MaSDiV

Supporting Mathmatics and Science Teachers in addressing Diversity and promoting fundamental Values

Professional Development Course
Modul 1 – achievement

ICSE International Centre for STEM Education

Pädagogische Hochschule Freiburg
Université des Sciences de l'Education · University of Education

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STEM, Diversity and Achievement

Aims of the Module

- To become aware of and enrich beliefs and practices for addressing diversity in science and mathematics classrooms
- To understand how to prepare a lesson plan with teaching methods that take the opportunity of diversity in achievement in the classroom
- To (re)design classroom materials into resources with IBL characteristics for creating learning environments to be used for including all students and addressing diverse achievement levels
- To provide experience with purposefully chosen teaching methods and resources for science or mathematics that take the opportunity of diversity in achievement among students

Ways of working

- Reflecting on existing beliefs and practices regarding addressing diversity and regarding IBL
- Providing and discussing concrete subject-specific examples
- Developing and reflecting on important principles for addressing diversity in science and mathematics classrooms
- Experimenting with and reflecting on teaching methods for diversity

Structure & Length of the Module

Overall length of the module: 240 min (4 hours) + 90 min homework
Overview of the sequence of activities

1.1: Introduction and exploration of experiences with diversity (30 minutes) 3
This activity affords a start from the participants' experiences with diversity in their classrooms and creates the need for collecting information for planning lessons.

1.2: Characteristics of inclusive education (15 minutes) 4
This activity can be used to create awareness among participants for characteristics of inclusive education.

1.3: Collecting information to build on what students know (30 minutes) 5
This activity introduces strategies to collect information for planning further teaching. In addition, the activity offers opportunities for discussing prejudices like teaching one strategy and avoiding language in science teaching.

1.4: IBL and diversity in achievement (60 minutes) 9
This activity explores the notion of inquiry-based learning (IBL) and the relation between IBL and taking the opportunity of diversity in the classroom.

1.5: Teaching methods for IBL and involving all students (45 minutes) 11
The aim of this activity is to exchange experiences with diversity-related teaching methods and to extend the participants' repertoire with IBL-based methods.

1.6: Addressing diversity through IBL and (peer) feedback (30 minutes) 12
This activity provides participants with examples by which diversity in achievement levels can be addressed through organizing (peer) feedback with IBL tasks.

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1.7: Design and prepare a lesson for a diverse classroom (30 minutes) 13

Benefits, risks and challenges of teaching and learning in diverse classrooms are discussed and participants prepare a lesson that takes the opportunities provided by diversity in their classroom.

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ACTIVITY 1.1: Introduction and exploration of experiences with diversity (30 minutes)

The aim of this activity is to introduce the aim and structure of the whole course and this module in particular, to collect teachers' own experiences (starting level), and to become acquainted with the participants of the course.

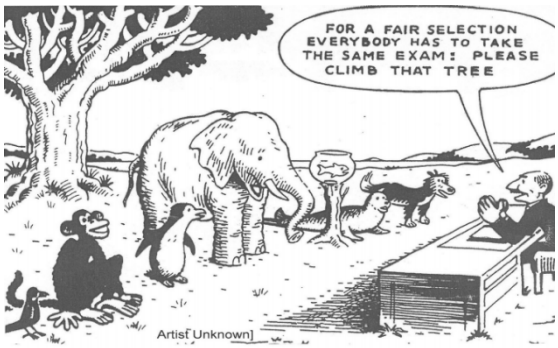
Pose the following question to the participants of the course: What do you know about your students and what consequential actions do you take?

Ask participants to work in pairs, considering the following questions.

- Think of two students in your class, one who is particularly strong and one who is finding the work very difficult. Take it in turns to describe the students' strengths and difficulties to your partner, in as much detail as possible.
- How did you become aware of these strengths and difficulties? On what evidence do you base your judgements? Test results? Memories of oral responses during lessons? Observations of the student working? Written work?
- In what ways do your experiences with these students affect your lesson planning? Give examples.

Lead a discussion of the findings from the groups. Focus on ways by which participating teachers collect evidence for basing judgements and how their understanding of diversity might affect their own lesson planning and students' image of and interest in science and mathematics. If possible, connect collection-ways and planning-strategies to characteristics of the knowledge domain: is it general and/or stem-specific?

This discussion is supposed to create the need for ways to collect more information of students that can be used to base judgements and to plan lessons that take these judgements into account.



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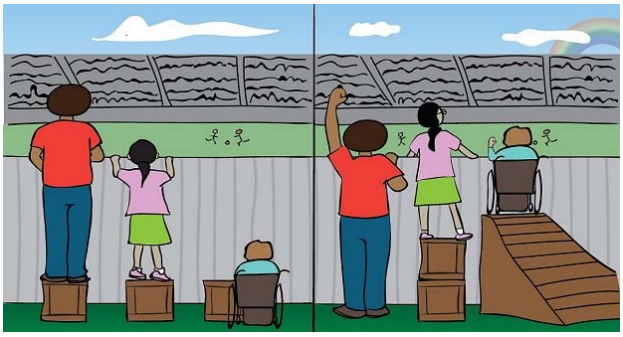

Retrieved from (at January 18, 2018): http://interactioninstitute.org/illustrating-equality-vs-equity/

