Science, mathematics, diversity and IBL in multicultural settings

Aims of the Module

- To acquire knowledge and understanding of cultural diversity and social inclusion in science and mathematics education, focusing on schools and the classroom.
- To understand and experience how the use of contexts in science and mathematics IBL tasks can support inclusive education and intercultural learning
- To acquire knowledge and understanding of the main challenges related to teaching in multicultural classrooms, such as creating an inclusive classroom culture.
- To be able to recognize and use opportunities to include culture-related aspects in science and mathematics teaching and dealing with controversial issues (dilemma's).
- To gain skills to apply the course knowledge into a practical knowledge related to interventions in multicultural classrooms
- To become reflexive of one's own normative position and values in relation to cultural diversity
- To learn how IBL can support students by taking into account their various cultural backgrounds
- To learn how to use IBL to promote students' intercultural competences by using realistic relevant contexts situated in different cultures.

Structure & Length of the Module

Overall length of the module: 280 min + 140 min homework
Overview of the sequence of activities:

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Activity 3.1 - Teaching your own diverse class (3 x 30 minutes)

Part a – how (culturally) diverse is your class?
The aim of this activity is to have teachers explore the meaning of *diversity* and *culture* and apply these to characterise their classrooms and think about ways to include all students in their teaching.

Ask participants individually on a sheet of paper to describe or visualize the (cultural) diversity of the student population in one of their classrooms (5-10 minutes).

> Note: do not yet provide guidelines on what is meant by culture or diversity. Participants can decide on this themselves, they may use aspects addressed in the course.

Have participants in small groups share their results and look for common elements of diversity and how they interpreted the term 'culture' (10-15 minutes).

Wrap up the findings In a whole group discussion and focus on these elements of diversity as well as the notion of culture (10 minutes).
Note: You may want to guide the discussion towards a broad understanding of culture: not just focussing on ethnic background, language and traditions, but also including more local subcultures (urban or rural) and -most important- what students may see as their 'personal culture' and the culture of the 'peer groups' they feel they belong to.

For diversity you can refer to the definition used by OECD[1]:

> "diversity" is a multi-faceted concept that can contain as many elements and levels of distinction as required. Work on the topic includes but is not limited to: age, ethnicity, class, gender, physical abilities/qualities, race, sexual orientation, religious status, educational background, geographical location, income, marital status, parental status and work experiences.
> *Educating teachers for diversity: Meeting the challenge. (2010). Educational research and innovation. Paris: OECD, p. 21*

Note that in the last part of this activity (1c) you can find more background on definitions of diversity and culture

Part b: IBL in a multicultural setting
The aim of this activity is to have participants see and discuss an IBL task in which the connection can be made to different cultural backgrounds and personal preferences of students.

We make use of the exemplary IBL task: 'design a healthy multicultural menu for your school-canteen'. Give participant some minutes to read the text below (which is also on worksheet 1). It is a short introduction (for students) on a series of lessons about designing a healthy multicultural meal or menu for their school.

> In this activity you will, in a small group, design a healthy, multicultural meal for your school. First you will need to do some research.
> - What is meant by a healthy meal? What makes a meal healthy?
> - What is multicultural in your school?
> - What are common meals in different cultures?

[1] see: http://www.oecd.org/edu/ceri/educatingteachersfordiversitymeetingthechallenge.htm

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Next you will need to decide on your meal
- What dishes will be in your meal?
- What ingredients are needed and how much of each?
- What does your meal cost?

In the end, you may want to check for other issues:
- Are there students in your school for whom this meal is not suitable?
- Is the meal animal friendly?
- etcetera

Note: You can find a worked out version of these lessons in the collection of classroom worksheets on the MaSDiv website.

Ask participants to talk in pairs (5 minutes) about the following questions related to the above introduction and the context (healthy multicultural meal) of these lessons:

Questions:
- What characteristics of IBL do you recognize in this assignment?
- What subject-specific content and concepts can be related to this context?
- What benefits and advantages does the use of this context present?
- Which opportunities and challenges does this context present for:
  - Relating to the different cultural backgrounds of all students?
  - Addressing fundamental values? (see module 2)
  - Inclusive education? (see module 1 for a list of characteristics).

Lead a group discussion. The aim is to hear the following (if necessary provide this yourself):
- This asks students to do some research within a given time frame (they need to think for themselves which questions they find most relevant, how to collect data, how to process their data and how to report on their findings). For each of these processes of inquiry a teacher can think in advance what kind of support/scaffolding is needed.
- This context can be related to concepts from biology, like: health, energy and nutrition (proteins, fat etc.) and concepts from mathematics, like: estimation of costs, measurement, proportion and quantities. These concepts may be made richer or more meaningful by applying them in this context and seeing the practical value.
- The context can be motivating for students because they can connect to it. It is easy to relate this context to different cultural backgrounds, because the menu must be 'multicultural'. Students can discuss what type of meals they normally eat at home, they can bring recipes (from their culture or family), they can find similarities and differences in meals and eating habits etc..
- The above helps realize inclusive education because it increases the participation of all students and values them equally. The differences between students are used as a resource to support learning.
- Fundamental values like worldwide (unfair) sharing of food and the availability of healthy food, can be discussed. By asking for example: what options would schools in Peru have? or in Syria? or in Sudan? etc..
  Note: You can also connect to the activity "Can the Earth feed us?" (see module 2 and a worked out classroom example on the MaSDiV website)
- Classroom culture and norms can get attention: respecting each other's ideas, collaborating, making decisions together in a 'democratic' way, etc.

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Part c – culture and diversity

In this part of the activity participants further explore the meaning of diversity of culture and of intercultural teaching. They discuss which paradigm (homogeneity, heterogeneity or diversity) best fits the situation in their school and their teaching practice.

Paradigm shift

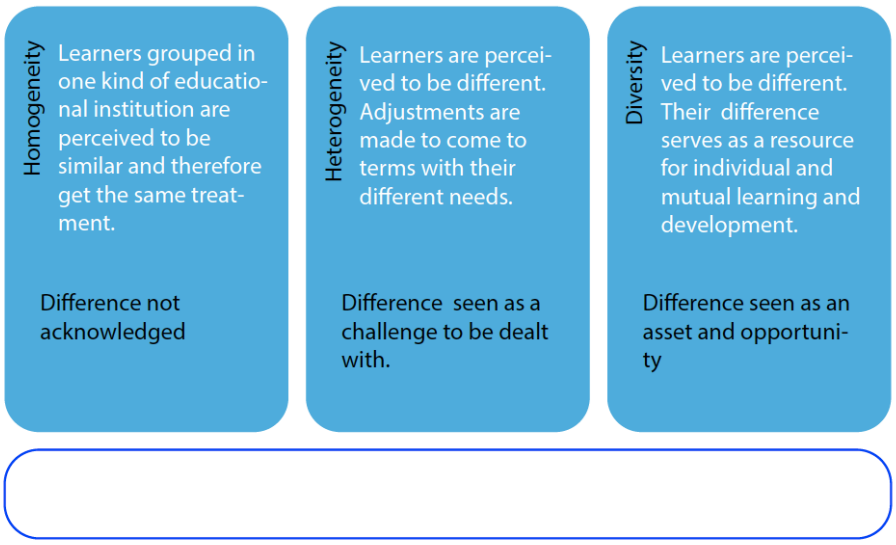
Note: we designed this part as a Think-Pair-Share (TPS) activity. You may change the way of working if TPS does not fit your group.

