites, video conferencing etc.)



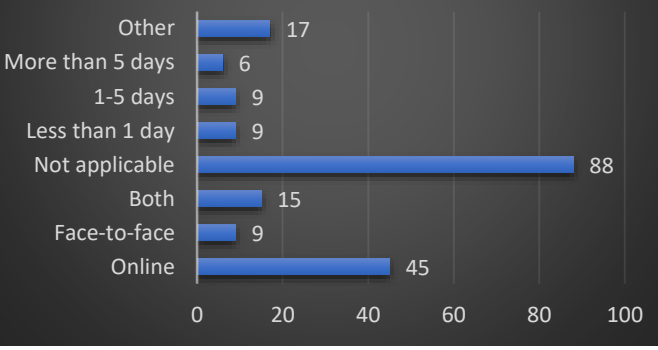
Equipment-specific training (interactive whiteboard, laptop, etc.)



Courses on the pedagogical use of ICT in teaching and learning



Subject-specific training on learning applications (tutorials, simulations, etc.)



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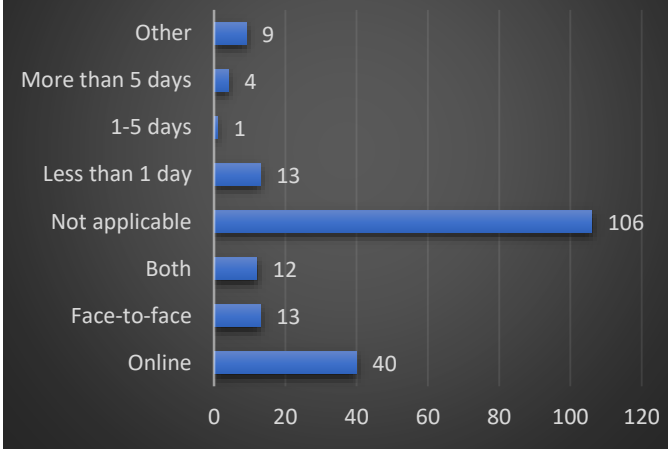
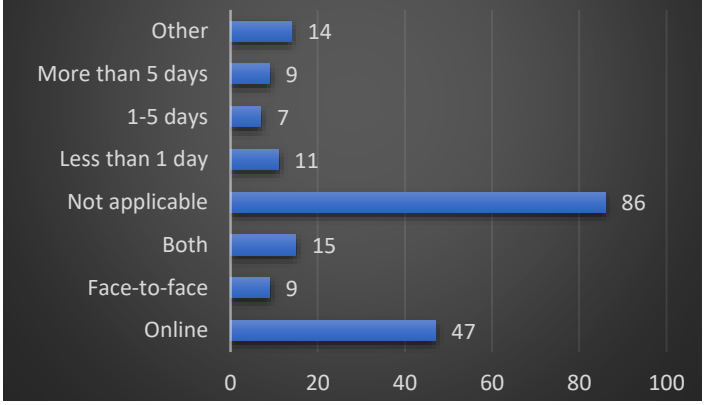
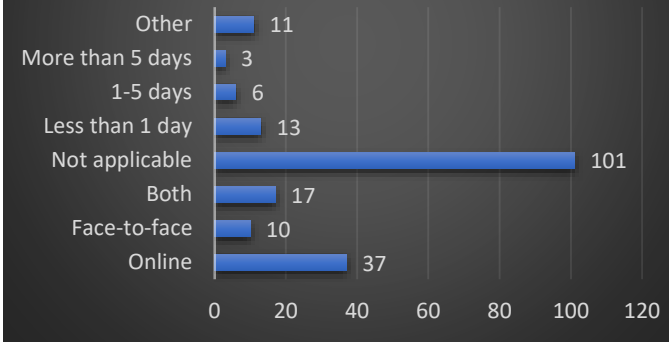
The use of Social media in the classroom



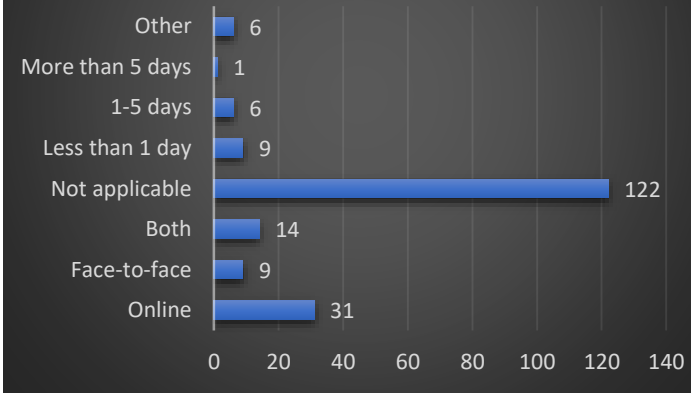
Personal learning about innovative STEM teaching in your own time



Other professional development opportunities related to innovative STEM teaching

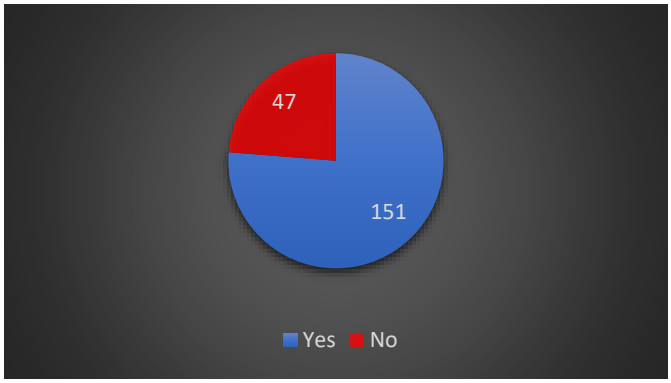


Cooperation with industry for the contextualisation of STEM teaching



27. Do your colleagues and head of school share a positive vision about innovative STEM teaching at your school, such as Project/Problem-Based Learning, Flipped Classrooms, the use of ICT tools in STEM education, Skills based learning and Inquiry based learning?

24% of responders stated that their peers and head of school do not share a positive vision about innovative STEM teaching:



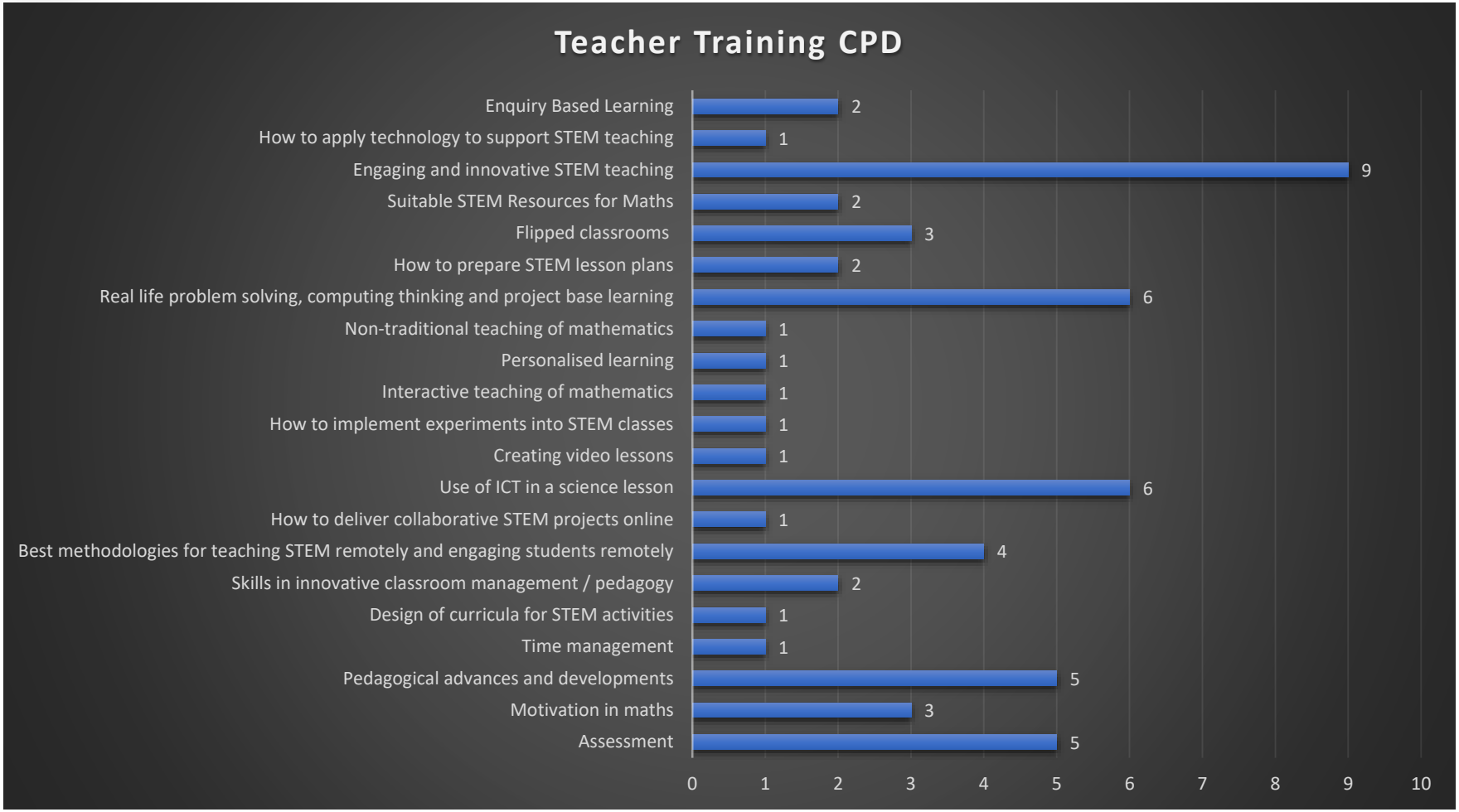
28. What kind of training you would like to participate in, to enhance your STEM teaching skills and knowledge?

102 responses were received out of the 198 survey participants, and the training types were categorised into the following fields:

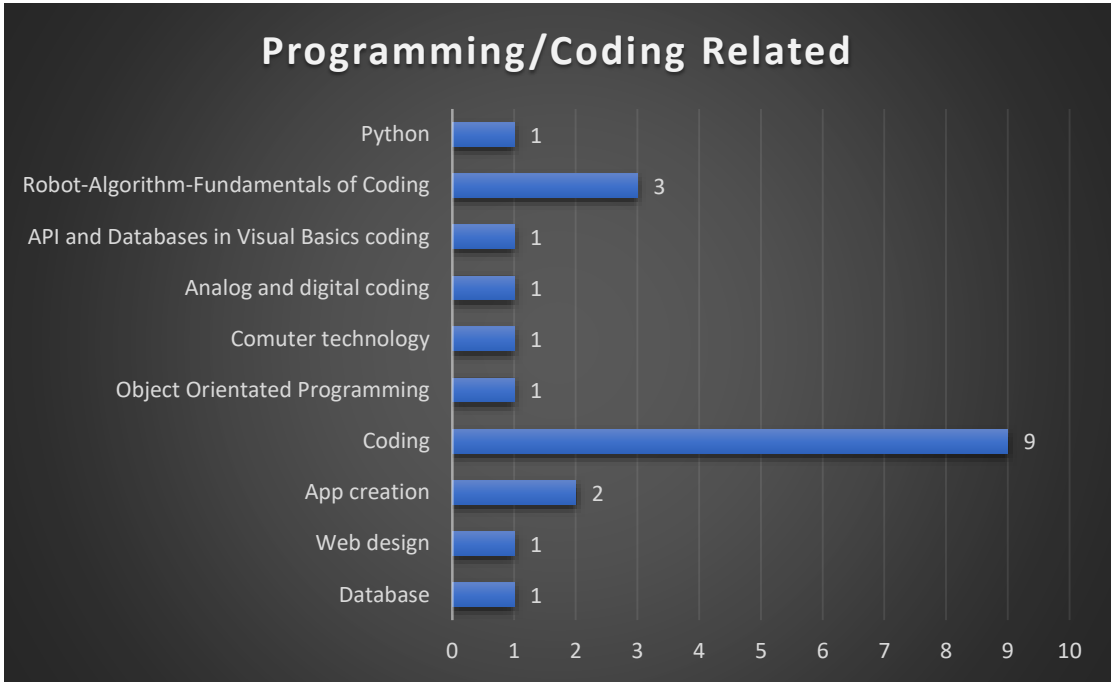
- Teacher Training CPD
- Pogramming/coding related
- Educational technology skills
- Vocational Skills development for teachers
- Careers related training
- Coaching and tuition

Regarding *Teacher Training CPD*, most of the respondents are keen to undertake “engaging and innovative STEM teaching” training, followed by “real life problem solving, computational thinking and project based learning” along with “the use of ICT in a science lesson”.