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ACTIVITY 1.2: Characteristics of inclusive education (15 minutes)

Characteristics of inclusive education can involve many elements (Booth & Ainscrow, p. 3):

Inclusion in education involves:

- Valuing all students and staff equally.
- Increasing the participation of students in, and reducing their exclusion from, the cultures, curricula and communities of local schools.
- Restructuring the cultures, policies and practices in schools so that they respond to the diversity of students in the locality.
- Reducing barriers to learning and participation for all students, not only those with impairments or those who are categorised as 'having special educational needs'.
- Learning from attempts to overcome barriers to the access and participation of particular students to make changes for the benefit of students more widely.
- Viewing the difference between students as resources to support learning, rather than problems to be overcome.
- Acknowledging the right of students to an education in their locality.
- Improving schools for staff as well as for students.
- Emphasising the role of schools in building community and developing values, as well as in increasing achievement.
- Fostering mutually sustaining relationships between schools and communities.
- Recognising that inclusion in education is one aspect of inclusion in society.

Before showing the list to the participants ask them what they do think about characteristics of inclusive education.
Next, show the list and discuss with the participants, which points can be recognized in their school context and which points are relevant for science and/or mathematics teaching. If possible, let them first explore the list in small groups.

The intended outcome of this activity is that the participants become aware of the variety of aspects that are related to diversity and inclusive education. Emphasise that this module is not only about differences in levels between students, but we need to take into account that this issue has a wide background, and in some cases we need to take a step backward to get a better understanding of what is happening in class.

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ACTIVITY 1.3: Collecting information to build on what students know (30 minutes)

In order to increase participation, reduce barriers to learning for all students and taking the opportunity of differences between students as a resource for your teaching, it is important to have a good understanding of knowledge and skills of your students. The aim of this activity is to further discuss the importance of collecting information of students' that is rich enough for taking well-informed and inclusive-oriented teaching decisions. Two specific ways for collecting information are discussed.

Present the following statement to the participants of the course:
"It's all very well telling us to build on what students know, but how can a busy teacher know what is going on inside 30 individual heads?"

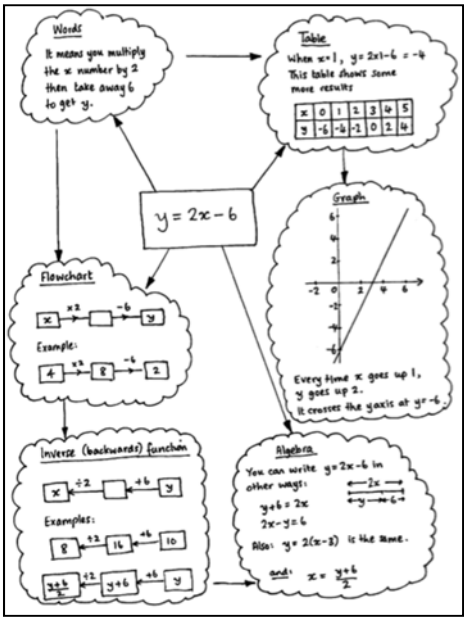
- How would you answer this teacher?
- What strategies do you have for finding out what students are thinking in your lessons? (building on activity 1.1)
- Discuss two suggestions for collecting information (mini white boards and posters), and watch the movies to see these in action (follow **link**) [1].

The two strategies described on the handout and in the videos accompanying this activity may help to make all students' thinking 'visible'.

Mini-whiteboards are a good resource for the following reasons:

- When students hold their ideas up to the teacher, it is possible to see at a glance what every student thinks.
- During whole class discussions, they allow the teacher to ask new kinds of question (typically beginning: 'Show me an example of....').
- They allow students to, simultaneously, present a range of written and/or drawn responses to the teacher and to each other.

Posters are also a powerful way of helping students to externalise their thinking. Perhaps the simplest way of using a poster is for students to solve a problem collaboratively, explaining the thought processes involved at every step. A second use of posters is to find out what they already know about a given topic. For example, a teacher can ask students to write down all they knew about y=2x-6. A discussion of the resulting posters enables the teacher to assess how much learners knew about equations and how well they were able to link ideas together. Posters are helpful tools for visualizing and keeping track of all students' shared understanding of a specific topic.



Retrieved from[1] (at January 8, 2018).

[1] http://primas.mathshell.org/pd/modules/6_Building_on_Knowledge/html/videos_c1.htm

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The activity could proceed as follows:

- Let the participants watch the videos and handouts. Discuss the potential of these ways of collecting information, also specifically focusing on deeper insights in different levels of achievement and learning from each other.
- Let the participants identify a topic that they have to teach shortly after the session that seems suitable for one of these approaches.
- Suggest further strategies for making students' understanding visible (e.g. one minute silence, one minute problems, and exit tickets at the Teacher Toolkit[2]).
- Discuss the topics and the ways to approach them. Give feedback/suggestions and provide time to let them prepare a lesson-plan (write down in advance what possible actions you could take based upon different feedback that you receive from your students).