Think: Show the figure below to participants and ask them to indicate individually where they are now in their school and in their own classroom teaching: homogeneity, heterogeneity or diversity?

Pair: Have participants in pairs (if possible make pairs of teachers from different schools) discuss their position on the scale in relation to the three 'paradigms' and ask them to illustrate this with a concrete example.

Share: With the whole group discuss how teachers feel about these paradigms; where they are now and where they hope to be in the near future. If applicable: what steps will they take to get there?

Paradigm shifts: from homogeneity to heterogeneity to diversity



What is the position of your school in this respect? (mark with an X)

Note: make sure that in the discussion participants are respectful and do not offend each other. Although there may seem to be a direction in the picture towards the paradigm of diversity, teachers and schools may have reasons to not want or be able to move there. Ask for reasons and address these respectful.

What is meant by diversity and culture?

Participants in small groups read and discuss the definitions of diversity and culture on worksheet 2. Ask them to focus on the questions:

- Which aspects of diversity are particularly important for mathematics and science education and why?
- Which of these aspects do you meet in your classes?
- Do you recognize the way 'culture' and 'intercultural situations' is being defined here?
- Can you give an example of 'intercultural situations' from your own teaching practice?
- How would you define cultural diversity?

Note: You may also use other or more definitions if you want to go deeper into the theoretical background.

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Activity 3.2 - Cultural roots of Science and Mathematics (45 minutes)

The goal of this activity is to have the participants challenge their own (implicit) values and beliefs about the nature and origin of mathematics and science, and to have them think about to what extent multicultural roots are equally addressed in their educational practice. Is the way we do, learn and use mathematics and science the same all over the world? And throughout history? The leading statement is: Mathematics/Science is an intercultural (or multicultural) subject.

Introduction (5 minutes)
Have participants individually write their answer (3 lines) to the question: 'What is science/mathematics for you?' on a small card.

Debate (2 rounds of 10 minutes + 5 minutes wrapping up)
Organize a debate (or use another way of working) to discuss one or more of the following statements:

- Science/mathematics is a neutral subject.
- Science/mathematics has nothing to do with culture.
- I can only recall famous Western scientists and mathematicians.
- Science and mathematics are objective disciplines based on a fixed body of knowledge that has been proven over time
- I do not have to pay attention to culture in my science/mathematics lessons because in my class there is no variety in cultural backgrounds amongst my students.

Note: on the internet you can find several guidelines for organising a (small) debate. Another way of working you may want to use here is having participants take position on a line from 'fully disagree' to 'fully agree'. When positions are taken, ask one or two participants to present their arguments. Do not go into debate. A third way of working can be to have participants give a brief pitch (max. 1 minute) about their view on one of the statements. See below for background and outcomes of the discussions.

Deepening knowledge (20 minutes)
In small subject-specific groups have participants do one or more of the following assignments**.** You may also decide to do one or more of these with your whole group.

Science-group: Compare your beliefs about what science is, using the descriptions written on the cards. Compare these to the descriptions of Indigenous Science and Indigenous knowledge from several sources (see worksheet 3). How are Western science and Indigenous science similar and different? Does this change your view/beliefs on the nature of science?

Biology-group: Watch the video on the biology of race and DNA evidence https://www.youtube.com/watch?v=VnfKgffCZ7U
Discuss the following questions: What is the conclusion of the video(s), is racial/cultural background a valid population indicator? Which underlying biological processes feed this need to categorize people into certain groups? Are we allowed to label people as different? What is race? How "hard" is scientific proof? When do we define groups in a population as different and why do we feel the biological urge to make distinctions between groups?

Mathematics-group: Study and discuss the example 'Who invented Pascal's triangle?' on worksheet 4. What does the name 'Pascal's triangle' suggest about the origin of this array of numbers? Is it important for you to know about the history and cultural roots of mathematics? What value might it have for (specific) students in your class to know about this? Would you use this example with your students? Do you know of other examples or theorems that have many different roots all over the world?

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Background and outcomes for the discussion(s)

The discussion(s) should lead to the understanding that, in order to include everyone in multicultural teaching, it is helpful to:

- be able to recognize and incorporate multicultural contexts
- have knowledge of subject background (origins, history, development, adaptation, adoptions and parallel evolution).
- relate to the multicultural background of the students in class.

Have participants share the outcomes of the assignments and focus on answering the question:
Is mathematics/science subjected to cultural differences?
You can choose a suitable method for exchanging opinions, fitting the composition and size of your group. In the discussion(s) the following observations and questions can be used.

- Some participants may think that contributions to mathematics and science are mainly of western origin. They may not be aware of contributions from other cultures and older or other civilizations like the Mayans, Egyptians, Persians, Indians, Aboriginals, Native American, Asians, Greek or Romans. If this is the case provide some (more) examples of non-western scientists and inventions, products, instruments etc. from indigenous science (like traditional medicine, celestial navigation, number systems).
- Ask participants if they would use (one or all of) these examples in their teaching or present them to their students? Why? Why not? Would specific students benefit more from these examples than others?
- You may also want to discuss whether participating teachers belief their subject is easy to use in or adapt to a culturally diverse setting. Or more specific if they feel that because their student population is culturally diverse, their subject lessons should relate to this as well. As in previous activities use the broader OECD definition of culture here to talk about culturally diverse classrooms (see worksheet 2)

Note: On the website https://www.nameorg.org/learn/ you can find sources (e.g texts, backgrounds, questions) about 'being an multicultural educator in mathematics or science': https://www.nameorg.org/learn/can_i_be_a_multicultural_educa.php)
https://www.nameorg.org/learn/i_teach_science_can_i_be_a_mu.php

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Activity 3.3 - Dilemma Cards (30 minutes)

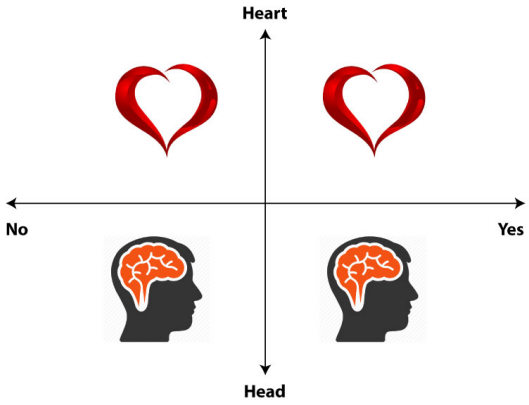
In this activity we change focus from science and mathematics as disciplines to everyday contexts or situations that play a role in teaching practice. In the activity we make use of dilemma's related to cultural background. Do the participants recognise that some "everyday" topics and contexts they use in their classrooms might be problematic for some students because of their background and moral values they were raised with? Do you feel that you can address these topics and have everyone in your classroom still feel safe and valued? Some considerations and techniques to handle such topics or dilemma's will be discussed.