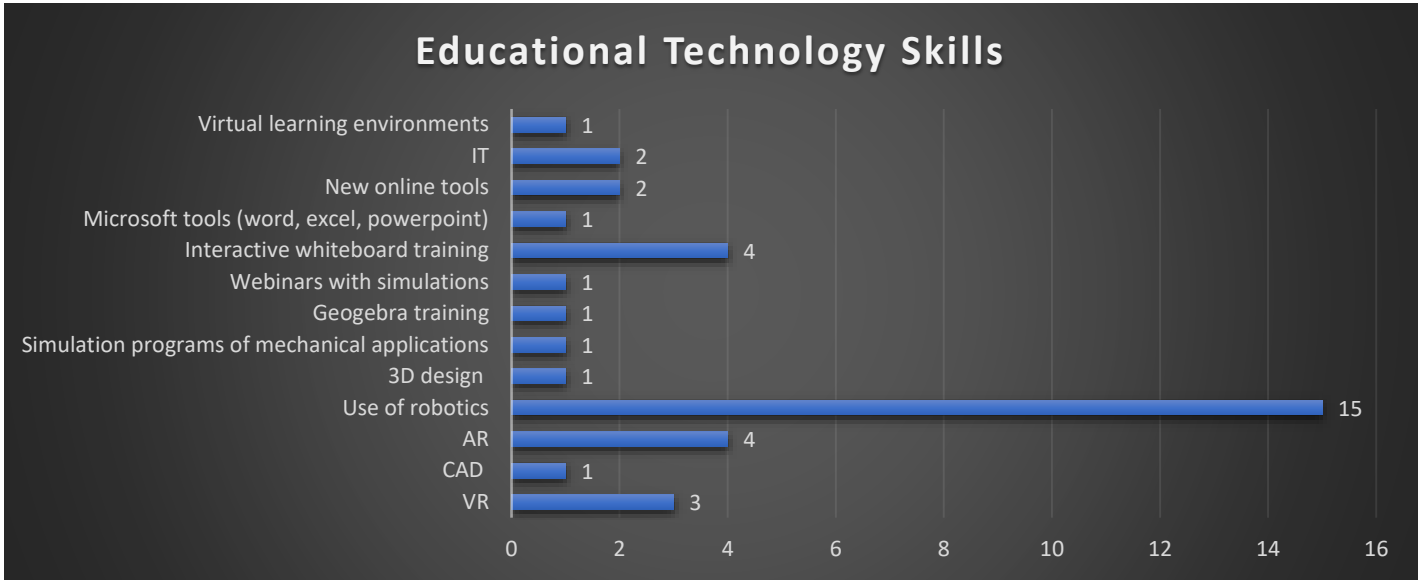
The following charts show the responses for the above stated 6 fields:



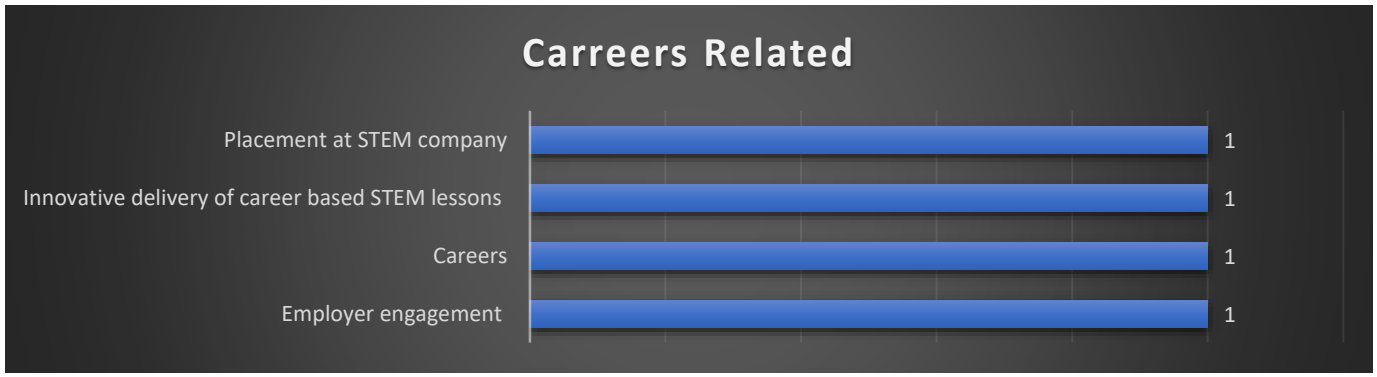
The following chart shows the required training identified regarding Programming and Coding related training:



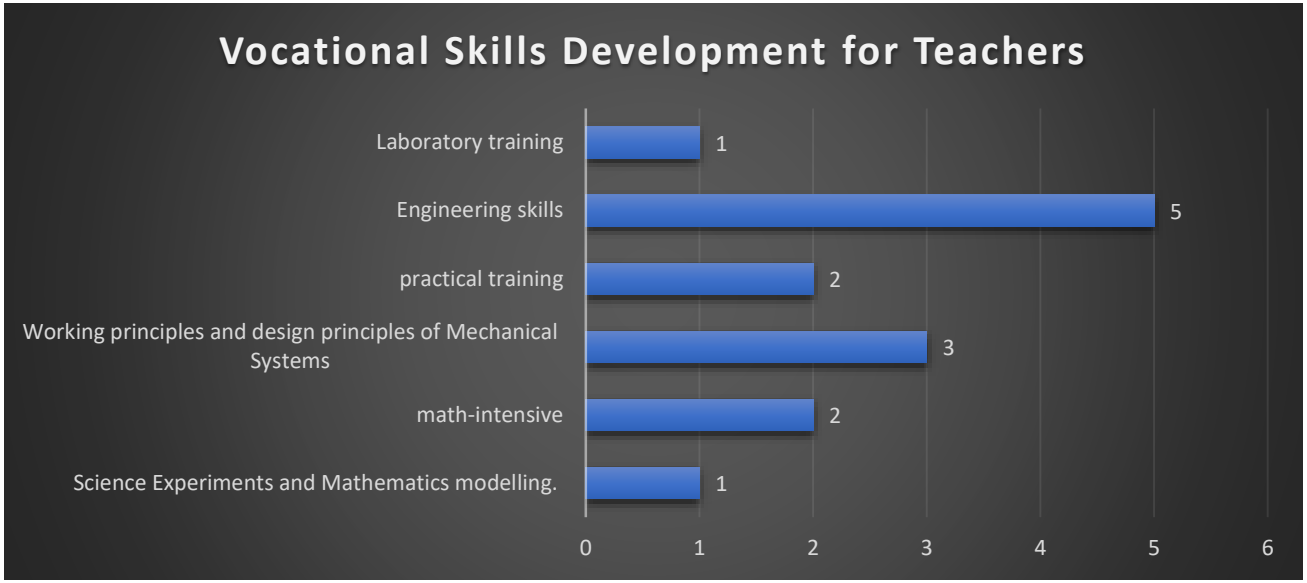
The following chart shows the required training identified regarding educational technology skills:



The following chart shows the required training identified regarding careers:



- The following chart shows the required training identified regarding Vocational Skills development for teachers:



Within the Coaching and tuition category only 1 area was identified: “Ideas and support for running a successful STEM club”.

It is evident from the responses that most of the respondents have shown interest to undertake coding, educational technology and the use of robotics related training.

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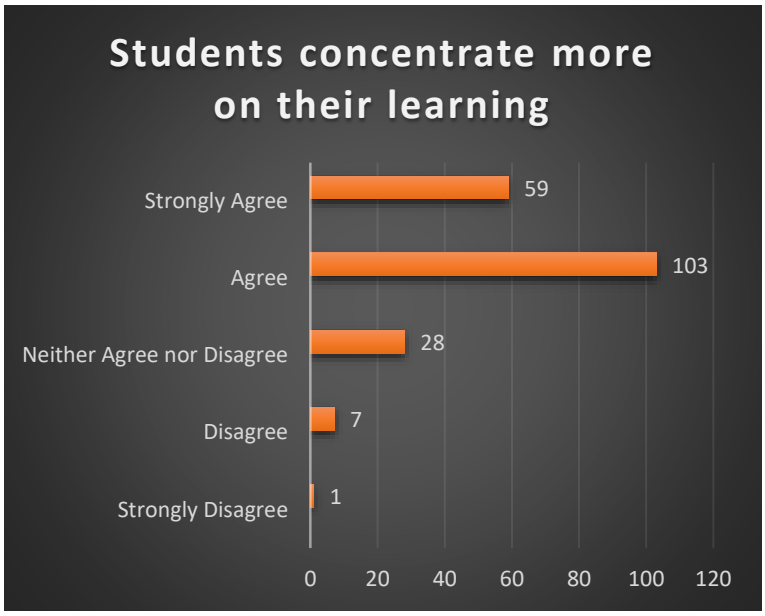
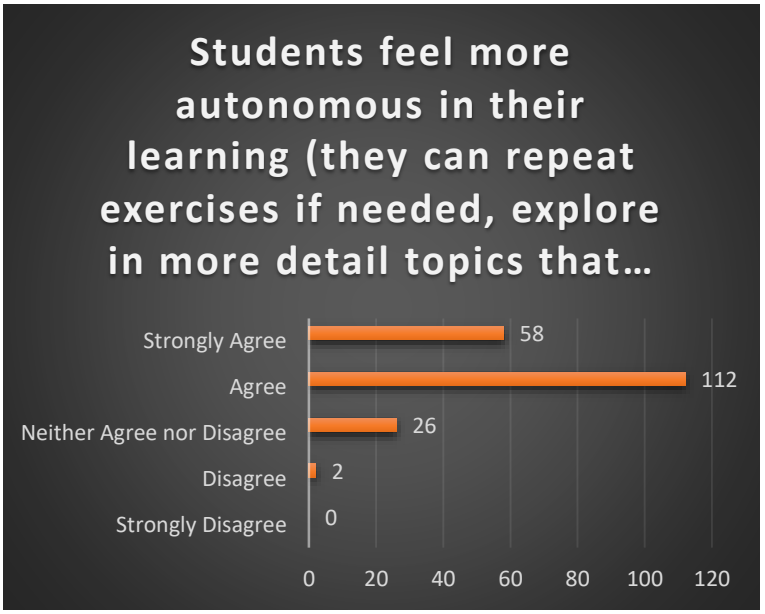
Section 6 – Your Opinion

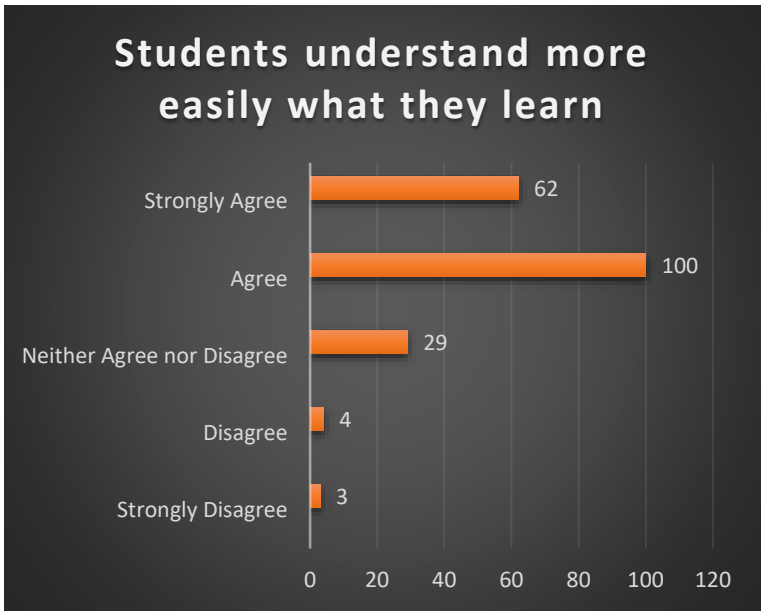
29. In your opinion, does innovative STEM teaching have a positive impact on the following?