Optional

- *Discuss the prejudice: Teach one solution strategy*

In addition, we present some example tasks that elicit different solution strategies. These tasks illustrate how more open and unfamiliar problem situations can be used to collect different ways of reasoning and representing by the students and how to use these in your teaching. At this stage it is important not to say "this is the way how to do it, forget the rest". First explore where your students are. Follow-up questions can be oriented on trying to find and understand reasons behind the differences (different primary schools, cultures, …). This understanding is conditional for building on what students know and making progress (preventing isolated facts and procedures). In a later stage consensus can be reached about an algorithm or an approach for a particular type of problems, and that it can be useful to practice the approach for becoming fluent and flexible in applications and further learning. And students need to be allowed to have a voice in the sequence of these steps.
Intended outcome of the discussion: an understanding of differences is a pre-requisite for further teaching.

- *Discuss the prejudice: Avoid language in science and mathematics teaching*

Furthermore, the PISA example tasks use written language for describing the context. Some argue that this makes task unnecessary difficult for low achievers and that teachers need to create similar tasks without any language to support their learning. What are advantages and what are risks of this approach?

Intended outcome of the discussion: language is needed for understanding and communication and avoiding all language creates dependent students.

The following two tasks can be used to make teachers aware of the creativity of students, and also of the importance to talk through graphs and to not expect all students to understand what is going on in a graph. A possible activity might be to first present the tasks to the teachers and ask them to solve the problems and next discuss possible answers by students and how discussions about these answers support deeper understanding.

[2] http://www.theteachertoolkit.com

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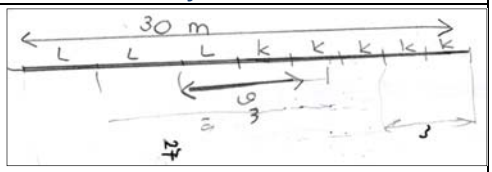
Task	Possible answers
Describe which sport you think this graph represents and why. + Golf + Skydiving + Fishing + 100-meter dash + Drag racing 	*"Golf, because the ball is first going into the air before it drops on the grass."* *"Skydiving since first speed is increasing when you dive out of a plane and after your parachute opened you drop with constant speed."* *"Fishing, because it looks like how you through with a fishing rod and in the end the bobber floats on the water."*
A rope of 30 meter is divided in 5 short and 3 long parts. A short and a long part together are 9 meter. How long is a short part?	 *Or solve with a system of equations or solve with (word) formulas and substitution.*

Another option to talk with students about science or mathematics is to show them some information or (Pisa) tasks and to let them think about what questions emerge from this situation and how to further investigate one or more of these questions.

MATHEMATICS UNIT 33: DRUG CONCENTRATIONS

QUESTION 33.1

A woman in hospital receives an injection of penicillin. Her body gradually breaks the penicillin down so that one hour after the injection only 60% of the penicillin will remain active.

This pattern continues: at the end of each hour only 60% of the penicillin that was present at the end of the previous hour remains active.

Suppose the woman is given a dose of 300 milligrams of penicillin at 8 o'clock in the morning.

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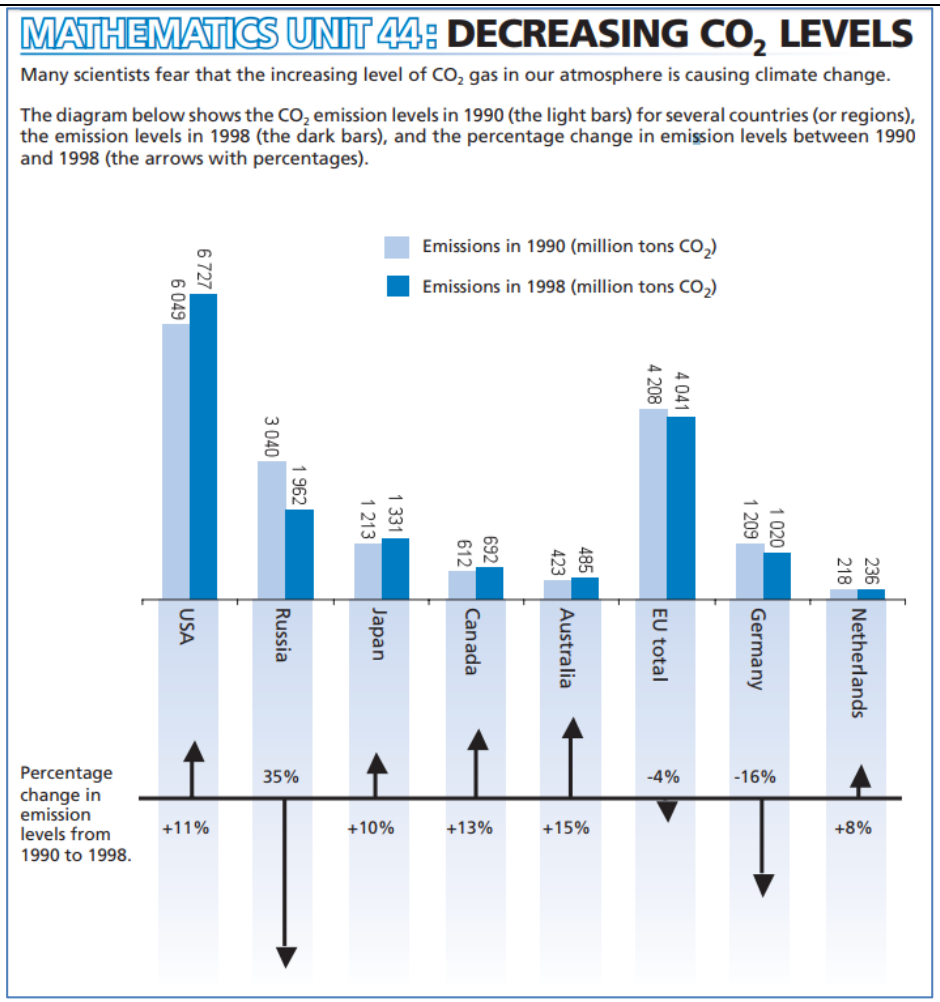