'Move reasoning'
In a (culturally) diverse classroom teachers may face dilemma's in their teaching. The set of cards on worksheet 5 can be used to have participants discuss dilemmas related to science or mathematics teaching in (culturally) divers classrooms.
Note that you may also use dilemmas related to socio-scientific issues as discussed in module 2.

We will use a way of working with these dilemma's, that combines reasoning with 'head' and 'heart' and involves also physical movement ('move-reasoning', see also module 2)[2]. Make sure there is enough room for participants to move along two axis (see figure xx).

Select one of the dilemma cards and read it aloud. Ask participants to form their opinion and take position along the axis running from "Yes I would discuss or perform this in my class" to "No I would avoid this topic in my class".

Next each participant considers whether his/her decision is based on feelings/beliefs (referred to as "heart") or on rationality/thinking (referred to as "head") and takes position in this direction as well. The head-heart axis is perpendicular to the yes-no axis. This will result in participants standing divided over the four quadrants.



Ask participants to explain why they took this particular position on each of the axes. Note: You may also ask them to explain their position immediately after they have chosen position on the yes-no axis. In that case you ask them first to explain why they took this position and then you ask them whether they reasoned more 'by head' or 'by heart' and you have them take their position according to the head-heart-axis. It is important to emphasize that all opinions are valid, meaningful and not up to debate. Be sure to ask participants on different positions to provide arguments: why did they take this position? Are there experiences in the past that formed their opinion? Is their opinion based more on beliefs/emotions or more on reasoning?

After some reasons/arguments haven been shared you may want to ask participants if they would rather move to another position now that they have heard more arguments . If participants have

[2] https://elbd.sites.uu.nl/wp-content/uploads/sites/108/2017/05/2599_2_artikelp.v.d.zandebeweegredeneren.pdf

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moved, ask some of them to explain what made them change their opinion. Was head or heart involved or both?

Note:
If the (class)room is unsuitable for this activity (e.g. if walking around is difficult due to unmoveable furniture or tight spaces) or if there are other reasons why the group of participants would like to remain in their seats you may use coloured cards to represent the four quadrants (yes-heart, yes-head, no-heart, no-head). Participants then raise the card that best fits their position.

Reflect on the activity especially on the effect of including the 'head-heart'-axis: how did this help participants? Research has shown that emotions play a role when reasoning about moral dilemmas[3]. Did the activity make this clear for participants? Also ask participants if they think it is possible and desirable to use this type of activity (move-reasoning) with their students to address for example cultural or socio-scientific issues?

Note: You can use the dilemma cards in several other ways. Choose the way that best fits your group.

- Have participants choose the dilemma's they are most likely to encounter in their daily teaching practice, and discuss these in small groups.
- Create three areas (poster or table for example) in the room and label these: irrelevant, relevant, very relevant. Hand out 5 cards to each participant let them divide their cards over these areas. Present the distribution of cards to the group and discuss if anyone wants to change the position of a card and motivate that decision. Can they convince the group to agree on changing the position of the card?
- Hand out or let the participant pick three dilemma's and let them describe how they would overcome these dilemma's in their classroom. In doing so have them share good practises from their own teaching.
- Ask participants to think of more dilemma's, for example ones that they did encounter in their daily practice. Add them to the list and discuss them briefly: do other participants have similar experiences

Note: You may want to encourage participants to use one of these teaching methods (ways of working with dilemma's) in their lessons. They may use the dilemma cards presented here and adapt them for use by students (this mainly involves rewording the dilemma's), or use subject related dilemma's or socio scientific issues (see module 2 for examples).

3 see for example: Van der Zande, P.A.M. (2011). Learners in dialogue. Teacher Expertise and Learning in the Context of Genetic Testing. Utrecht: Utrecht University (PhD thesis).

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Homework: design of a teaching activity

The aim of this activity is to have participants prepare an IBL-teaching activity for their diverse class using a context-based approach and incorporating elements addressed in the previous activities. They may choose to focus on (1) using a context that uses cultural diversity of students as a 'resource' (2) addressing the cultural roots of mathematics or science or (3) including moral dilemmas or socio-scientific issues related to cultural diversity.

Note: This activity must be done before the last meeting of the course. You may want have participants start designing the teaching activity during a session, but this is not compulsory it can also be just 'home work'

Preparation – optional: during a meeting
Have participants work together in small subject specific groups on designing a first draft of the teaching activity. Let them prepare a general outline in which they :

- Identify the class, the topic and the elements they want to include (see above)
- Formulate (SMART) learning goals and make sure the activity and teaching method fit the intended goals.

Have participants briefly discuss the following questions

- How will your teaching activity (the context and IBL) ensure the involvement of **all** students and take into account the (cultural) diversity in your class? What is your role as a teacher?
- Will it be possible for all your students to relate the activity to their own cultural background? Which elements in the activity support this? What is your role as a teacher to achieve this?

Design and try out - homework
Have participants finalize the activity at home and try it out in school. Ask them to bring their materials to the next meeting and the filled in sample evaluation form on worksheet 6 and (optional) prepare a brief presentation about their experiences (3 minute pitch, poster, 2 ppt sheets etc,).

Presentation and discussion – in the last meeting
Have participants share/present their teaching activity (materials and experiences). You can do this in small groups or in the whole group.
Discuss topics from the sample evaluation form such as: did it work out as they hoped/expected? What went well? what was difficult?
You can also use the questions that were discussed during the preparation.

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Activity 3.4 – Different ways to tackle and solve a problem (45 minutes)

The aim of this activity is to have teachers become aware how students' cultural backgrounds may influence the way they do science and mathematics, and more specific how they perceive and work on open (IBL) problems. Note: This activity may seem especially interesting for participants who teach multicultural classrooms with students who (recently) came from different countries/(sub)cultures, but it can be used with any group of teachers.

Part a: Different ways to count and calculate (examples from mathematics)
Participants study worksheet 7 (2 pages) that contain examples of different ways to make calculations (multiplication and division) on paper. Ask them to analyse each calculation method and compare it to the one they use themselves and the one their students may use.

Discuss how (cultural) background and culture may influence ways of calculating, especially if students or participants went to school in other countries. Further discuss how participants would deal with these differences in class:

- Do they have all students use the same (their) method? Do they allow students to use their own methods?
- Would they have compare and discuss the different ways in a class discussion?
- Would they use these different methods as a topic for investigation by students themselves?
- Would they themselves as teachers provide other procedures or algorithms. For example (ancient) methods for multiplication like: lattice-multiplication (ancient Iranian) or multiplying by lines (Japanese) or multiplication by doubling and halving (ancient Egypt).

Note: Be respectful towards all reactions. You may connect this to the three paradigms of activity 1c.

Part b: Different ways to react to open problems (and IBL)
Participants may have noted that their students react in different ways to open problems and IBL. This may be influenced by students own learning style, by how familiar students are with open problems and IBL etc. But it may also be influenced by what their experiences and (culture-based) beliefs are about 'how school and learning works'. For example if students are used to a teacher being the 'all-knowing' authority, they may not feel comfortable to think about their own ways of solving a problem.

Make groups of three participants: two will act as problem-solvers and one as observer/note-taker.
Present one or both of the following open problems (the first one is more math-oriented, the second one relates to science) :

- How much water will you save while brushing your teeth if instead of leaving the tap open you close it?
- How could you separate the salt from the sand taken from a beach?