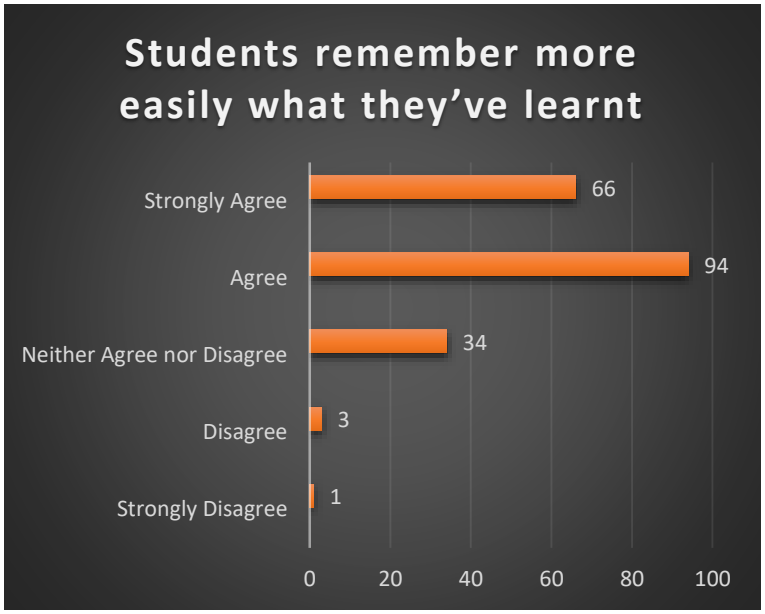
Based on the results, the majority of the respondents agreed and strongly agreed that the top three areas are positively impacted by innovative STEM teaching:

- Students concentrate more on their learning
- Students feel more autonomous in their learning (they can repeat exercises if needed, explore in more detail topics that they are interested in, etc.
- Students develop their critical thinking









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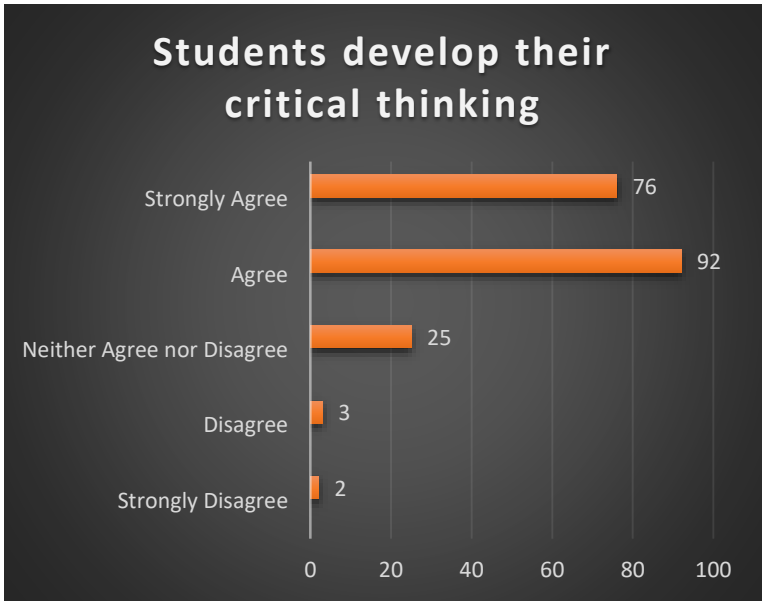
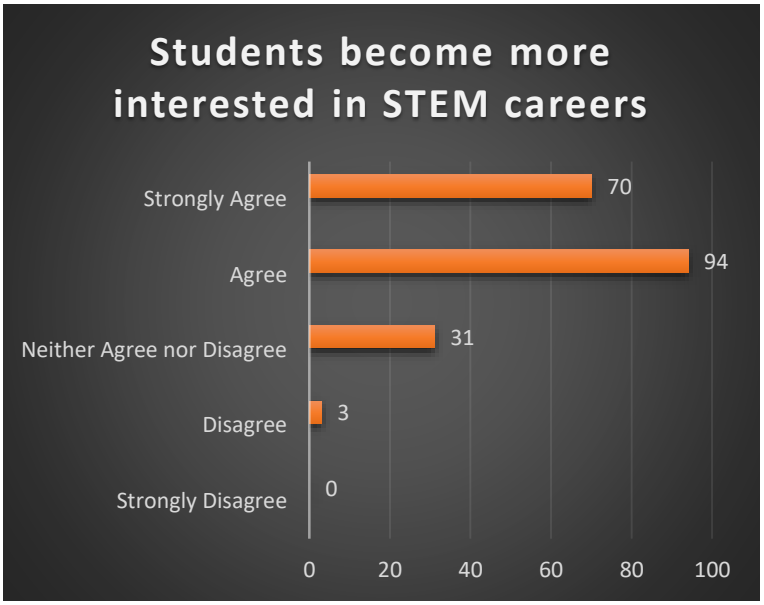
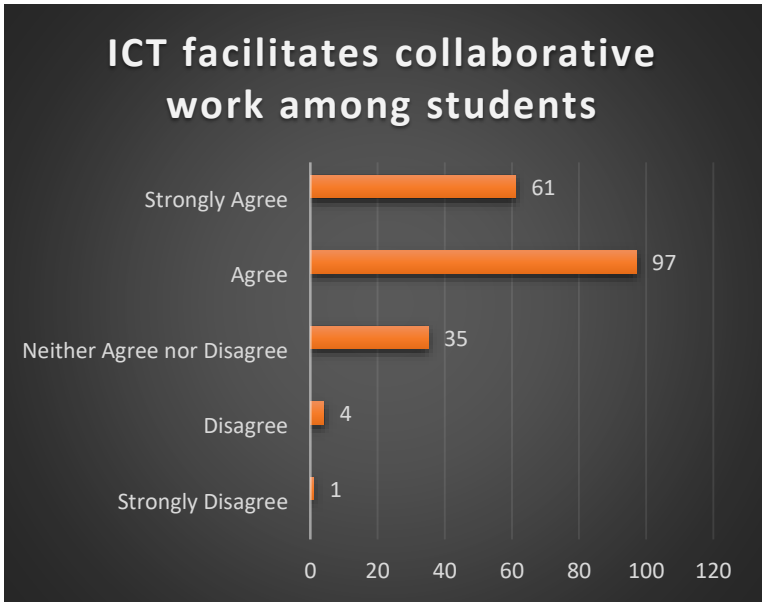




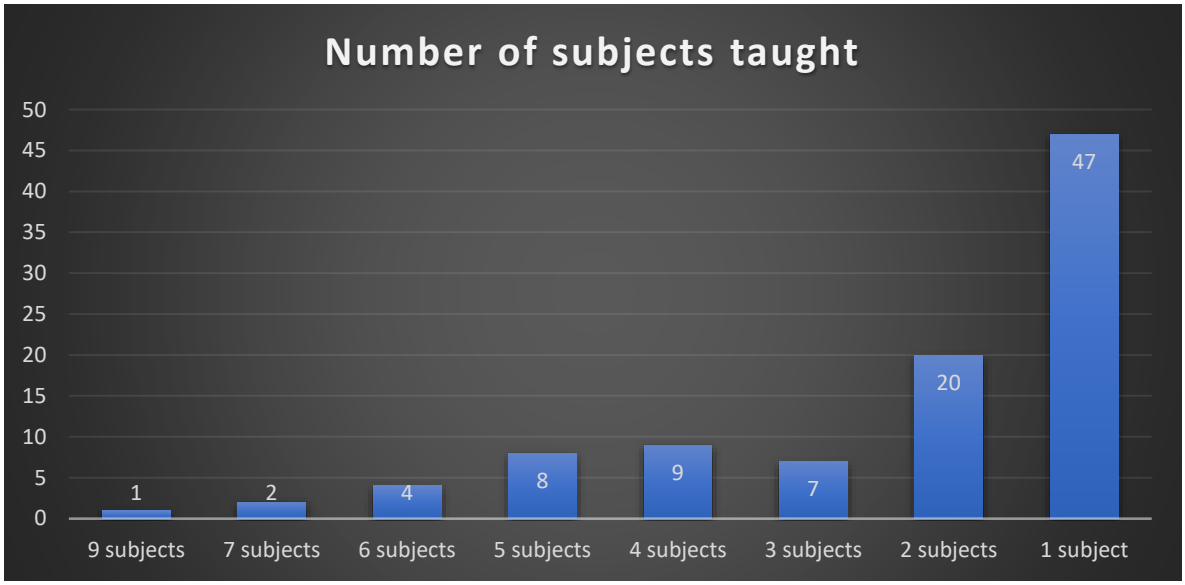


Section 7 – If you teach more than 1 STEM subject

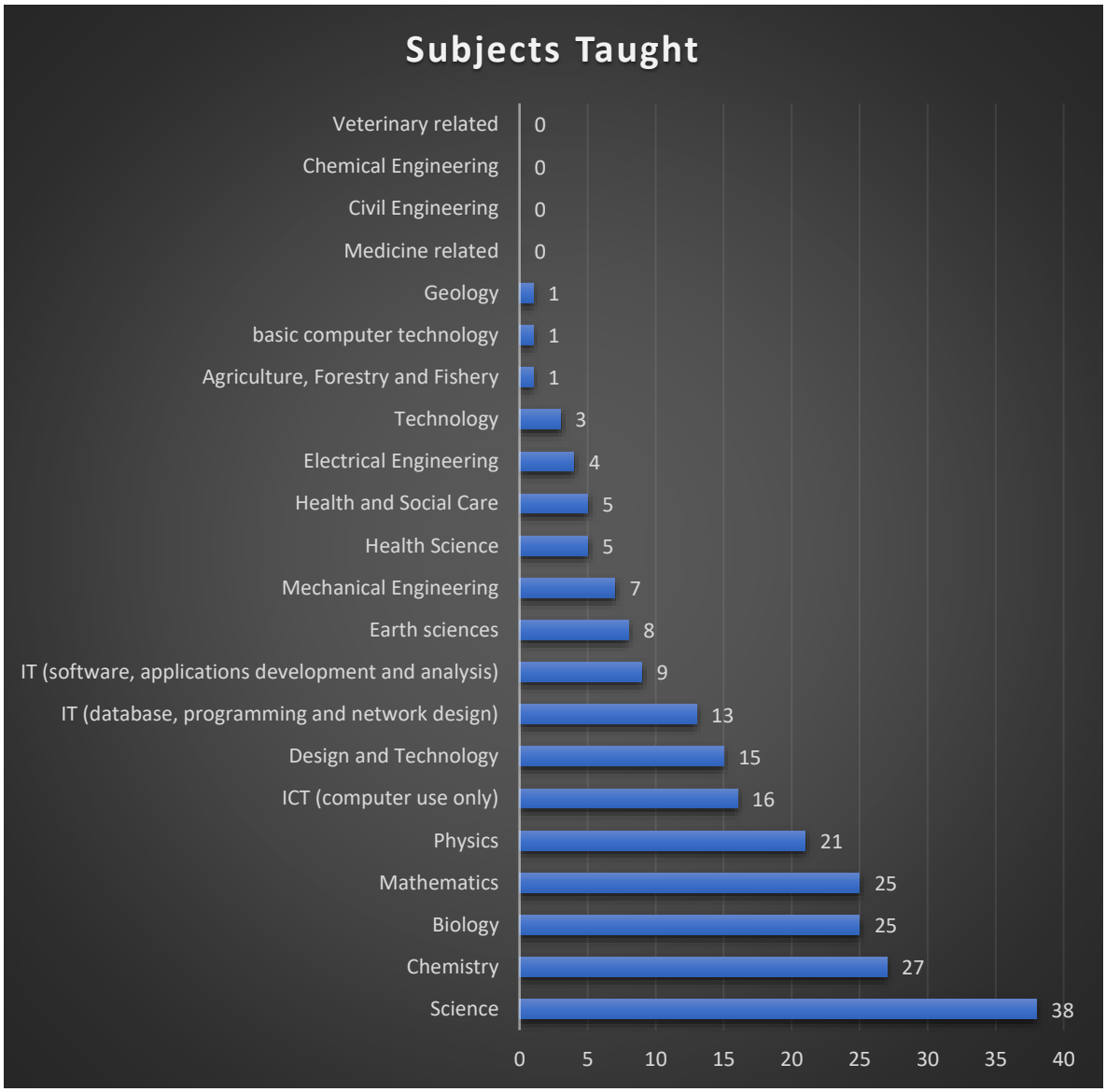
If you teach more than 1 STEM subject and would like to provide further information on the resources you use, training and resources/materials required, please complete questions 30, 31, 32, 33 and 34. Otherwise please submit the form.