Stimulating students to reason in science or mathematics can also be promoted by providing statements about scientific concepts and asking students to decide whether these statements are never, sometimes or always true. This activity is developed within the Primas-project. Below two statement cards related to reasoning about percentage. With the participants can be discussed what the opportunities are of these options (stems of tasks or statement cards).

Never true, sometimes true or always true[3]:

Pay rise	**Sale**
Max gets a pay rise of 30%. Jim gets a pay rise of 25%. So Max gets the bigger pay rise.	In a sale, every price was reduced by 25%. After the sale every price was increased by 25%. So prices went back to where they started.

Besides an understanding of using these tasks for collecting information about what students know and can do, another outcome of this activity is that participants become aware that classroom activities can be inspired by inquiry processes: questioning situations (in the Pisa tasks) or providing evidence for a conjecture with one counter example or a generalizing statement (in the statement cards). For that reason such tasks can be a resource for what nowadays is called inquiry-based learning.

[3] Many alternative statements, also for science can be found in: http://primas.mathshell.org/pd/modules/3_Learning_concepts/html/index.htm

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ACTIVITY 1.4: IBL and diversity in achievement (60 minutes)

The aim of this activity is to introduce and further explore the notion of inquiry-based learning (IBL), characteristics of an IBL learning environment (including tasks) and of IBL teaching methods, and the relation between IBL and taking the opportunity of diversity in the classroom.

If possible, homework in advance could be: watch the video of Building a school with bottles in Honduras[4].

- Discuss the video of Building a school: what are students doing? Do you recognize elements of doing research yourself?
- Introduce IBL as a way to extent the teachers´ teaching repertoire. Teaching methods and resources in IBL are inspired by one or more phases of inquiry like questioning, hypothesising, planning, collaborating, systematically experimenting, evaluating and communicating. In contrast to exposing content and concepts in mathematics and science, IBL expects students to be more active and take more responsibility for their own learning as they learn to work individually or in groups.
- Discuss the video from the perspective of IBL, and next from the perspective of diversity. IBL-related questions: who is posing the main question(s) to be investigated? Who prescribes strategies? Who is responsible for planning and experimenting? What is the role of the teacher during the lesson to transfer responsibilities and to support progress and convergence? Diversity-related questions:
    - What characteristics of the learning environment offer opportunities to all students to engage in the activity?
    - Which opportunities/challenges are provided for students on different achievement levels?
    - What is the role of the teacher to support all students?
    - What were the (differentiated) learning goals of the activity?
- Conclude with a reflection on the relation between IBL and dealing with diversity.

In IBL teaching methods and resources explicitly focus on one or more phases of inquiry. IBL expects students to be more active and take more responsibility for their own learning as they inquire individually or in groups. They are expected to explore and discover, ask questions, identify problems, find solutions, create models, formulate hypothesis, devise experiments, share, reflect and communicate their findings. While doing so, they learn about these research competences as well as content related concepts and skills. And emphasize once more: we don't intend to change education with this approach. The need for practicing, storytelling, modelling, etcetera, will not disappear. However, in our interpretation, ideas from IBL are expected to enrich teaching practices and to offer new opportunities to involve all students in the teaching and learning process.

[4] http://primas.mathshell.org/pd/modules/1_Student_led_inquiry/html/videos_1.htm

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Let the teachers plan a lesson with IBL characteristics (task, resources, teaching method, learning goals) using the Building a School situation. Discuss how they will:

- introduce the situation to students;
- organise the classroom and the resources needed
- deal with a diversity of interests, inquiry skills and content-related skills;
- how to provide support to all students (how to take care with diversity in performance, in quality of their work, time needed, …)
- answer the question "Why are we doing this in mathematics / biology / chemistry / physics?"
- conclude the lesson in a way that gives all students a better understanding of the nature of scientific processes involved.