The two solvers together solve the problem out loud. The observer makes notes about the process.

In a whole group discussion share how solvers worked on the problem, focus on the process and issues like:

- was the problem clear?
- how did they start? could they immediately start? what did they do, discuss, …?
- what knowledge did they need (and use)? Everyday knowledge as well as scientific knowledge?
- did they just try things? did they dare to make mistakes? and discuss them?
- how did they deal with insecurity?

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Next have participants (in subject specific) small groups discuss how they think their students would react to these (or similar) open problems and IBL?

- What would be students first reaction and how would they proceed (use the questions above)?
- What influences the way in which different students react. Do background, culture, language, previous experiences play a role?

Also discuss what participants would do with these differences in class:

- not use open problems and IBL
- provide special help/hints for students who experience problems
- have students help each other/work in mixed groups
- discuss these differences in class and make use of the different qualities of their students.

Note: Be respectful towards all reactions. You may connect this to the three paradigms of activity 1c and to module 1.

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Activity 3.5 – Students as scientists (30 minutes)

The goals of this activity are: to have participants find out how their students 'see' science/mathematics and become aware of how students' cultural backgrounds may influence this. They think about contributions (their) students can make to science and/or to their cultural community and to think of scientific citizenship as broader then just being curriculum or subject based. Students can act as scientist by identifying problems and developing solutions to solve these. Participants recognize the value role-models of scientists can have for enhancing self-efficacy of their students. They are able to help their students find role-models each of them can identify with.

Part a: What is science and mathematics?
Participants have written and discussed their own definitions/meanings/beliefs on the nature of science and mathematics (in activity 2). They may have noticed that results differed within the group, this may be influenced by factors such as (cultural) background, age, education, gender etc..

Refer to this experience (activity 2) and ask participants to think of ways to find out how their students see, do and think about science and mathematics. Give participants about 5 minutes to brainstorm about this question.

Discuss ideas in the group. Note: For all the ideas and examples participants bring in, it is important to make sure that in class teachers talk with their students about differences in opinions/beliefs/views and also talk about how these differences may be related to (cultural) background and experiences.

Some ideas that may come from the group or that you want to bring in yourself are:

- Have students write by finishing sentences like 'for me mathematics/science is ……' 'What I like most about mathematics/science is…' 'In my own life mathematics/science is ….' etc.. Discuss differences in class.
- Have students first find and study a role model (scientist) and then ask them to write what science/mathematics is. Discuss in class. Note: see activity 5 for an example.
- Ask each student to take a picture of science/mathematics in or around their home/living environment. Have them bring the pictures to class and prepare a 30 second pitch to present the picture: why did they choose this object/situation? How does it relate to science/mathematic? How is it connected to their (cultural) background and environment? what does it mean to them? Talk with the whole class about different aspects of science/mathematics that can be seen in the pictures and how these relate to students (personal) culture.
- Ask students to look for science topics in the media (tv-news, newspapers, magazines, internet blogs, instagram, facebook, etc.) and present these in class. Discuss what they recognize, what is 'scientific' in the examples and how this influences their 'view' on (school)science. Stress that these 'views' are personal and thus diverse!
- Ask students what a particular science/mathematics topic or concept means for them and how this plays a role in their own environment/life. Concepts/topics may include: *energy*, *force*, *construction*, *symmetry.* Discuss this in class and stress that it is good to see diversity.
  Note: You may use the classroom example 'Defining nature' on worksheet 8.

Part b. Case study
Have participants read and discuss the case study of Boyan Slat (worksheet 9) who started to be a scientist when he was still in high school. Note: If you know local examples of students who act as scientists, make these into case-studies to use with this activity.

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Participants discuss the case study in small groups using the following questions.
About the case-study:

- What message does this example present to you?
- Can you relate this example to science/mathematics?
- What scientific qualities of the student contributes to the success of their actions?

About their own teaching:

- Would you present this example to your students? If so, how would you do this? What tasks would you give your students?
- How do you expect your students to react? You may want to distinguish different reactions of different (groups of) students.

Next participants share the findings from the small group discussions. You may use various methods to do so. Choose one that fits your group (pairing up, whole group discussion etc).
Guidelines for further discussion (course leader). You may ask participants:

- What do you picture your students doing with the scientific knowledge and skills you taught them, in 5 or 10 years from now? How about the more general skills like: IBL, Problem solving, research techniques etc.
- What other skills would you like to teach your students to be successful in their career or adult life?

Part c. Scientific role models

Discuss with participants how role models of scientists that students can identify with, may enhance their self-efficacy[4] when doing science. Ask participants to think about the following questions (you may use ThinkPairShare).

- Do you know of scientists your students admire or see as a role model? Which scientist do you expect your students to identify with? Take into account the diversity in your student population.
- Do you think it important to stimulate your students to broaden their perceptions on science and scientists? Why?
- What can you do in your lessons (activities, tasks, assignments) to help students to identify more with scientist and to relate their perceptions of science and scientists to their own background/history/gender/culture/

In a whole group discussion share ideas. These may include:

- Have students draw a 'scientist at work' and analyse and discuss what these drawing show: are they ‘traditional’ in the sense that they show an (older) male person in a laboratory? Are they ‘sensationalised’ showing a ‘monster-like’ or comic-book-like person in a basement with horror elements? Are the ‘broader than traditional' showing a woman, a non-white minority person in a non-traditional laboratory. Can students identify with their scientist?
- Have students select and investigate a Nobel prize winner or other scientist with a background or from a (sub)culture they can identify with. Have them share or present their findings (on a poster).

Ask students to 'find' a scientist, they are in some way personally related to (friends, family, neighbourhood, network, sports, music ….) and interview this person about their background, their work and how they came to be a scientist.

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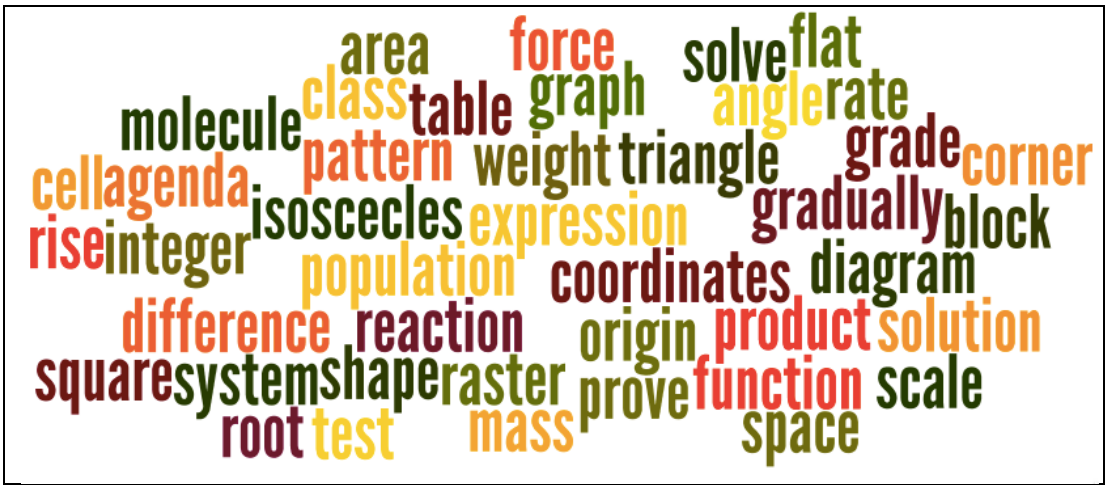
Activity 3.6 – Language in multicultural science and mathematics classrooms (30 minutes)

The aim of this activity is have participants see the relevance of language for science and mathematics and learn ways to stimulate the development of language along with the development of scientific and mathematical concepts. Participants become aware of the importance to address language for all students and they learn about topics that are special for multi-lingual classrooms.