30. Other STEM subjects taught

Out of the 198 teachers, 100 of them stated that they teach more than 1 STEM subject. The following chart shows that 47 teachers out of the 100 teach one more STEM subject on top of their main STEM subject and 20 of them teach 2 more STEM subjects additional to their main STEM subject:

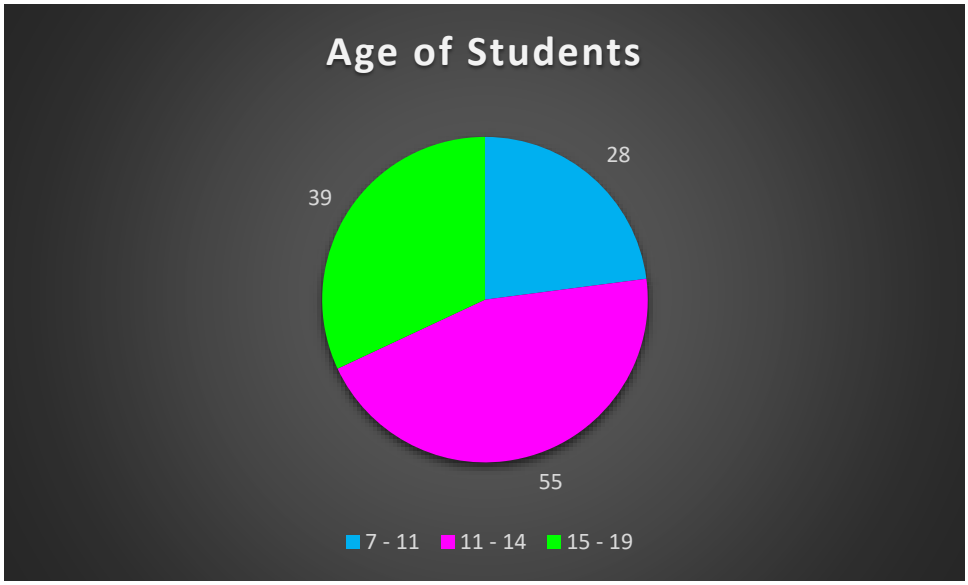


The following chart shows the additional STEM subjects, which are taught by the 100 teachers, who stated they teach more than 1 STEM subject:



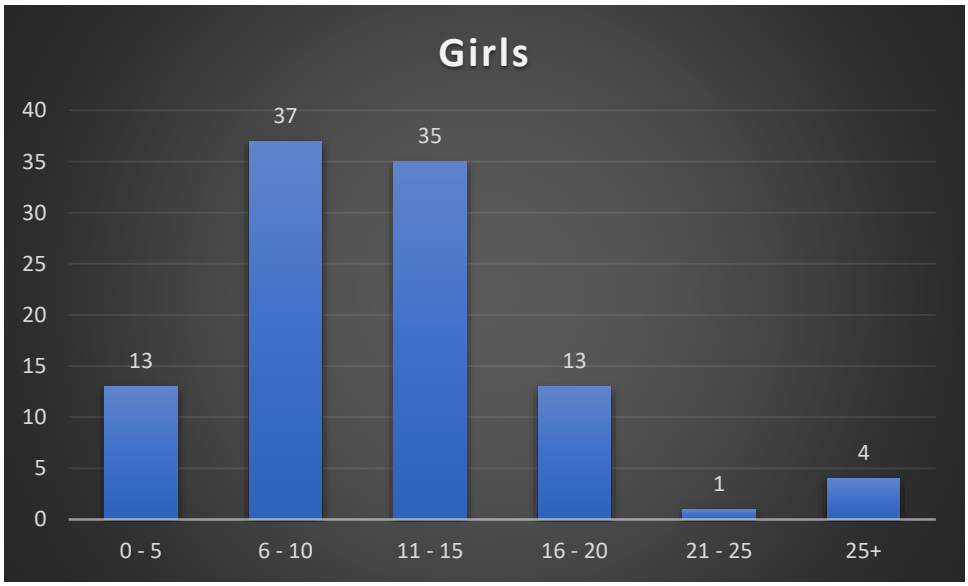
31. Age of students

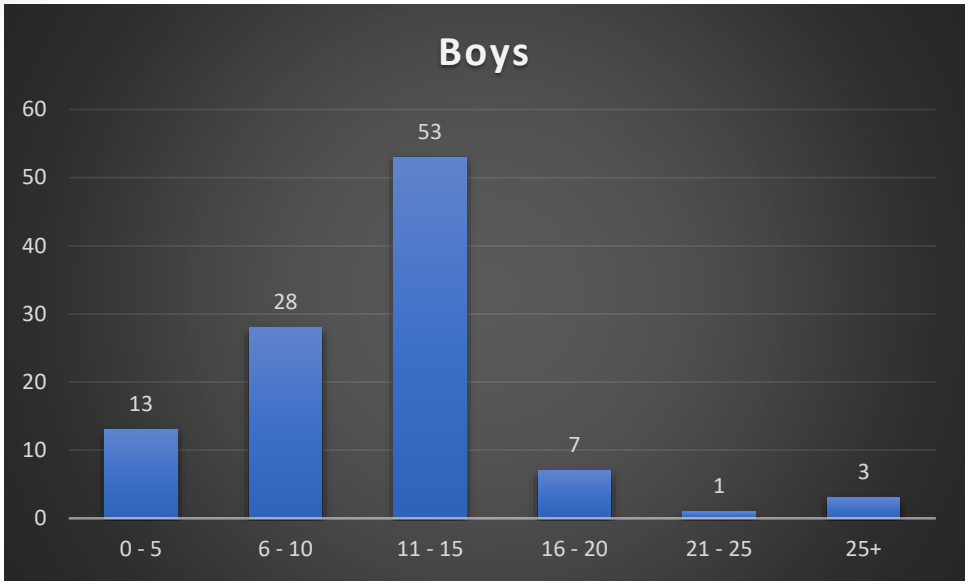
Out of the 100 teachers who stated they teach more than 1 STEM subjects, the majority, 55 of them, teach 11 to 14 years old students:



32. Gender breakdown of your class

The following chart shows the gender and age breakdown of those STEM classes, which are taught by those 100 teachers, who stated they teach more than 1 STEM subjects:





33. If you use different resources and materials for your other STEM subjects, please state them here:

The following resources were identified by the 4 responses:

- Twin Science
- Essay and academic papers
- PC lim
- IPads & Computers

34. If you would like to participate in different professional training to enhance your STEM skills and knowledge relating to your other STEM subjects (other than already specified in question 28.), please state them below:

The following resources were identified by the 6 responses:

- Careers
- Education on innovative STEM teaching, Technology integration into STEM plans
- Virtual Reality and Augmented Reality in STEM
- online tests
- Analog and digital coding, Augmented and virtual reality, Analog STEM experiences, Organisation and management of the learning space in multi-areas (e.g. 1 + 4 Indire model)
- Python

Section 8 - Conclusion

This state of the art report analyses and draws conclusions from the survey completed by 198 STEM teachers across Europe. They provide information about the status of current teaching methods, challenges as well as existing professional development opportunities for STEM educators at the national level.

The results of the mapping exercise described in this state of the art report set the stage for further activities in the "Improving STEM Education across European Schools" project. It has been demonstrated that professional development opportunities vary according to the cultural and institutional context in the 6 European partner countries. This report has tried to respond to this diversity of perspectives, contexts, and initiatives and has attempted to extract the benefits of different approaches. It has selected a number of good practices which could serve as an overview of existing methods to achieve desired goals in the EU context and which will be included in a joint platform of resources to be developed and used by all involved partners. However, one desired learning outcome for the AISR will be to build the capability of educators to move from knowledge and vision to implementation and hence to an active contribution to a transformational development in the European STEM education area.

The following teaching methods, Teaching with experiments, Flipped Classroom and Inquiry based learning, are used mainly for 25% of the class, which depending on the length of the class, is an average of 12 minutes. To get the best results from these methodologies, it is recommended to employ them for more than 25% of the class and have a consistent approach when using them as a learning tool.

Based on the results regarding these methodologies it is quite clear, that teachers in most of the partner countries would benefit greatly from teacher training workshops on the appropriate use of these strategies within the classroom. The majority of the teachers from the partner countries stated that they use 'Traditional Direct instructions' for 25% and 50% of the class. Although direct instruction is an accepted form of teaching, however, if it is carried out with no other variation within the lesson on a long-term basis, this can lead to students losing interest and becoming disenfranchised from the learning process. For a full breakdown see Annex II.

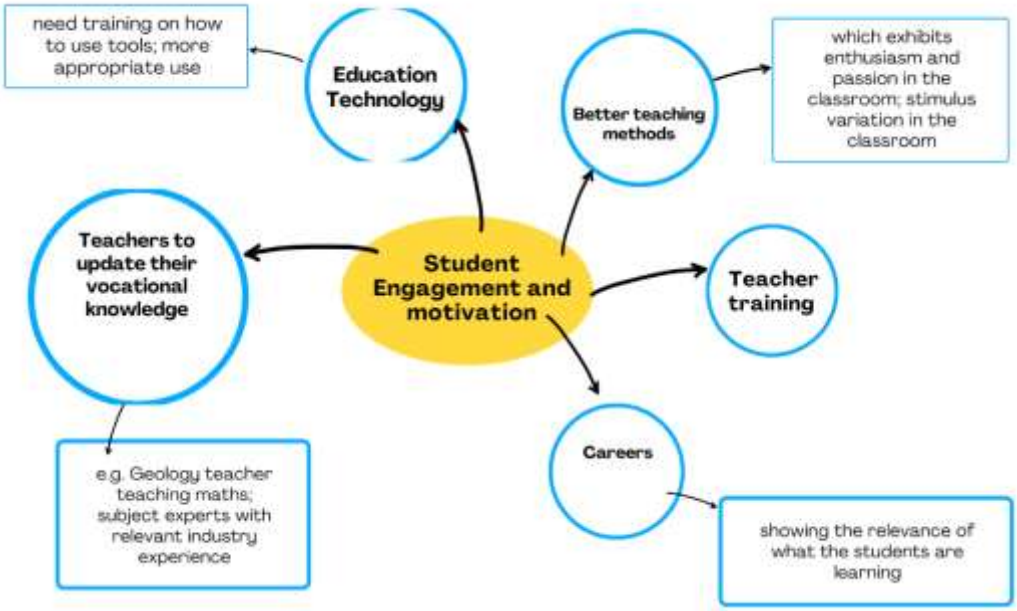
It is clear from studies, that more innovative teaching methods within lessons keep the students engaged and increase their learning and understanding. However, it should be noted that these innovative strategies need to be planned out and need to be appropriately used or their effectiveness will be diminished. There needs to be a culture of innovation within the schools, in order for teachers to adopt these innovative technologies such as game based learning and the use of robotic and other similar types of innovative technologies.