After they have designed lesson plans, compare the lesson plans and discuss the differences and similarities. Specifically focus on how a weak student might get extra support. A first reaction, or pitfall, can be to tell an expected strategy or answer. Some alternative ways for providing support are:

- have process-related hints at hand (e.g. try a simpler case; draw a picture; list the variables involved; …)
- let them collaborate (e.g. what did your neighbour do?)
- extra sub-questions/tasks to scaffold the inquiry process
- provide all steps that structure the inquiry-process, but in an unordered way, and ask students to order them (a simple option to involve students in the inquiry guided by cookbook experiments or structured tasks)

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- representatives of a group can go outside the classroom to find hints
- representatives of a group can go to an expert (the teacher) to get answers on their questions (stimulates them to collaborate and to learn to ask helpful questions)
- also maybe by emphasizing particular steps of the IBL cycle by special tasks

Present and share the following findings from research :

- IBL leads to better understanding of scientific content (Minner et al. 2010), regardless of students' ethnicity, gender and social economic status (Wilson et al. 2010).
- IBL impacts positively on students' motivation and attitudes (Bruder & Prescott, 2013, Amaral et al. 2002), thus promoting achievement (Deci & Ryan 2002).
- Greater improvements in students' science literacy and research skills, but lower gain in self-confidence in scientific abilities maybe due to experiencing complexity and frustrations, and over-estimation of traditional taught students (Gormally et al. 2009).
- IBL's student-centeredness creates stimulating learning climates; the EU working group (EC 2015, 2013) explicitly recommends IBL for preventing early school leaving and supporting migrants.

Further reading and inspiration and resources on IBL in science can be found here:

http://mascil-toolkit.ph-freiburg.de/inquiry-and-ibl-pedagogies/ibl-pedagogies-in-science/
http://www.mass4education.eu/

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ACTIVITY 1.5: Teaching methods for IBL and involving all students (45 minutes)

Teachers have experiences with diversity in their classrooms. The aim of this activity is to exchange experiences with teaching methods and to connect new methods to teachers' existing repertoire. Most known teaching methods are oriented on differentiation by creating homogeneous level groups. These methods foster an image of what a "normal" student is and discrete categories for labelling all other students on either side of the spectrum. Such differentiated methods have the risk of creating a "fixed effect" on a student's development (Larina and Markina, 2019). In this activity alternative strategies are explored that address, or take the opportunity of, diversity by including all students and moving forward with the whole class. These strategies are connected to inquiry-based learning (IBL). This activity starts talking about strategies that stimulate sharing the many voices in the classroom and using them as an opportunity for learning on diverse achievement levels.

First ask the participants to describe the diversity in their lessons (different levels of understanding, different cultures, different …) and how they address this diversity in their lessons (from a cognitive perspective). Discuss these practices, and enrich their collection (if needed) with the following strategies to address diversity:

- Creating level groups and using differentiated materials
- Providing out of school support for low- and/or high achievers

What are advantages and disadvantages of these approaches? Confront the teachers with the research finding of a possible 'fixed effect' on students.

Next, discuss how to address diversity with teaching strategies that (i) involve all students to participate in class discussions about mathematical or scientific concepts, (ii) that offer students the opportunity to work on a task on their own level, and (iii) that provide teachers the opportunity to give level-feedback in connection with organizing whole class progress.

- Think-pair-share
- Peer-instruction[5]
- No-hands up, providing wait time[6]
- Using low-floor-high-ceiling tasks (e.g. discussing statements that are never, sometimes, always true; students' own productions)
- Escape rooms to offer tasks of diverse levels, for varied interests and ways of working (an example activity is provided[7])
- Concept cartoons and concept maps
- Hands-on activities
- Creating heterogeneous expert groups to investigate multifaceted topics[8]

In particular discuss how to ensure that weaker as well as high-achieving students participate, collaborate, feel included and have the opportunity to contribute and also to enrich their mathematical and/or scientific understanding. For instance:

- providing time for students to seek for their own solution-path in their own speed,
- allowing weaker students to reflect on their own first and then contribute to the discussion,
- stimulating quick and high-achieving students to face extra challenges, and
- formulating learning goals in advance that are content-related and diversity-related.

Intended learning outcome: Diversity in the classroom implies the need for diversity in teaching methods.

[5] http://web.mit.edu/jbelcher/www/TEALref/Crouch_Mazur.pdf
[6] https://improvingteaching.co.uk/2013/08/17/increasing-wait-time/
[7] See worksheet of annex 2: Escape your teacher!
[8] See worksheet of annex 3: Creating heterogeneous expert groups for energy production

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ACTIVITY 1.6: Addressing diversity through IBL and (peer) feedback (30 minutes)

The aim of this activity is to provide participants of the course with examples by which diversity in achievement levels can be addressed through organizing (peer) feedback when working on IBL tasks. The key issue is to provide students with information they can act on and that improves their learning. A powerful strategy is to ask students to assess the work of others. This helps them to appreciate and learn from different solution methods. Such a role shift has several learning advantages:

- It encourages students to consider alternative methods. In many mathematics and science lessons, students are only presented with one method for doing each task. They do not therefore come to appreciate the strengths and weaknesses of alternative approaches.
- It encourages students to consider methods that they would have not have normally chosen. When solving mathematical problems, for example, research shows us that many students do not choose to use algebra or graphical methods.
- It enables students to see the purpose of IBL tasks more clearly. Many students just consider the purpose of the lesson as to 'get the right answer'. In assessing work, particularly against provided criteria, students are encouraged to appreciate the relative qualities of different methods.

This activity involves watching a video clip of a lesson in which secondary students assess student work that has been provided by the teacher[9]. This work was chosen to represent five different approaches to tackle a mathematical problem. Before the lesson, the students had been asked to attempt the problem individually, without help. In this follow-up lesson, students first try to comprehend the sample work then they evaluate it. Before watching the video clip, do the task yourself, and consider the sample work with a group of colleagues, if possible. As an alternative the work of four students on a science task can be used (see next page).