Part a – the relevance of language for learning mathematics and science
Have participants look at the word-cloud below.



- In the whole group ask participants what they notice and what kind of words they see. Keep this very brief.
- Next participants individually select about words that are typical for their subject.
- Next form small mixed-subject groups and have participants discuss the questions below:
    - Which of these words are also part of our daily language? How is the meaning different in your subject and in daily life?
    - Write down two typical expressions (or sentences) using one of these words. One in daily language and one for your subject.
    - What problems do you expect your students may have regarding this 'shift of' meaning? Is this different for students who are native speakers in your language and for students who are not?
    - Think of ways to help your students acquire the 'language of mathematics/science'.

In the whole group present some theory/background on language-sensitive subject teaching. You can use the texts on worksheet 10 or you may use literature about this topic from your own country. Stress that it is important for participants to actively pay attention to the language of their subject, but also to school-language involved. This is important for all students not only for students with another 'home-language'. It helps to start the introduction of a new concept in a familiar context (for which students have the language) and to formulate subject related language goals for each lessons. Also have students speak and write to produce language and provide language-support. like for example a scheme, a structure for formulating a text, mindmapping, …… etc.

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Part b – multilingual classrooms
Have participant read the text below.

> Teachers can help all students learn science by allowing diverse approaches to scientific reasoning in their classrooms. For example, students might use both their first and second languages to engage in science. Jean-Charles, a student in a sixth-grade bilingual classroom, used English to clarify technical terms not present in his first language, Haitian Creole. **By expressing his ideas in two languages, he used his full range of linguistic capabilities to develop more in-depth arguments and understanding of metamorphosis in mealworms** (Warren, Ballenger, Ogonowski, Rosebery, and Hudicourt-Barnes 2001)[5].

Have participants in small groups discuss the topic addressed in this text. You may make mixed groups with participants who teach in multilingual classes and teachers who don't. Use the following questions to guide the discussions in small groups:

- What is your opinion about students in your classes using more than one language?
- Do you have students in your classroom with a bilingual background? Are they allowed to use their 'mother tongue' language for peer communication? Exchange arguments for and against the use of students first language (T1).

In a whole group discussion collect arguments for and against students using T1 and try to refine the arguments by having participants add under which they would allow this and conditions under which they would forbid it.
Extend the discussion if it fits the group, especially when a large number of participants teach multilingual classes.

- Would it be a problem to cluster native speakers in a group to let them discuss the subject theory in their "own" language before translation it to the language in school?
- What would you need to aid the students?
- Are there other solutions/examples you can use to incorporate multiple languages?

Note: in this area there is no general 'right' or 'wrong' solution. What can best be done depends heavily on the local situation.

Evaluation
Use the last 5 minutes for a reflection on the PD course: summarize the course (use for example the schema from the manual) and ask if participants can link all modules and which aspects they are going to incorporate in their teaching. You may also ask them to write tops (what did they value) and tips (what could be improved).

[5] Brown, P. L. (2007). Cultural Diversity in the Science Classroom. http://static.nsta.org/files/sc0707_60.pdf. Science and Children, Summer 2007, 60-61.

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Worksheet 1 – description of classroom activity

Design a healthy multicultural meal

In this activity you will, in a small group, design a healthy, multicultural meal for your school.

First you will need to do some research.

- What is meant by a healthy meal? What makes a meal healthy?
- What is multicultural in your school?
- What are common meals in different cultures?

Next you will need to decide on your meal

- What dishes will be in your meal?
- What ingredients are needed and how much of each?
- What does your meal cost?

In the end, you may want to check for other issues:

- Are there students in your school for whom this meal is not suitable?
- Is the meal animal friendly?
- ….

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Worksheet 2 – Definitions of culture and diversity

Diversity

Definition

… "diversity" is a multi-faceted concept that can contain as many elements and levels of distinction as required. Work on the topic includes but is not limited to: age, ethnicity, class, gender, physical abilities/qualities, race, sexual orientation, religious status, educational background, geographical location, income, marital status, parental status and work experiences.

… the definition of "diversity" for this work can be framed as: characteristics that can affect the specific ways in which developmental potential and learning are realised, including cultural, linguistic, ethnic, religious and socio-economic differences.

Educating teachers for diversity: Meeting the challenge. (2010). Educational research and innovation. Paris: OECD, p. 21

Culture

Box 3: **Defining culture**

"Culture" is a difficult term to define because cultural groups are always internally heterogeneous and contain individuals who adhere to a range of diverse beliefs and practices. Furthermore, the core cultural beliefs and practices that are most typically associated with any given group are also constantly changing and evolving over time. However, distinctions may be drawn between the material, social and subjective aspects of culture, that is, between the material artefacts that are commonly used by the members of a cultural group (e.g., the tools, foods, clothing, etc.), the social institutions of the group (e.g. the language, the communicative conventions, folklore, religion, etc.), and the beliefs, values, discourses and practices which group members commonly use as a frame of reference for thinking about and relating to the world. Culture is a composite formed from all three aspects, consisting of a network of material, social and subjective resources. The full set of cultural resources is distributed across the entire group, but each individual member of the group only uses a subset of the full set of cultural resources that is potentially available to them (Barrett et al., 2014).

Defining 'culture' in this way means that any kind of social group can have its own distinctive culture: national groups, ethnic groups, faith groups, linguistic groups, occupational groups, generational groups, family groups, etc. The definition also implies that all individuals belong to multiple groups and have multiple cultural affiliations and identities (e.g. national, religious, linguistic, generational, familial, etc.). Although all people belong to multiple cultures, each person participates in a different constellation of cultures, and the way in which they relate to any one culture depends, at least in part, on the perspectives that are based on other cultures to which they also belong. In other words, cultural affiliations intersect, and each individual occupies a unique cultural positioning.

People's cultural affiliations are dynamic and fluid, that is, what they think defines them culturally fluctuates as an individual moves from one situation to another. These fluctuations depend on the extent a social context focuses on a particular identity, and on the individual's needs, motivations, interests and expectations within that situation.

Intercultural situations arise when a person encounters someone else who is perceived to have one or more cultural affiliations that differ from their own. Such encounters can involve people from different countries, people from different regional, linguistic, ethnic or faith backgrounds, or people who differ from each other because of their lifestyle, social class, age or generation, etc. Intercultural encounters occur when cultural differences are perceived and become important because of the situation or the individual's own orientation and attitudes. In such situations, intercultural competence is required in order to interact, communicate and understand the position and perspective of the other across the perceived cultural group boundary.