There were over 50 online tools/software mentioned that teachers incorporate into their lessons i.e. Google classroom and Kahoot, which seem well utilised, however, other free resources such as Google Jamboard or OneNote seem to be underutilised. Schools need to develop an innovative ethos, and they also need to be willing to give developmental time to their teachers in order for them to be able to investigate the full portfolio of free resources that are available. Traditionally, it has been up to the goodwill of teachers to investigate which free resources are available, but the time taken for them to do so was predominantly outside of their contractual hours.

Schools also need to enable access to professional development workshops for their teachers, so they can discover how and when to use these free innovative resources. This finding is also backed up by the responses to question 24 and 25, where 70% of teachers stated that there is no refresher STEM training conducted on a regular basis, and 87% stated that professional development is not compulsory nor applicable. It is a worrying finding that 34% of teachers stated that professional development is not applicable, as it is a well-accepted fact, that professional development for teachers is a vital importance to ensure that they are working with updated knowledge and skills. The absence of this can have a detrimental effect on student learning within the classroom.

Based on the findings of this report, it is very clear, that a lot of work needs to be done on the training of teachers regarding student engagement and motivation, online assessment and appropriate use of digital technologies and teaching methodologies. Therefore, the lesson plans and e-modules that project partners will develop as part of intellectual outputs 1 and 2, will focus on these areas. Please see the mind map in Annex I. showing student engagement and motivation as a central theme and the peripheral professional development categories that were drawn up based on the findings of this survey.

Annex I. Mind map

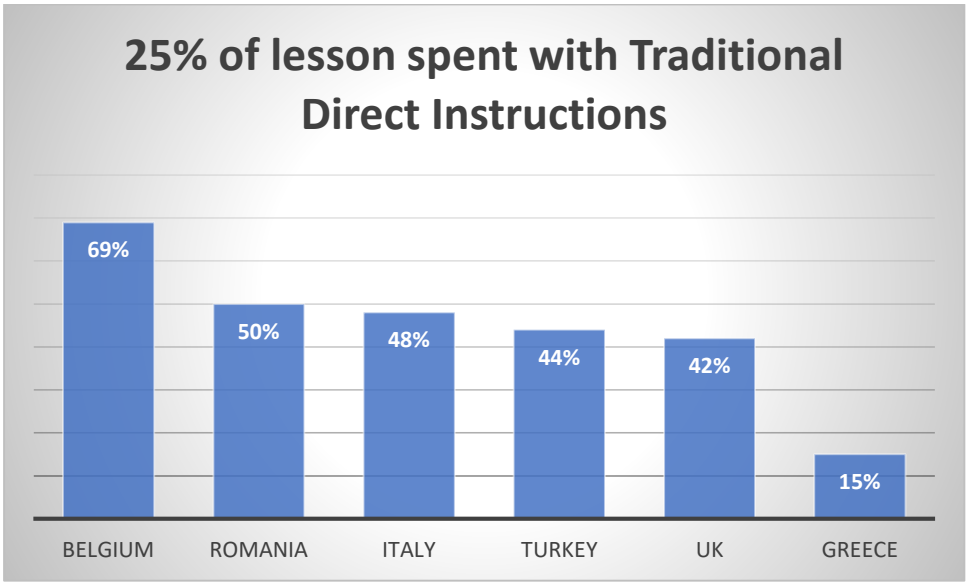


Annex II.

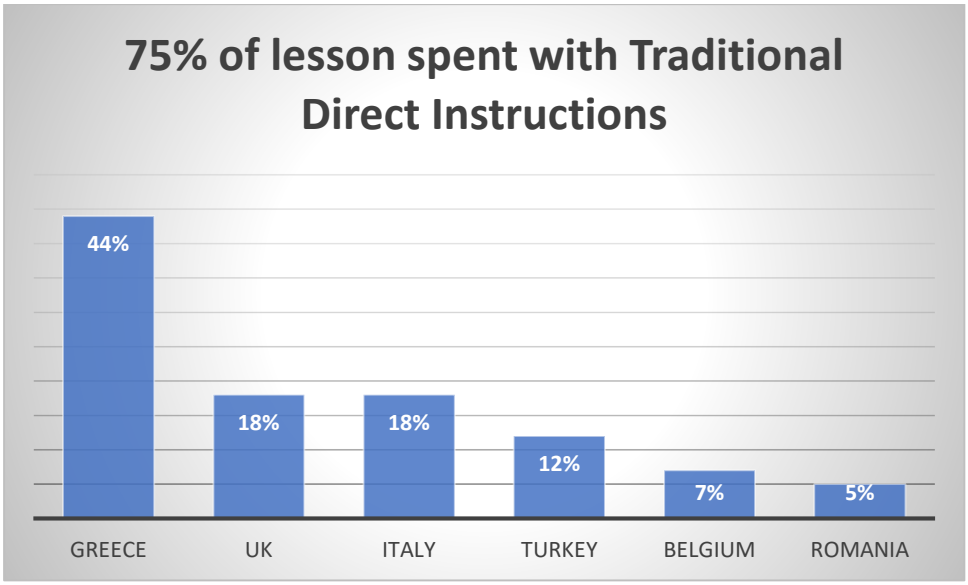
Question 7. Which of the following pedagogical approaches do you use in your STEM class? On average, how much time do you spend on them?

As most of the teachers stated that they use direct instruction for 25% and 50% of the class, the following charts show the breakdown of responses per partner countries:

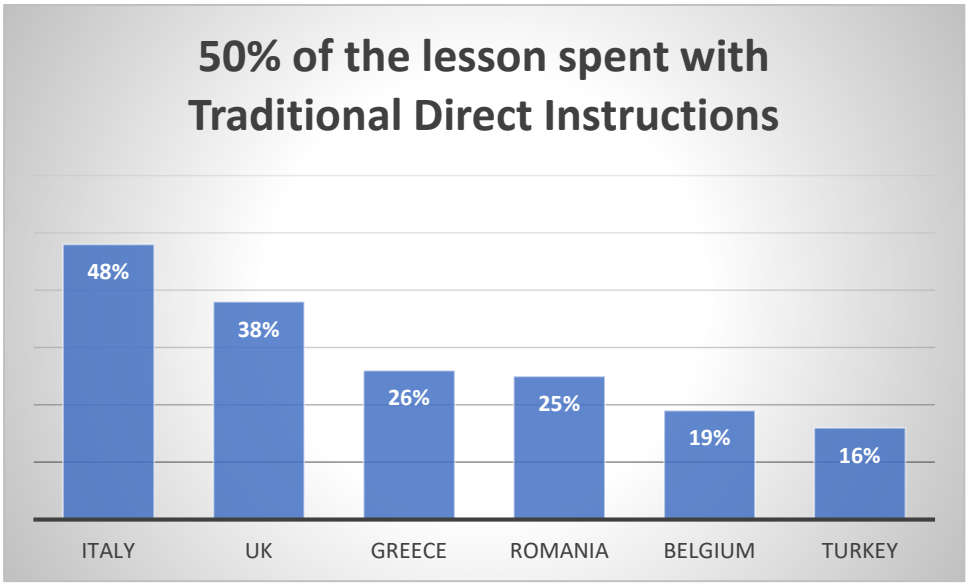
69% of the Belgian teachers stated that they spend 25% of their lessons using traditional direct instructions, while only 15% of the Greek teachers do.



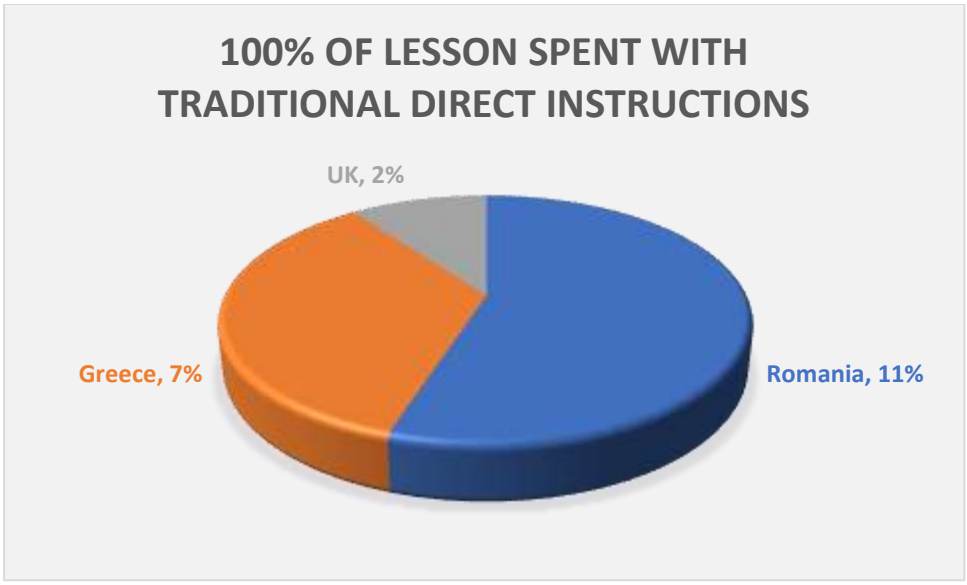
The results showed that most of the Greek teachers spend 75% of their lessons with traditional direct instructions:



48% of the Italian teachers spend 50% of their lessons with traditional direct instructions:



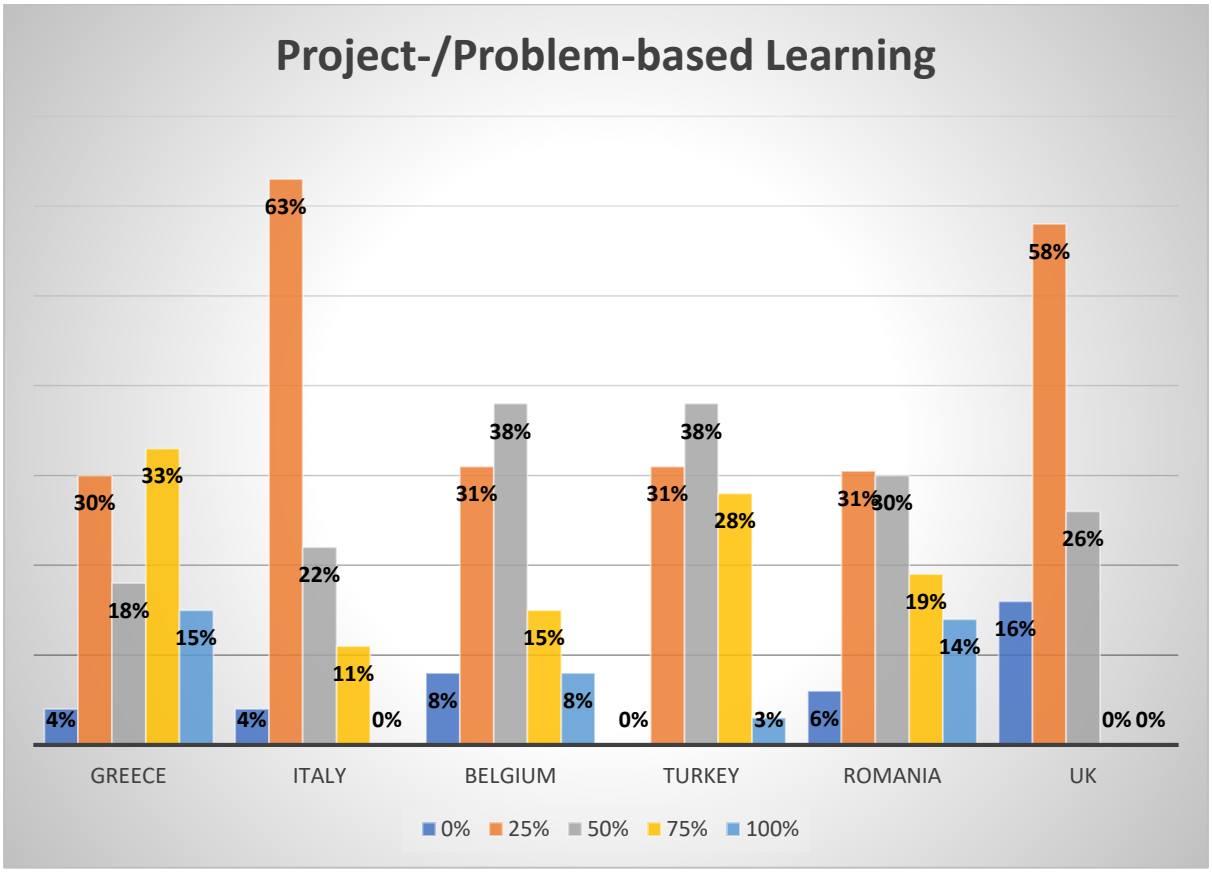
None of the Belgian, Italian and Turkish teachers indicated that they spend 100% of their lessons with traditional direct instructions.