- What IBL processes are evident in the sample work?
- What diverse levels of reasoning does the sample work illustrate?
- Anticipate the issues that will arise when this sample work is assessed by low-achieving students and what issues will arise by high-achieving students.

Now let the participants watch students as they assess the sample work, and then go on to improve their own work.

- What aspects of the provided work do students attend to?
- What criteria do students use as they assess the sample work?
- What do students learn from assessing the sample work?

Discuss with the participants the possible comments of teachers that some students attend more to the neatness of the sample work than to the quality and communication of the reasoning employed. Other teachers might be concerned that students will uncritically 'copy' sample work (see worksheet in Annex 1).

- How do you respond to these concerns?
- What criteria would you use for choosing sample work to use with students?

[9] http://primas.mathshell.org/pd/modules/7_Self_and_Peer_Assessment/html/videos_b.htm

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ACTIVITY 1.7: Design and prepare a lesson for a diverse classroom (30 minutes)

The aim of this activity is a better understanding of and reflection on the benefits, risks and challenges of teaching and learning in diverse classrooms by using characteristics of resources and classroom management for preparing and organizing a lesson that takes the opportunities provided by diversity in the classroom.

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- Summarize characteristics of teaching methods for dealing with diversity:
  - Differentiate in teaching methods (use of closed, open tasks; provide choices in the learning trajectory; provide choices in theoretical or more practical competences related to a topic; …)
  - Differentiate in level of (optional) tasks after short theoretical introduction (repeat, more in depth the same topic, more other topics)
  - Differentiate in time for a learning route (and provide extra materials for those who like to speed up or for those who like to have additional practice)
  - Use open inquiry tasks on which students can work on their own level of performance. Sources of inspiration are:
    - Primas – learning concepts through IBL: a module with a lot of examples (http://www.fisme.science.uu.nl/toepassingen/28628/)
    - Mascil: open tasks in workplace contexts (http://www.fisme.science.uu.nl/publicaties/subsets/mascil/)

- Let the participating teachers prepare a teaching activity to try out (about … with the aim to …). Be explicit about (coherent) tasks, teaching methods and learning goals.
  - Identify in advance three students in your classroom on different performance levels and predict how they will tackle the activity (scaffold with a handout). Formulate learning goals for each of the students.
  - Plan how to use, build on or take account of these different approaches in your lesson plan (including tasks, teaching methods and learning goals).
  - Include a reflective activity in your lesson plan by which all students can receive feedback on the aims of the activity and their own work/understanding.

- Discuss the planned activities and the lesson plans with the participants (first let them give feedback on each other). Focus on the three case students and make sure that it becomes explicit how to involve them in the lesson.
- Provide the participants with information about the try-outs of the planned activities: when and how to conduct a try-out (preferable in couples so that you can observe each other's lessons) and how to report about it (e.g. a short written or oral report about the situation, the intervention, the hypotheses, the results and lessons learnt from the course perspective; include a short video clip of a few minutes).

Use the sample evaluation form to report on your experiences (see annex 2).

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Annex 1: Worksheet with sample work of a science activity[10]

What Is Causing the Changes in pH?

On the table in front of you are samples taken from a pond over the course of several years.
Use the equipment provided (wide-range pH paper, pH test kits) to find the pH of each sample.
Give a justifiable explanation as to what might be causing any changes in pond pH.
Predict what effects these changes might have on plants and animals in the pond's ecosystem.
What things could be done to reverse these changes?

Rivers Unit Assessment #4

On the table in front of you are samples taken from a pond over the course of several years.

1) Use the equipment provided to find the pH of each sample. Record your results below.

1965	1969	1972	1978	1982	1986	1990	1995
PH7	6	6	2	4	4	2	4

2) Use the computer provided to plot and label a bar graph of this data.
3) State below any trends you see in the data.

the PH goes down

The trend identified is simplistic and does not account for fluctuations.

4) Give an explaination as to what might be causing the changes in pond pH.

polution forms and and Acid rain

5) What effect might this change have on plants and animals in the pond?

it would kill them.

6) What things could be done to reverse these changes?

we could use bacteria and filtars and we could use the waste water treatment.

The explanation lists possible causes but makes no attempt to explain the data.

Treatments are suggested, but the link is not made to pH levels.

Rivers Unit Assessment #4

On the table in front of you are samples taken from a pond over the course of several years.

1) Use the equipment provided to find the pH of each sample. Record your results below.

65	69	72	78	82	86	90	95
7	6	6	2	4	4	2	4

2) Use the computer provided to plot and label a bar graph of this data.
3) State below any trends you see in the data.

pH leveld out in the end
The water is very acidic in 1982

4) Give an explaination as to what might be causing the changes in pond pH.

If a farmer used a different kind of fertilizer and it leaked into the pond.

5) What effect might this change have on plants and animals in the pond?

it would make to much nutrients and the algea would grow rapidly and kill the animal life in the pond.

6) What things could be done to reverse these changes?