Source: OECD, global competency for an inclusive world

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Worksheet 3 – What is indigenous science?

Source: https://wisn.org/about/what-is-indigenous-science/

Like Western science (WS), Indigenous science (IS) relies upon direct observation for forecasting and generating predictions; it's power lies in its ability to make connections and perceive patterns across vast cycles of space and time. Indigenous scientists are trained in various specializations such as herbalism, weather observations, mental health, and time keeping, and there are tests to ensure IS validity.
One marked difference between the two sciences: Data from IS is not used to control the forces of nature, but instead is used to find methods and resources for accommodating it. Other critical distinctions apply to IS, including:

- Indigenous scientists are an integral part of the research process and there is a defined process for ensuring this integrity.
- IS tries to understand and complete our relationships with all living things. All of nature is considered to be intelligent and alive, thus an active research partner.
- The purpose of IS is to maintain balance.
- IS collapses time and space; our fields of inquiry and participation extend into and overlap with past and present.
- IS is holistic, drawing on all senses, including the spiritual and psychic.
- The end-point of an IS process is an exact balance where creativity occurs.
- We always remain embodied in the natural world. In other words, when we reach the moment/place of balance, we do not believe that we have "transcended." Instead, we say that we are normal.
- Humor balances gravity and is a critical ingredient of all truth seeking, even in the most powerful rituals.

Source: Wikipedia

The terms *traditional knowledge*, *indigenous knowledge* and *local knowledge* generally refer to knowledge systems embedded in the cultural traditions of regional, indigenous, or local communities. Traditional knowledge includes types of knowledge about traditional technologies of subsistence (e.g. tools and techniques for hunting or agriculture), midwifery, ethnobotany and ecological knowledge, traditional medicine, celestial navigation, ethno-astronomy, the climate, and others. These kinds of knowledge, crucial for subsistence and survival, are generally based on accumulations of empirical observation and on interaction with the environment.
In many cases, traditional knowledge has been orally passed for generations from person to person. Some forms of traditional knowledge find expression in stories, legends, folklore, rituals, songs, and laws. Other forms of traditional knowledge are expressed through different means.
[..]
A report of the International Council for Science (ICSU) Study Group on Science and Traditional Knowledge characterises traditional knowledge as:

> "a cumulative body of knowledge, know-how, practices and representations maintained and developed by peoples with extended histories of interaction with the natural environment. These sophisticated sets of understandings, interpretations and meanings are part and parcel of a cultural complex that encompasses language, naming and classification systems, resource use practices, ritual, spirituality and worldview."

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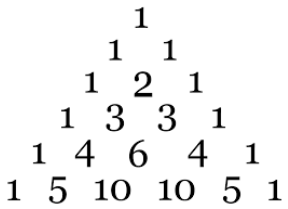
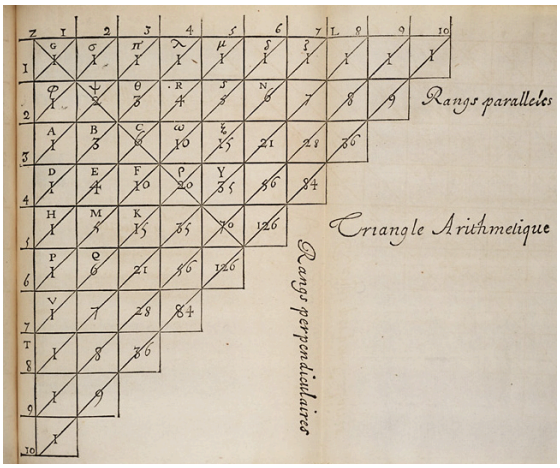
Worksheet 4 - who invented Pascal's Triangle?

1. What do you know about this picture? Write everything you know.



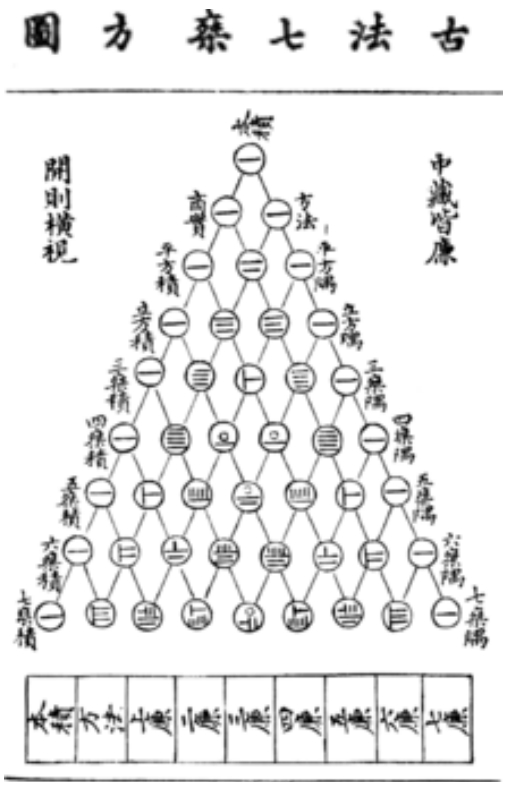
In 1665 the French mathematician Blaise Pascal drew this version of the triangle, that later was named after him, at least in the Western world. But did Blaise Pascal really invent this mathematical triangle?



2. Study the picture[6] on the right, that comes from a Chinese mathematical work by Zhu Shijie, dated 1303.

- What do you notice?

- What is the system used to write the numbers?



Did the Chines then invent Pascal's Triangle? Study the picture on the next page.

[6] Source: wikipedia

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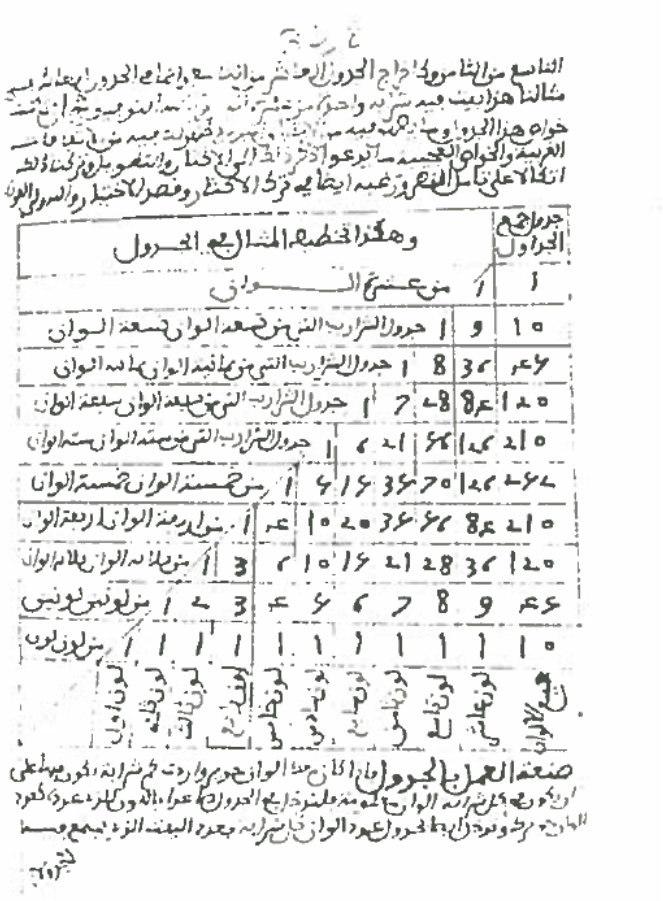
3. Write at least five aspects you find interesting about the picture to the right.
- What is the language?
- Can you read the numbers? Is it easy to recognize the numbers? Why?
- What patterns do you see?