Q. 7. Project/problem based teaching methodology breakdown for each country

It is recommended to use this type of teaching methodology for 75% of the lesson as it takes time for students to familiarise themselves with the problems and to understand exactly what is being asked of them in terms of problem solving and project based learning approaches. Especially if this methodology is coupled with team working activities e.g. group project work to allow time for students to discuss, interact, formulate hypotheses, develop a methodology, test the method and carry out the investigation. Time also has to be given to collating data and drawing conclusions and forming recommendations.

From the results, it can be seen that Greek teachers use the problem based approach most for 75% of the lesson, followed by Turkey, Romania, Belgium and Italy. UK teachers did not state that they use this methodology for 75% of the lesson.



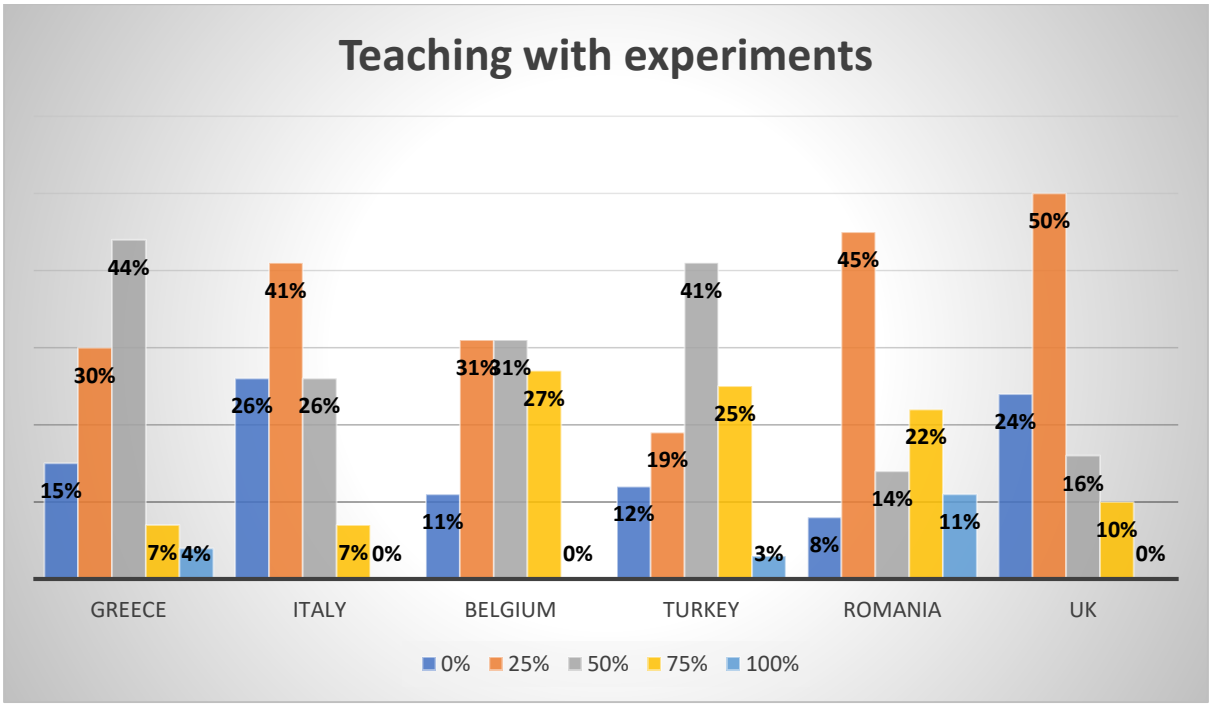
Q.7. Teaching with experiments teaching methodology breakdown for each country

Teaching with experiments and providing hands on learning in STEM education is very important. Students are more engaged, and they are more likely to remember what they have learned because of their experience. According to research, students who engage in hands-on experiences achieve at rates as much as 20% higher than their peers who are not similarly engaged.

From the results, it can be seen that 26% of the Italian teachers do not use this type of teaching methodology at all, followed by UK with 24%, then Greece with 15%, Turkey with 12%, Belgium 11% and Romania with 8%.

Most of the teachers use this teaching methodology for 25% of the lesson, therefore it is believed that these refer to teacher demonstrations where students did not actively participate in the experiment.

Teaching with experiments methodology is recommended to be used for 100% of the lesson allowing time for students to carry out the required experiment and discuss results. It can be seen from the results, that only 11% of the Romanian teachers use this methodology for 100% of the lesson, followed by Greece with 4%, then Turkey with 3%. The Italian, Belgian and UK teachers stated that they do not use this methodology for 100% of the lesson.

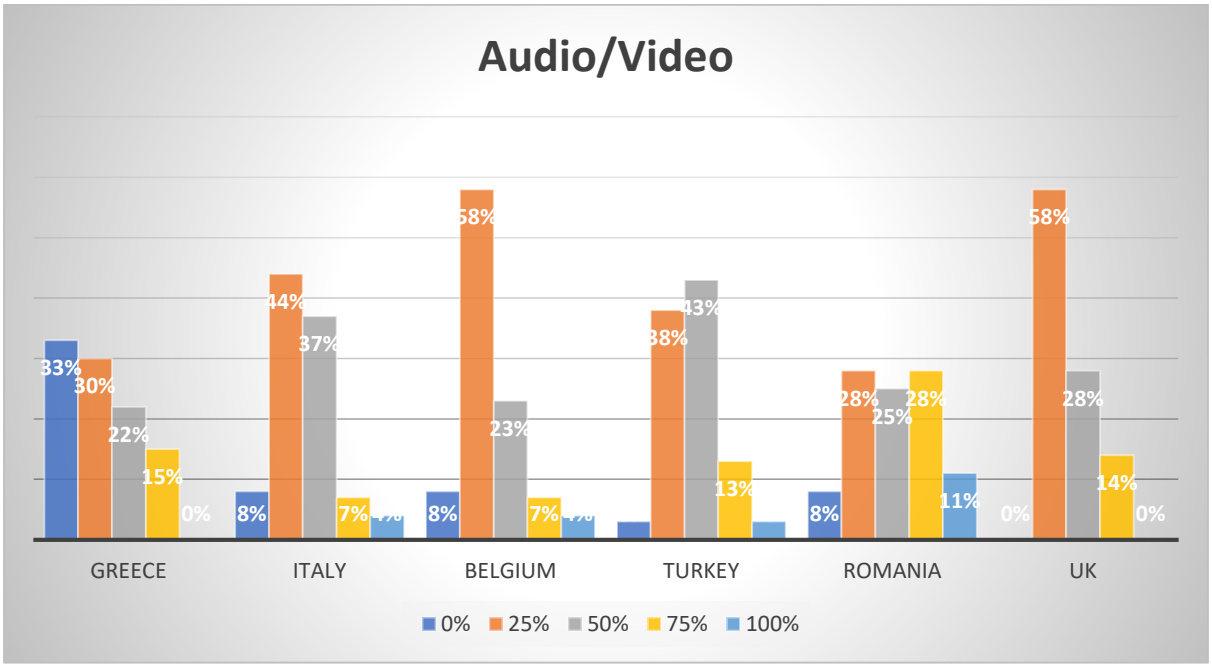


Q.8. Audio/Video Materials as a learning resource when teaching a face-to-face STEM class

Guo *et al*., 2014 analysed results from 6.9 million video-watching sessions and they found that the maximum median engagement time for a video *of any length* was 6 minutes, therefore making videos longer than 6–9 minutes is likely to be wasted effort.

It can be seen from the results, that Greek and UK teachers do not use Audio/Video materials for 100% of the lesson, whereas 11% of the Romanian teachers do, followed by 4% of both Italian and Belgian teachers and 3% of Turkish teachers. However, most of the teachers use this type of resource, when teaching a face-to-face STEM lesson:

- 58% of both UK and Belgian teachers
- 44% of Italian teachers
- 38% of Turkish teachers
- 30% of Greek teachers
- 28% of Romanian teachers.

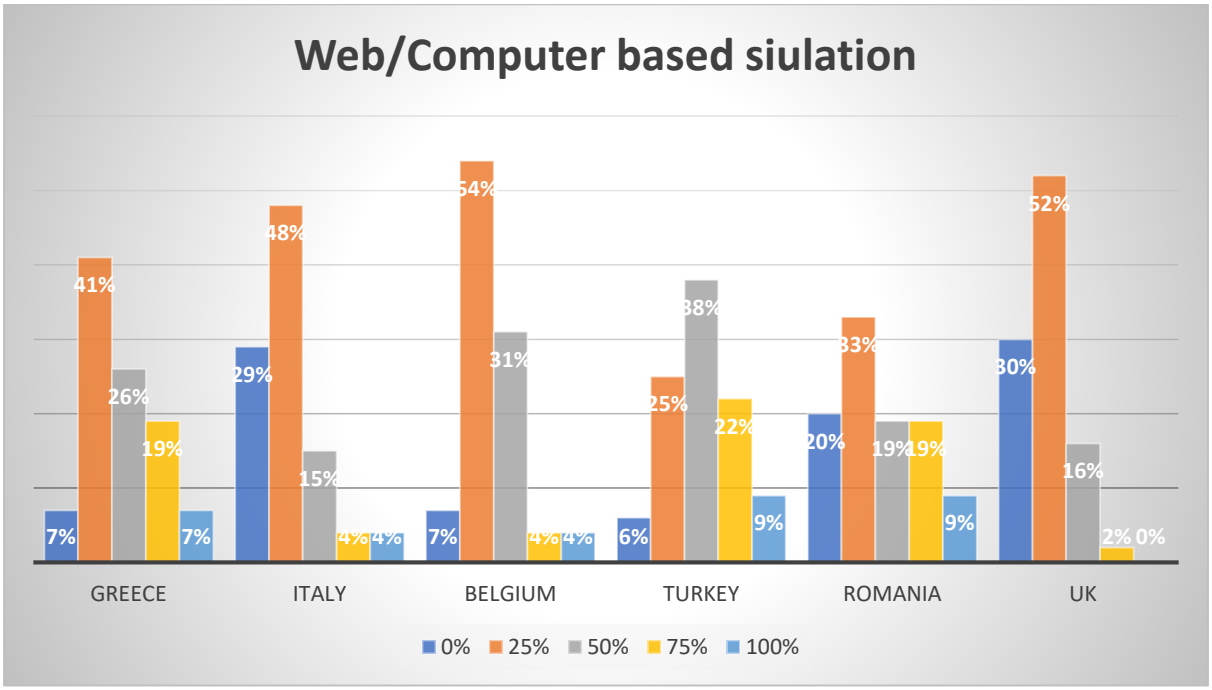


Q.8. Web-based as a learning resource when teaching a face-to-face STEM class

Web and or computer based simulations was the other most popular teaching method when teaching face-to-face. Experiential learning, such as simulation, encourages higher-order learning, which promotes critical thinking abilities and self-directed learning. Based on research, students involved in experiential learning have a greater understanding of their subject matter than students in a traditional lecture-only class. There are three elements necessary for effective simulations:

- Preparation
- Active student participation, and
- Post-simulation debrief.