To stop the fertilizer and reduce the nutrients in the pond. I would put chlorine into the water to reduce the nutrients

The student was able to state aspects of the data but was unable to clearly articulate a trend.

Explanation is not consistent with available data, although the effects were consonant with the explanation given by the student.

Rivers Unit Assessment #4

On the table in front of you are samples taken from a pond over the course of several years.

1)Use the equipment provided to find the pH of each sample. Record your results below.

1965 - 7 1978 - 5 1990 - 2
1969 - 7 1982 - 4 1995 - 5
1973 - 6 1986 - 4

2) Use the computer provided to plot and label a bar graph of this data.
3) State below any trends you see in the data.

as the years get later Acidity gets greater but in 1995 Acidity is almost normal

4) Give an explaination as to what might be causing the changes in pond pH.

Pond probaly just started getting monitored in 1995 so something was done about it but before the all that acid rain was going into this pond and there was no way for it to neatrulize it.

5) What effect might this change have on plants and animals in the pond?

all living thing would probably die. At least the majority of them.

5) What things could be done to reverse these changes?

local industrys that are burning combustion Fossil fuels could either raise their smoke- stacks or cut down all together.

The student provides reasonable (if partially unrealistic) suggestions to reduce the effects of acid rain.

The trend is correctly identified, consistent with data collected, and the variations are noted.

Rivers Unit Assessment #4

On the table in front of you are samples taken from a pond over the course of several years.

1) Use the equipment provided to find the pH of each sample. Record your results below.

2) Use the computer provided to plot and label a bar graph of this data.
3) State below any trends you see in the data.

I see the pond water getting more + more acidic until it has been treated with alkalits neutralize the effects.

4) Give an explaination as to what might be causing the changes in pond pH.

It is probably getting more acidic from acid rain. In 1995, someone has probably treated it, or eliminated some of the amount of acid.

5) What effect might this change have on plants and animals in the pond? What gets more acidic all life in the pond fails. Microscopic bugs die. Then larger bugs die fish feed on the bugs so they die until there is no life left in the pond. Plants first dry up and die.

6) What things could be done to reverse these changes? you could treat water with alkaline to neutralize the acid. Or just eliminate the acid source.

	pH
1965	7.5
1969	7
1973	6.5
1978	6
1982	4
1986	4
1990	2.5
1995	4

Explanation is detailed and shows knowledge of inter-relationships.

The student accurately identified the trend and suggests human activities related to data interpretation.

The pH measurements are more precise (to the nearest length) showing evidence of tool use.

[10] https://www.exemplars.com/education-materials/free-samples/6-8-science

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Annex 2: Worksheet with example tasks for an Escape room

Escape room: Escape your teacher!

"Lock" your students in a room or chain them together and let them cooperate as a team and combine their scientific knowledge and practical skills (learned in your class) to escape. Make groups of 4 or 5 students let them compete against other groups, address their competitive traits (Nicholson 2013). "Which group scores the best escape time?" Or hide a "price" or treat they can find whilst following the clues in the room.

Added value of educational escape rooms

Not only is this a very activating teaching method to challenge your students subject-wise, but you also address other important skills student should develop (McGonigal 2011). Skills like: critical thinking, collaboration, communication and creativity, all of which are related to inquiry-based learning. The possibilities are endless. Depending on your goals and group you can select additional or exchange exercises that reflect the diversity in groups capabilities or challenges. For example mix "typical" humanities and science skills, use different languages or cultural aspects or combine physical assignments with lingual or graphic puzzles.
In addition, escape classrooms can be an excellent way to prepare for an exam/test subject or serve as an interdisciplinary activity. Time management is very flexible, just add more exercises or even use individual puzzles from online escape rooms as activating teaching methods. Or really challenge your students and let them create their own escape room for their classmates (or other levels).

Quick guide on creating an educational escape room:

- Buy a lock, any lock will do but each has their own properties. There are locks with three, four or more letter or number combinations, or use and actual safe or just a regular lock with a key. Just remember that the type of lock can give rise to different type of assignments.
- Depending on the lock or combination of locks you have create (or download) your puzzles. Or create a series of riddles and puzzles that lead to the location of the price or key.
- Do not make it unnecessarily complicated, combine either multiple choice questions, lab assignments or other exercises you already have/use in your daily practice.
- How many students? Teams of 4 or 5 students are ideal.

A few (worked out) examples:
http://escapetheclassroom.nl/english/
https://www.breakoutedu.com/about

Tips:
Be creative with what you have, for example the botanical garden in town. Combine with geocaching or a guest lecturer. Don't use only school knowledge but incorporate famous movie characters or quotes, popular music or current news headlines. Try to inspire colleagues this can open up interesting interdisciplinary perspectives.

Strong elements:
Addressing different (student) skills (e.g. collaboration, communication, creativity, domain knowledge, …), engaging activity, challenges can be connected to the curriculum.
However, this teaching method needs time for preparation.