This figure is a page from a work by the Moroccan Mathematician and medical doctor named Ahmad al-Ad'dari ibn Mun'im who lived in Marrakech around 1200.

This is even not the oldest source in which the triangular pattern appears. If you want to know more you can study texts about the history of mathematics.

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Worksheet 5 – Dillemma cards

All dilemma's begin with "would you as a teacher ……"

Perform a microscope practical to examine the hairs of students

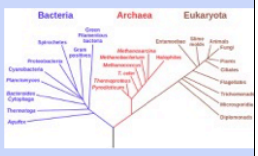
Have mixed girl/boy groups in an exercise where there has to be physical contact? (first aid course, armwrestle, contact sports, team building, etc.)

Have your students study food or perform tasting tests during Ramadan or other abstinence periods

Hand out (random) treats on a specific occasion in your class (Birthday, good class results, winning a game/award)

Describe an Era as 4.000 years BC (or other calender issues)

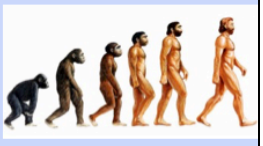
Discuss the genetic distances between human populations (or on the phylogenetic tree)



Let your students construct a family tree (or interview grandparents)

Give theoretical lessons on inoculation, blood transfusion or transplant organs

Discuss the evolution theory

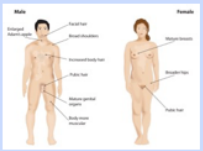


Let the students perform a blood typing analysis

Measure body parts or height and weight in class

Discuss current political issues and news in your classroom

Teach your students about puberty and sex



Talk with your students about: sexual orientation

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Worksheet 6 – sample evaluation form

Name			
School			
Subject		grade	
Which activity was used (short description of resources and teaching method(s))			
How does your activity involve students in inquiry-based learning?			
How and why do you think that your activity will: - relate to and make use of the diverse cultural backgrounds of your students? - address the cultural roots of mathematics or science - have students reason about moral dilemma?			
Experiences during the lesson: what student behavior did you observe (different than normal)? What did you observe with respect to different cultural backgrounds levels?			

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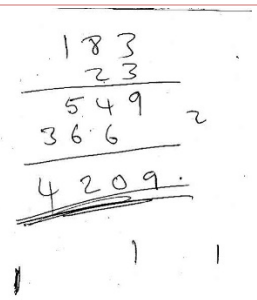
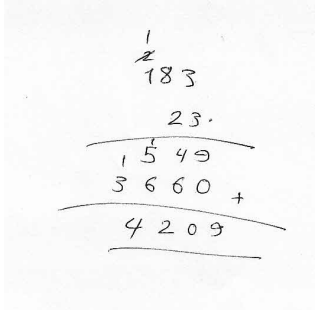
Worksheet 7 – different procedures for calculation

multiplication

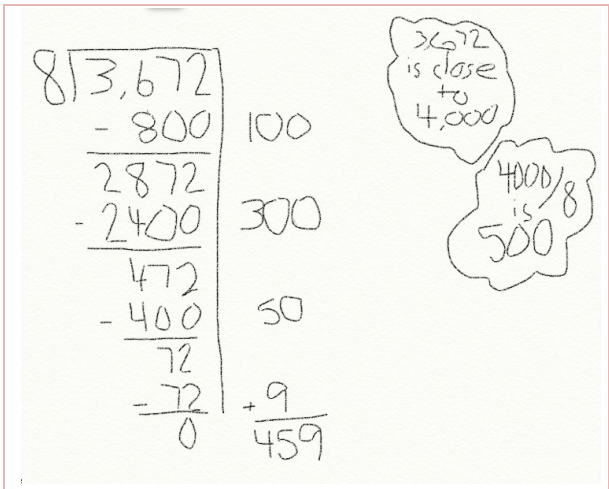


183 x 23 =

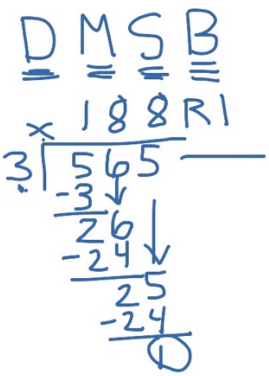


183 x 23 =

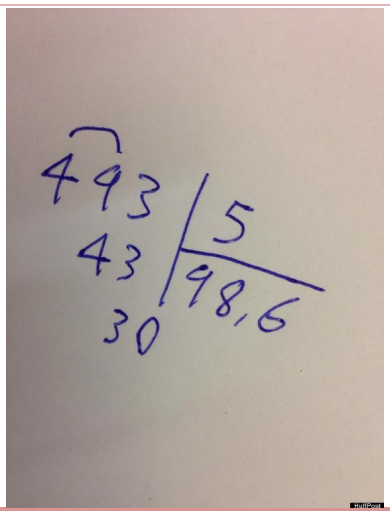
division



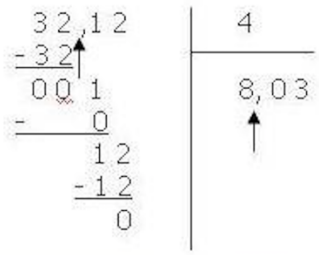
3672 ÷ 8 =



565 ÷ 3 =



493 ÷ 5 =



32,12 ÷ 4 =

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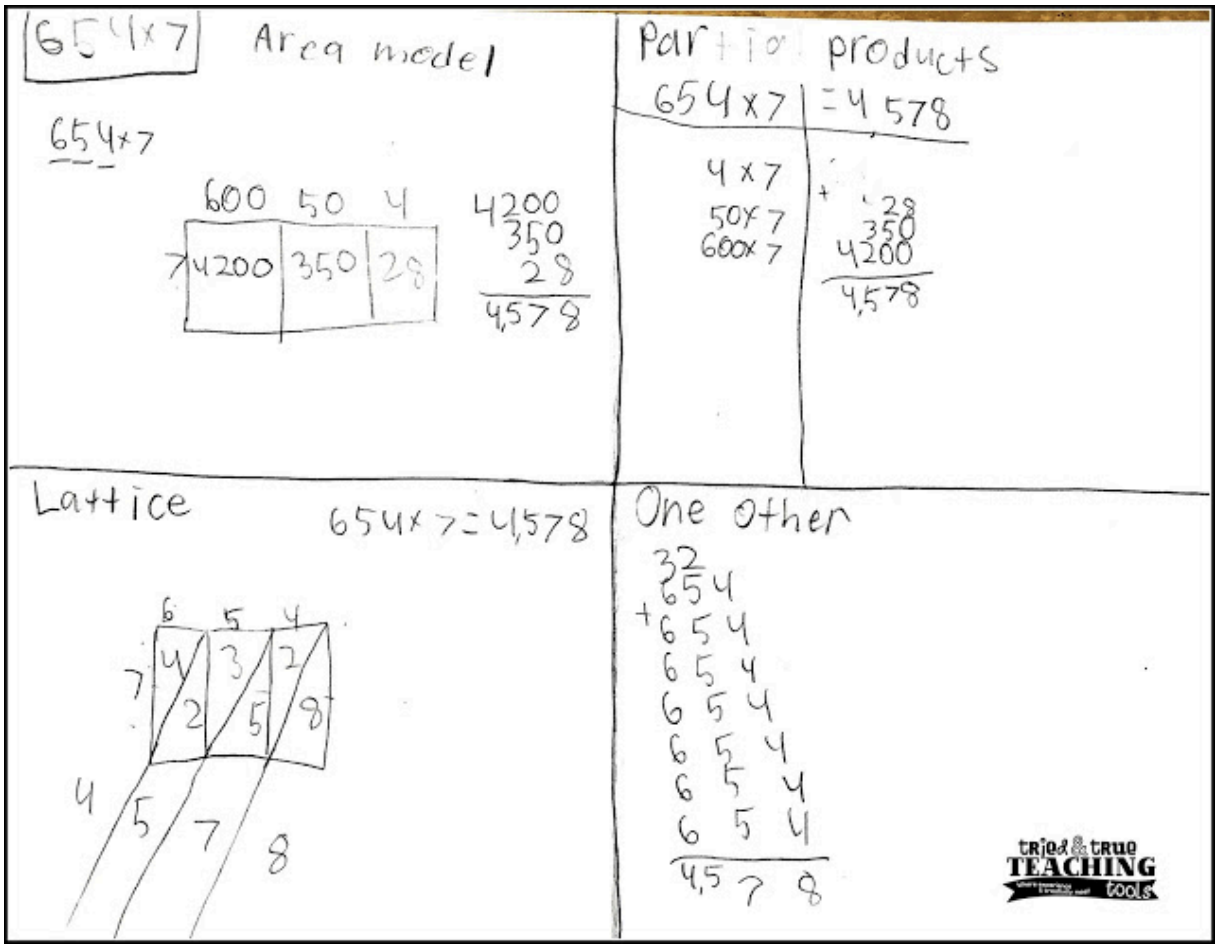
Worksheet 7 - Continued



7

[7] retrieved on 23 January 23 2018 from http://www.triedandtrueteachingtools.com/2016/11/multiplication-madness.html

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Worksheet 8 – defining nature

Tanning on the beach, walking your dog, swimming in a lake, cycling to school, without even realizing it you are constantly present in "Nature".

What do you define as nature and what do you find important when it comes to nature? Answer the following questions:

1. How would you describe nature?
2. How important is nature to you?
3. Do you spend time with your family (activities) in nature? (if yes where?)
4. Have you ever been into a nature reserve or natural area?
5. Describe the requirements a nature reserve/area should have according to you.
6. Do you often “use” nature? Maybe because of sports or another hobby or activities?

After answering these questions, take a look at the following pictures (1-6) which of these photographs fit your perspective of nature?

→ Rank the photo’s according to your perspective on nature. Which represents your view on nature best and which fits the least to your perspective?

Picture 1 till 6: Different “nature” areas.

→ Discuss your list of rankings with one or two of your classmates. Do you have different views on nature? Do you strongly agree or disagree on how you define nature? What do you think contributes to these differences? Note: You may want to use your answers to questions 1 to 6.
→ Repeat this activity with your parents and/or grandparents, do they have different ways of defining nature? how do you think these differences/similarities arise? We will talk about your findings next lesson.

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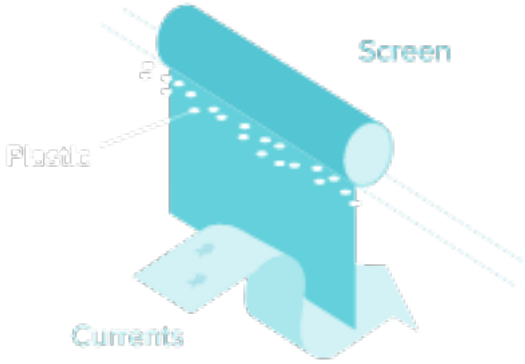
Worksheet 9: Students as scientists – case study

Boyan Slat (27 July 1994) is a Dutch inventor and entrepreneur who creates technologies to solve societal problems. At the age of 16 when Boyan Slat was in upper secondary school, he invented a way to clean up the oceans and remove all the plastic soup. He wrote a paper for his exam about this idea. At the age of 18 he founded The Ocean Cleanup a group that develops advanced systems to rid world's oceans of plastic. see: http://www.boyanslat.com/	
Instead of going after the plastic, Boyan devised a system though which, driven by the ocean currents, the plastic would concentrate itself, reducing the theoretical clean-up time from millennia to mere years. The first clean-up prototype was deployed in June 2016. Watch this video https://www.youtube.com/watch?v=6IjaZ2g-21E to see how it started and study this webpage https://www.theoceancleanup.com/technology/ to see how the technology works.	

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Worksheet 10 - relevance of language[8]

Treating language with care

Learning science is, in many ways, like learning a new language. In some ways it presents more difficulty in that many of the hard, conceptual words of science – such as energy, work, power – have a precise meaning in science and sometimes an exact definition, but a very different meaning in everyday life. Science education thus involves dealing with familiar words, like energy, and giving them new meanings in new contexts. Equally, many of the 'naming' words of our lives have been commandeered by science. Consider: element, conductor, cell, field, circuit, compound. This is made worse because many of the terms of science are metaphors: for example, a field in science is not really a field. Science education also involves introducing new words – sometimes in familiar contexts (e.g. tibia, fibula) but at other times in unfamiliar contexts (e.g. allele, enzyme, longitudinal). Another category of language which science teachers (and many other teachers) use has been christened the 'language of secondary education' (see Chapter 3). The list includes modify, compare, evaluate, hypothesize, infer, 6 Language and literacy in science education recapitulate . . . and so on. These are words used by teachers and exam papers but rarely heard in playgrounds, in pubs or at football matches. What should science teachers do about their specialist language and the language of secondary education? Our general approach in this book is that we should all treat language with care, to be aware of its difficulties and to bear in mind that although pupils can and do use scientific terms in speech and writing this does not imply that they understand them (this is equally true of journalists, other writers and radio or TV pundits of course). But this does not imply that we should 'skirt round it' or try to avoid the language of science and constantly translate it into the 'vernacular'.

[…].

But learning to use the language of science is fundamental to learning science. As Vygotsky (1962) pointed out, when a child uses words he or she is helped to develop concepts. Language development and conceptual development are inextricably linked. Thought requires language, language requires thought. Viewed from a negative angle, 'difficulty with language causes difficulty with reasoning' (Byrne et al. 1994).

[…]

Finally, we all need to remind ourselves that there is far more to science communication than verbal language, i.e. the spoken and written word. Words are important but in science more than any other subject we rely on a combination and interaction of words, pictures, diagrams, images, animations, graphs, equations, tables and charts (Lemke 1998; Jones 2000). [9]

[9] Retrieved 24 january 2018 from:https://www.mheducation.co.uk/openup/chapters/0335205984.pdf

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