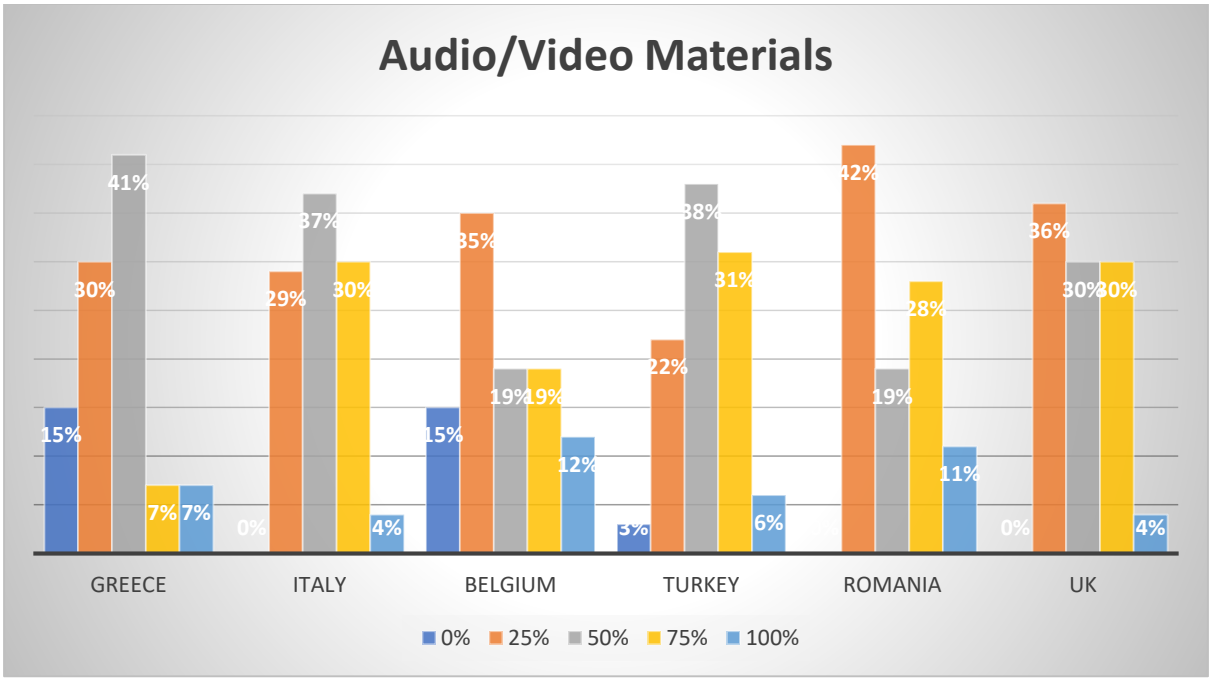
Therefore, it is recommended to use simulations for about 25% -50% of the lesson, depending on the scientific concept and experiment. The results show, that the majority of UK (52%), Belgian (54%), Italian (48%), Greek (41%) and Romanian (33%) teachers use simulation for 25% of the lesson. However, the majority of Turkish teachers (38%) use simulation for 50% of the lesson. There are science teachers who do not use simulation at all with 30% of UK teachers, 29% of Italian teachers, followed by 20% of Romanian teachers, 7% of Belgian and Greek teachers and 6% of Turkish teachers.



Q. 10. Audio/Video Materials, Robots/Boards and Online game based tools (Kahoot, Socrative etc.) as a learning resource when teaching an online STEM class

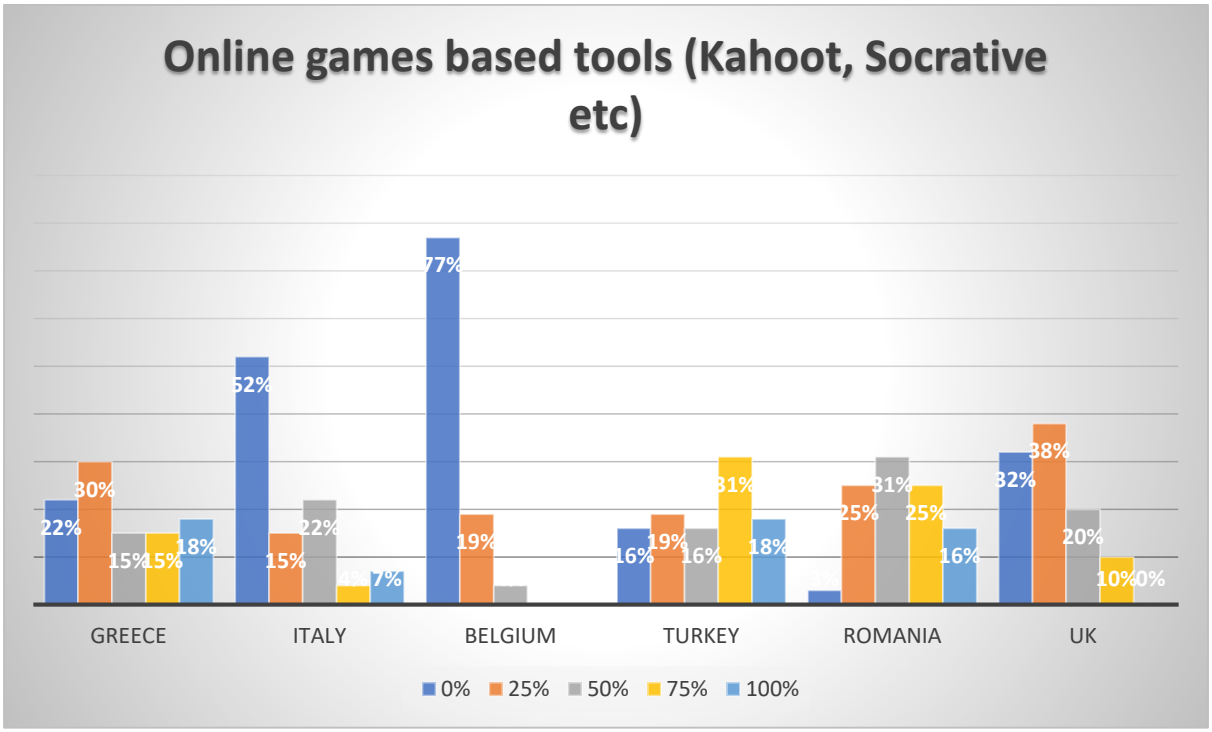
Audio/Video Materials

As for face-to-face teaching, Audio/Video materials was one of the most popular resources that teachers use when teaching online. The following chart shows, that the majority of Romanian (42%) teachers, UK (36%) teachers and Belgian (35%) teachers use this resource for 25% of the online lesson, whilst the majority of the Greek (41%), Turkish (38%) and Italian (37%) teachers use Audio/Video Materials for 50% of their online lessons.



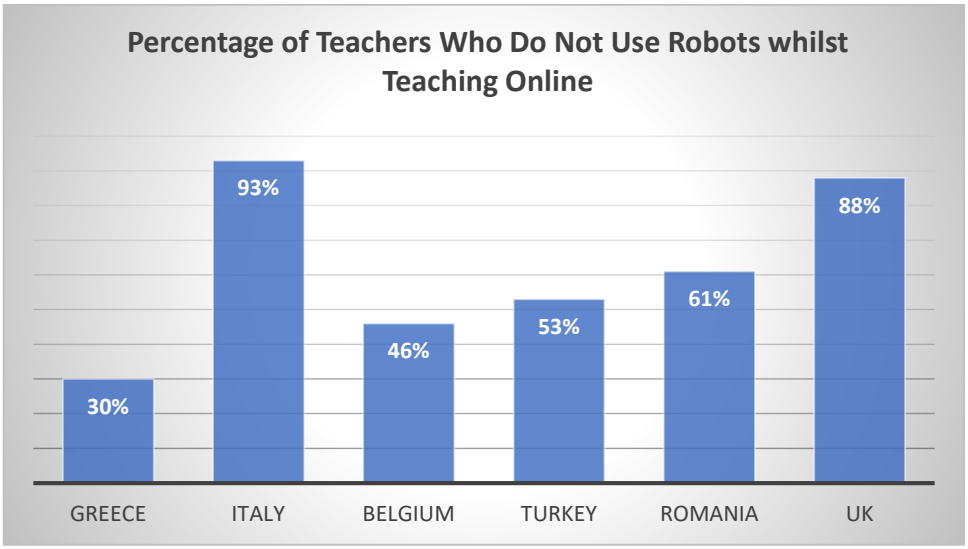
Online game based tools (Kahoot, Socrative etc.)

Online games based tools such as Kahoot and Socrative was the other most used resource when teaching online. The chart shows that the time spent with such resources greatly varies from country to country, 77% of Belgian and 52% of Italian teachers do not use these resources while teaching online. However, the majority of teachers from Greece (30%) and UK (38%) use online game based tools for 25% of the lesson, whilst the majority of Romanian teachers (31%) use it for 50% of the lesson and 31% of Turkish teachers use these resources for 75% of the lesson.

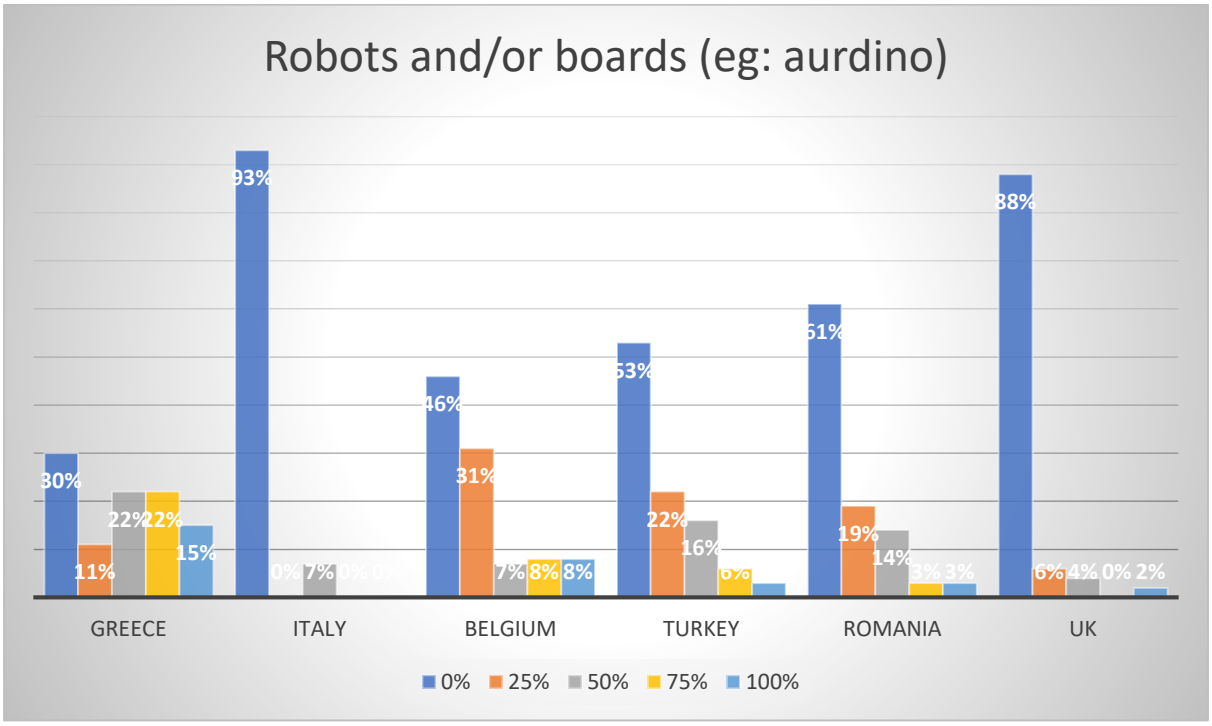


Robots/Boards

Robots and boards (i.e. arduino) was the least used resource while teaching online. It can be seen from the results, that the highest number of teachers who do not use such resources are from Italy, followed by UK, Romania, Turkey, Belgium then Greece.