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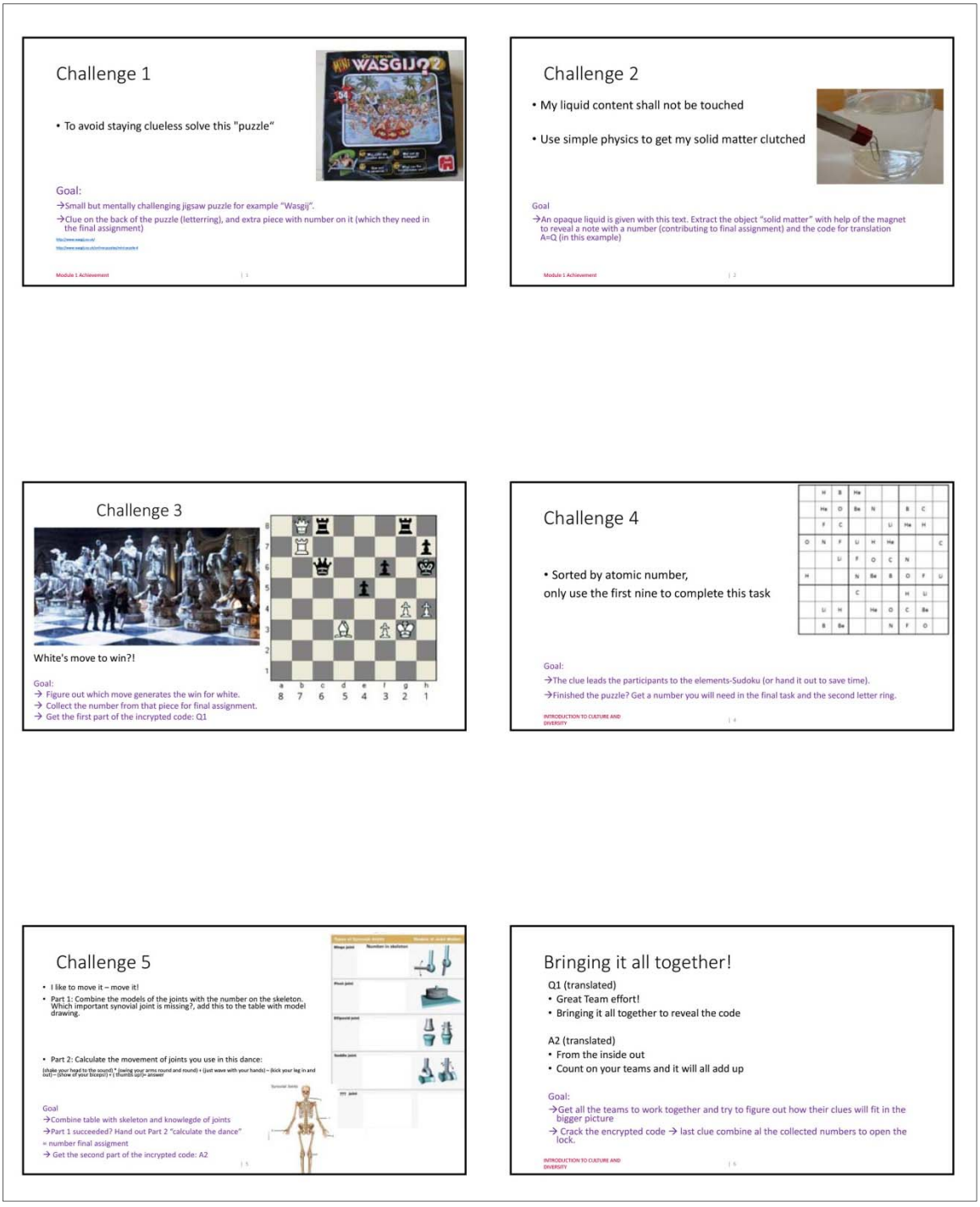

Figure: Five challenges for a fast escape room during a PD course

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Annex 3: Worksheet with example for creating heterogeneous expert groups

Creating heterogeneous expert groups for energy production

Topic: energy production (grade 7-9)

Divide the class in heterogeneous expert groups that will investigate different ways of producing energy. Each group investigates a type of energy production:

- Hydropower
- Wind energy
- Sun energy
- Biomass
- …

Each group investigates:

- how energy is produced,
- where it is produced,
- what are the advantages and what are the risks,
- …

Each group prepares a presentation of circa 10 minutes and during a series of consecutive lessons (or weeks) each group presents their findings. The rest of the class listens and have 5 minutes for questions.
At the end of the lesson the group meets the teacher and reports about the process and the collaboration between the group members, and – if needed – the teacher can grade the group (the grade will be a mixture of content, presentation and collaboration).

A follow up activity can summarize the different ways of producing energy and provide – for instance – production plans for different areas around the world.

Added value of educational expert groups

"One of the most important elements of teaching is providing students with plenty of opportunities to actively engage in learning with their peers. I have decided to start a five-part series of posts that will outline my favourite cooperative learning strategies that I have used in my classroom. I will begin with "Expert Groups," a strategy that can easily be used in grades 3-8+, and one that I find especially useful when teaching a class of diverse learners."
http://gottoteach.com/2014/07/expert-groups-cooperative-learning.html

"The main goal is to involve the students in thoughtful evaluation of different knowledge claims with a science dimension" (Kolsto 2000).

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Annex 4: Example 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 address diversity in achievement levels?			
Experiences during the lesson: what student behaviour did you observe (different than normal)? What did you observe with respect to different achievement levels?			

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