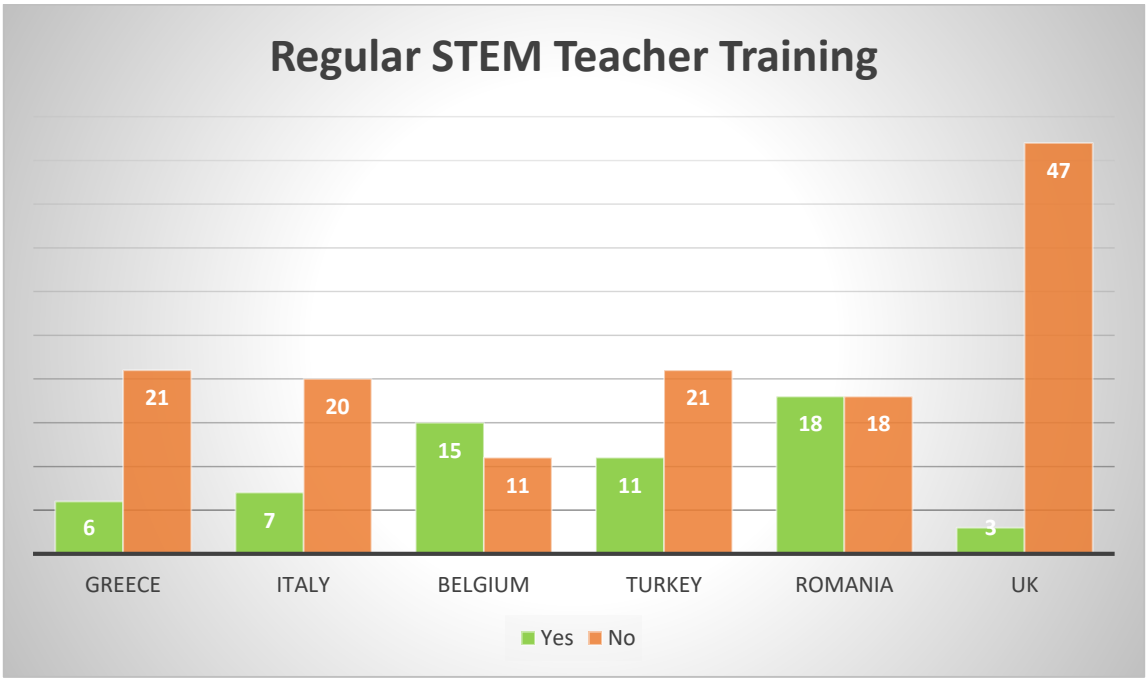


The results also show, that Belgian (31%), Romanian (19%), Turkish (22%) and UK (6%) teachers, who use such resources, they mainly use it for 25% of the lesson, while 22% of Greek teachers mainly use robots/boards for 50% and 75% of the lesson respectively and 7% of Italian teachers use these resources for 50% of the lesson.

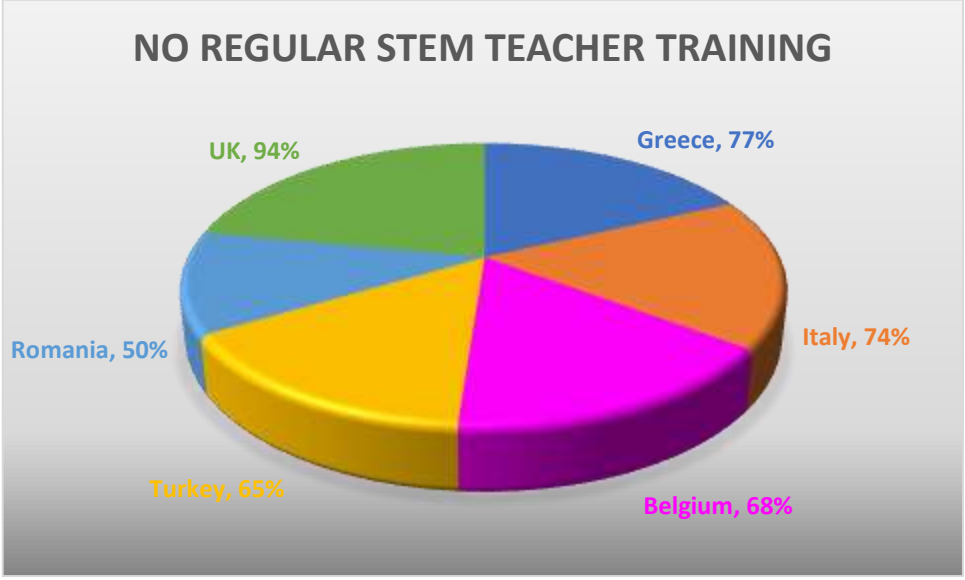


Q. 24. Are STEMM teacher training refresher courses conducted on a regular basis?

The majority of the teachers stated that STEM teacher training refresher courses are not conducted on a regular basis. The following chart shows the results for each country.



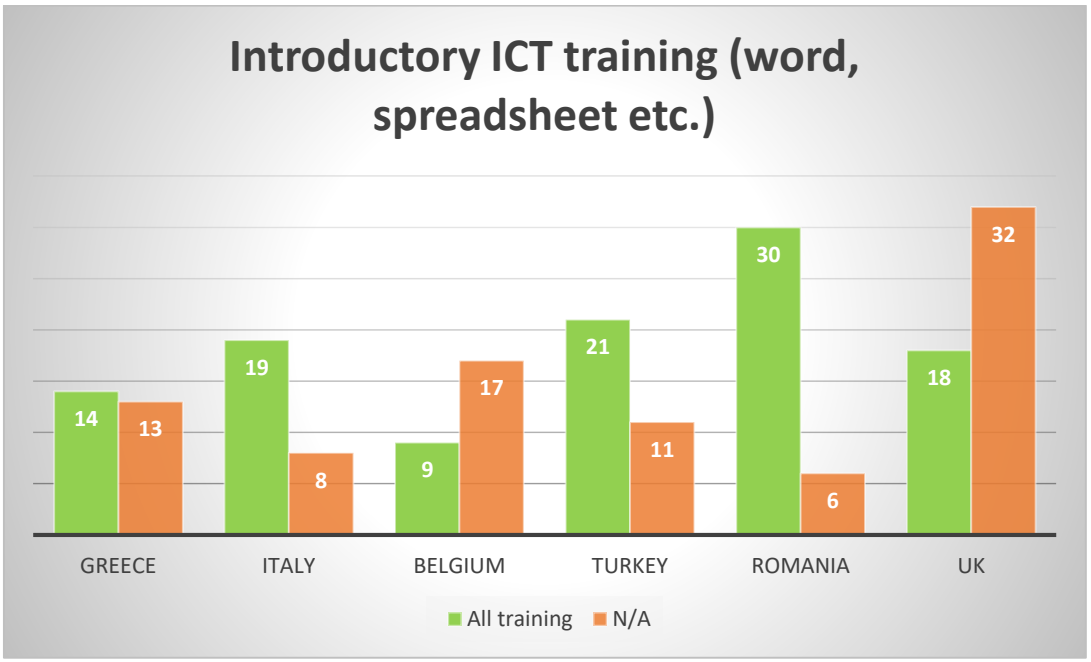
The following chart shows the percentage of the teachers who do not participate in STEM refresher training on a regular basis, with the number of UK teachers amongst the highest and Romanian teachers amongst the lowest.



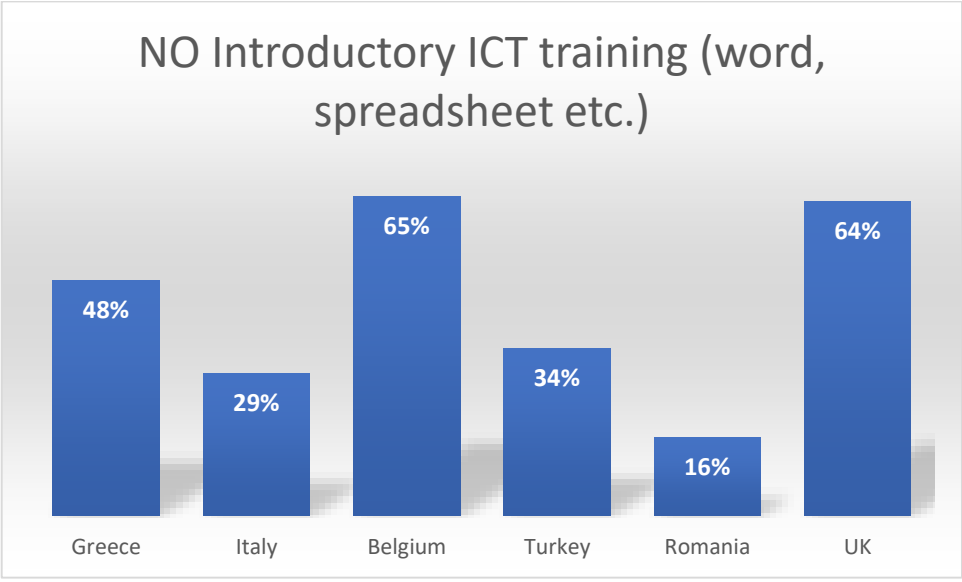
Q.26. In the past two school years, have you undertaken professional development? Please also indicate the mode of delivery and the time spent on the training.

The majority of the respondents participated in Introductory ICT training (word, spreadsheet etc.) and Personal learning about innovative STEM teaching in their own time.

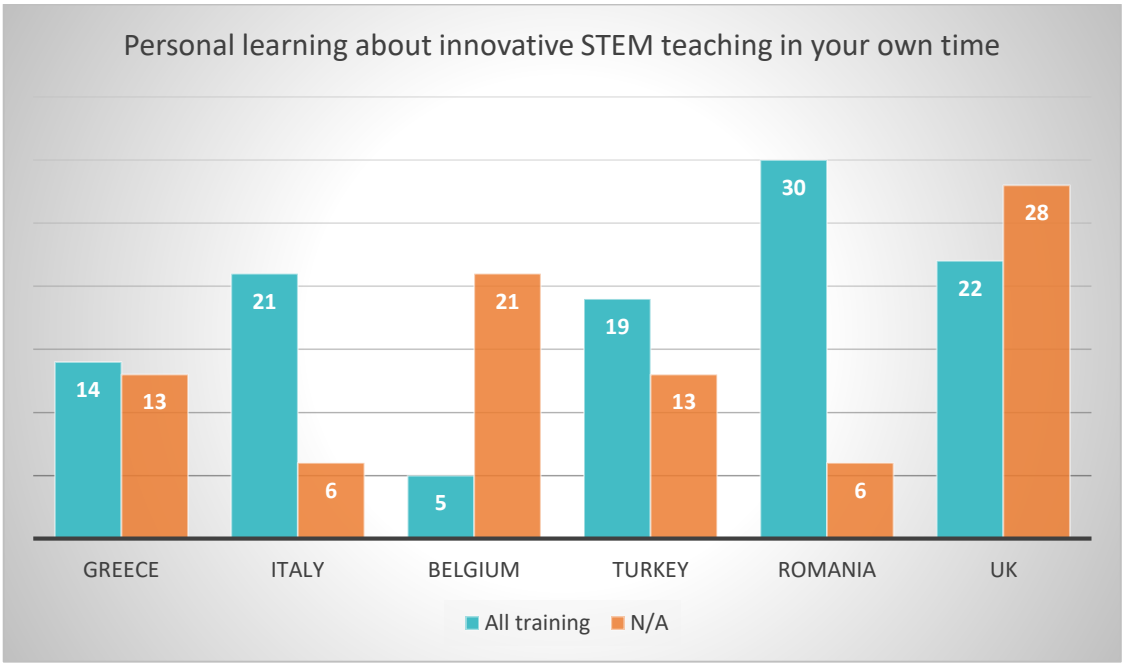
The following chart shows the number of teachers for each country, who participated in introductory ICT training in the past 2 years. The term "All training" means that respondents indicated that they participated in both online and face-to-face training.



The following chart shows the percentage of teachers for each country, who did not participate in introductory ICT training in the past 2 years.



The following chart shows the number of teachers for each country who participated in personal learning regarding innovative STEM teaching on their own personal time. The term “All training” means that respondents indicated that they participated in both online and face-to-face training.



The following chart shows the percentage of teachers, who did not carry out personal learning regarding innovative STEM teaching on their own personal time: