



Module 6



PEDAGOGICAL APPROACHES TO MATHEMATICS AND SCIENCE TEACHING IN MULTICULTURAL CLASSROOMS

Worksheets



These *worksheets* based on the work within the project multicultural learning in mathematics and science initial teacher education (IncluSMe). Coordination: Prof. Dr. Katja Maaß, International Centre for STEM Education (ICSE) at the University of Education Freiburg, Germany. Partners: University of Nicosia, Cyprus; University of Hradec Králové, Czech Republic; University of Jaen, Spain; National and Kapodistrian University of Athens, Greece; Vilnius University, Lithuania; University of Malta, Malta; Utrecht University, Netherlands; Norwegian University of Science and Technology, Norway; Jönköping University, Sweden; Constantine the Philosopher University, Slovakia.

The project multicultural learning in mathematics and science initial teacher education (IncluSMe) has received co-funding by the Erasmus+ programme of the European Union under grant no. 2016-1-DE01-KA203-002910. Neither the European Union/European Commission nor the project's national funding agency DAAD are responsible for the content or liable for any losses or damage resulting of the use of these resources.

IncluSMe project (grant no. 2016-1-DE01-KA203-002910) 2016-2019, lead contributions by Potari, D., Triantafillou, C., Psycharis, G. & Zachariades, T., National and Kapodistrian University of Athens, Athens, Greece, Sakonidis, C., Democritus University of Thrace, Alexandroupolis, Greece, Spiliotopoulou, V., School of Pedagogical and Technological Education, Patras, Greece, Triandafillidis, T. & Papailias, P., University of Thessaly, Volos, Greece.

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I. Introducing pedagogical approaches to mathematics and science teaching in multicultural classrooms



Activity 1.1: Sharing prior teaching experiences in multicultural settings



Work in groups



15 mins

Discuss in your group briefly about the meaning of the term “multicultural classroom”. Then try to answer the following questions

- If you haven't tried teaching in a multicultural classroom, what do you think the challenges are?
- If you have already taught in a multicultural classroom, what challenges have you experienced?

Share some of your experiences in the group and in the whole classroom.

I. Introducing pedagogical approaches to mathematics and science teaching in multicultural classrooms



Activity 1.2: Working with empirical data in multicultural settings (1)



Work in groups



45 mins

Below, we provide three episodes concerning mathematics and science teaching in multicultural settings. Episode 1 refers to the teaching of refugee students that takes place in school classes within Reception Structures for Refugee Education (RSRE) in Greece. Episode 2 refers to the teaching of mathematics in a minority school in Thrace (North Greece). Episode 3 is taken from Harper (2017) and describes an approach in science teaching that takes into account students' cultural identities.

Episode 1

Below, there is an excerpt from an interview given by a teacher (T) who works in an RSRE in Greece (primary education) to a researcher (R). The teacher has already taught how to add natural numbers up to 20. The teacher comments as follows:

T: It is easier to teach mathematics than other subjects to refugee students.

R: How this can be explained?

T: It has to do with the symbols and the fact that mathematics is a universal language. When I mentioned the sign 'plus' in the lesson, pupils immediately understood what was about. It [*i.e. the sign +*] refers to quantities, things already known. I also used the number line from 1 to 20 and it worked. Pupils can easily solve problems like 10 plus something equals 15. We first learn numbers orally, before writing them with symbols. We express the numbers in English, then in Greek and then pupils say the numbers in their own language. They asked me to repeat the numbers in their language even though my pronunciation was not always right.

Episode 2

This episode comes from an interview with a 17 year-old student (Fatma) (who lives in a muslim minority village in north Greece. Fatma is a student in the last grade of the upper secondary education. In her school, all the students belong to this minority and the lesson is in Greek. After an introduction to the concepts of derivative and tangent line of a curve in the classroom setting, the teacher organised a lesson in the laboratory where the students explored these concepts dynamically with the use of Geogebra. The interview took place after the lesson in the laboratory.

F: In the class we had a lot of unknown words that now seem familiar to us. We can ...

T: Why?

F: We saw dynamically how the line [*i.e. secant*] which was green moved on to the tangent line which was red. We saw that the two lines became one. In the classroom it was difficult to understand. On the screen we realised that this has to do with axes, points, figures. So, it

was easier to understand.

T: You mean that the words became images.

F: Yes. Now, the word 'tangent' brings to our minds a moving line that cuts the curve finally at one point. Images are easier than words because we have difficulties with the Greek language. At primary school the lessons are in Turkish while our mother tongue is Pomac. I remember at the first grade of the secondary school we did not know what 'plus' or 'minus' mean. Although we knew the signs, we didn't know the meaning of them.

T: Did you understand that the sign '+' means addition?

F: Yes, but I was confused when the teacher asked me to add two numbers or to solve an addition problem.

Episode 3

This episode is selected from the paper of Harper (2017) that describes a teaching strategy (Photovoice) that takes into account students' cultural identities in the teaching of science. The extract from the paper given below describes the process of classroom implementation.

"Photovoice, a method used predominantly in public health research, allowed students and teachers to construct a reciprocal relationship through shared storytelling that served as the foundation for the cross-cultural learning community (Wang, 2006). Participants were given disposable digital cameras the second week we met; each student practiced with a sample camera. I [the teacher] gave students the following prompt: Take photos of your culture and science at home. We defined culture as games that you play, activities and people that you value, and things that characterised your home life. Two weeks later, we held a focus group discussion in which their photos served as the prompt. The following questions were asked in the focus group:

- (1) Pick out your favourite photo. What do you see? Why is this one your favourite?
- (2) Pick out your best science photo. What do you see? Why is this photo important?
- (3) Pick out your best culture photo. What do you see? Why is this important?

Students then selected five of their own photos to develop into a visual narrative which became the base for the narrative portraits (see figures 2–3) we teachers developed at the end of the programme. In this way, students participated in the storied cultural narrative of the learning community by contributing their own embodied knowledge of culture and science. Students took these visual narratives home once the teachers photographed them." (pp. 373-374)



Figure 1.1. Narrative portrait of James

Harper, S. G. (2017). Engaging Karen refugee students in science learning through a cross-cultural learning community. *International Journal of Science Education*, 39(3), 358-376.

Assignment. Work in groups.

- Discuss in the group what issues related to mathematics and science teaching in multicultural setting you identify in the three episodes.
- Identify what classroom practices are addressed in the three settings and justify their importance.
- Based on your group discussion prepare a short report on two teaching strategies that you would adopt in teaching mathematics and science in multicultural classrooms. Justify your choices and discuss about their potential and limitations. Share these ideas with the whole classroom.

I. Introducing pedagogical approaches to mathematics and science teaching in multicultural classrooms



Activity 1.3: Working with empirical data from multicultural settings (2)



Homework in groups



30 mins

Read the following extract from the paper of Prediger, Clarkson and Bose (2016):

We are in urban Germany where Amir and Ekim, two 12-year-old boys that attend 6th grade, are participating in the MuM-Project (mathematics learning under conditions of multilingualism, see Prediger & Wessel, 2011). Both students were born in Germany from immigrant parents, have Turkish as their first language, below average performance in mathematics, and good interpersonal communication skills but limited language proficiency in German. The teacher speaks only German.

The following excerpts come from an episode where Amir and Ekim are trying to solve the following word problem:

Analphabets in the world. According to a UN (United Nations) report, $\frac{1}{4}$ of all adults in this world are analphabets, that means, they cannot read. Due to this, they cannot learn many professions, $\frac{2}{3}$ of all analphabets are women.

After Amir and Ekim had read the problem, the teacher talked to the students about analphabets and asked from them to rephrase the problem in their own words.

In the next excerpt Ekim is trying to make sense of the phrase “ $\frac{2}{3}$ of all analphabets are women”:

Excerpt 1

- 59 Ekim Oh wait, shortly. One quarter [*whispers something not understandable*]
 60 Amir Loud!
 61 Ekim Of one quarter are two-thirds
 62 Amir Women
 63 Ekim Who cannot read. Eh, we will write: thereof are two-thirds
 64 Amir Shall I comma? Mhm. [*negating his own question*]
 65 Ekim No, don't think so. Thereof are tw-two-third [*whispering*], [*louder:*] two thirds women, who cannot read.
 66 Amir [*writes down a slightly changed phrase: "Thereof are two-thirds of women who cannot read"*]

Later on, the teacher asked the students to evaluate Tobias'—an imaginary student—interpretation of the problem: “Wow, $\frac{2}{3}$ of all women cannot read? Is that

possible?”. She asked Ekim and Amir to compare their answer with Tobias’ but Ekim remains confused. The teacher suggested representing the problem with a drawing. The students made the following drawings and they interacted with the teacher in excerpt 2.

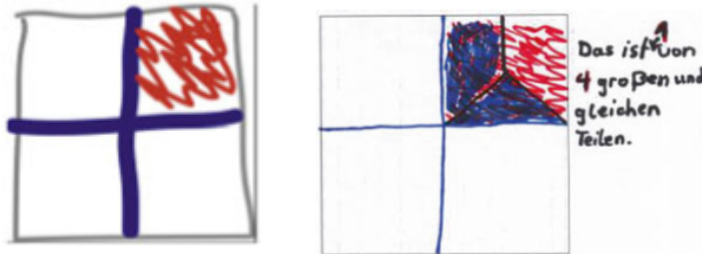


Figure 1.2. The first and second attempts of Amir and Ekim to solve the problem graphically

Excerpt 2

- 164 I Yes, that is very good. And when we refer it back to the text now, can you explain to me what it means for the situation in the text? Again with the information—ehm—that the whole square are all humans in the world?
- 165 Ekim Well this [*hints to the whole square*] are all adults and that [*hints to the red quarter*] are all adults who—eh
- 166 Amir who cannot read
- 167 Ekim exactly. who cannot read. And thereof, now two-thirds are women who cannot read.
- 168 I Mhm. [*agreeing*] Do you draw that, too? Can you draw that into it?
- 169 Ekim Two-thirds
- 170 Amir Thirds. [*break 4 sec*] Yes.
- 171 Ekim Shall we do that here? [*hints to the red quarter, but the interviewer does not react. Ekim answers himself without any break*] Yes, don’t we? We must do that.

Later on in the session, the students returned to Tobias’s solution and tried to explain why it was wrong. In Amir’s words Tobias was wrong because:

- 354 Amir Mmh, he has not the one quarter... drawn.

Prediger, S., Clarkson, P., & Bose, A. (2016). Purposefully Relating Multilingual Registers: Building Theory and Teaching Strategies for Bilingual Learners Based on an Integration of Three Traditions. In R. Barwell et al. (eds.), *Mathematics Education and Language Diversity*, New ICMI Study Series (pp. 193-215). Springer.

Consider the following issues and then prepare four slides to report your work in the whole class. Work in groups of three.

1. By the way Amir and Ekim talk and write about the problem, what can you suggest about their initial understanding of the phrase “ $\frac{2}{3}$ of all analphabets are women”?
2. Identify the different teaching strategies applied by the teacher. Did they end up to be of any assistance to Amir and Ekim? (Excerpt 2)
3. Amir and Ekim, even though they were born in Germany, their fluency in academic German was limited. On the contrary, both students were competent in their everyday, interpersonal communication. Can you visualize how the low academic proficiency in German might have affected the students’ participation in school mathematics?

II. Considering pedagogical approaches to mathematics and science teaching in multicultural classrooms through the lens of research and theory



Activity 2.1: Reporting on the activity 1.3



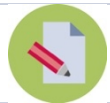
Whole class discussion



15 mins

Three groups present their slides from the homework and discuss their ideas in the class.

II. Considering pedagogical approaches to mathematics and science teaching in multicultural classrooms through the lens of research and theory



Activity 2.2: Addressing theoretical issues concerning multicultural mathematics teaching



Work in groups



40 mins (20' + 20')

'Giving life' to mathematical ideas

The construction of meaning of mathematical ideas calls for the participation in mathematical activities and assigning meaning to linguistic, graphical and symbolic aspects of these activities. Models of teaching that aim at establishing connections between different forms of representations of mathematical ideas and processes have gained momentum in the decades passed (Fig. 2.1).

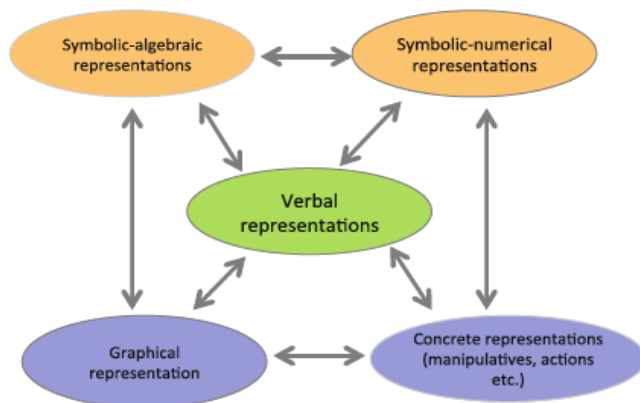


Fig. 2.1 Different forms of representation (Prediger, Clarkson, & Bose, 2016)

Despite teachers' best intentions, the implementation of this model of teaching has not always been successful (see Fig. 2.2).

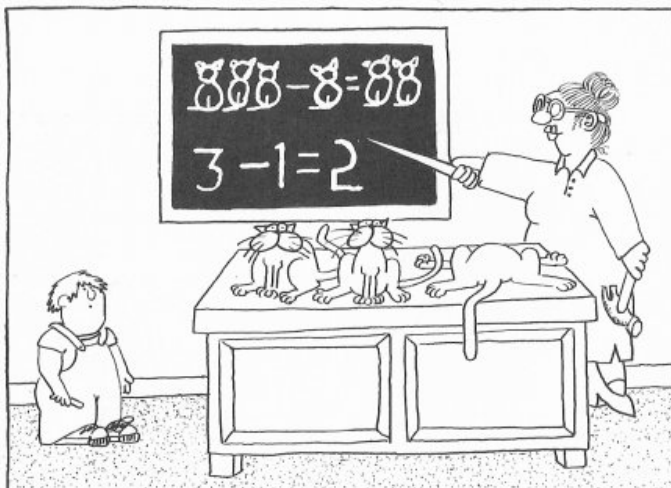


Fig. 2.2 Giving 'life' to mathematical ideas (from Skip Morrow's *The Second Official I Hate Cats Book*)

Language in the mathematics classroom

Learning mathematics as learning a language, takes more than building a vocabulary of terms and their accompanied syntax. For example, the similar objects in everyday life and in mathematics may carry a varying degree of strictness of likeness in the characteristics of the objects. Prime is an adjective when it addresses certain seats at a concert, but it becomes a noun when it addresses a number. At the same time a statement concerning “any number” conveys a general principle for all numbers.

Students participate in discussions in the mathematics classroom by bringing knowledge from everyday life that relates to mathematical ideas and processes. The purpose of teaching, as most teachers perceive it, is to build the students’ mathematics or technical language by distinguishing it also from the students’ everyday language. What many teachers often overlook though is the development of the school language, which relates to the academic use of natural language as it takes place in the school.

So far then we have discussed about three different forms of language that determine a student’s participation in school mathematics, those of the everyday, the school and the technical or mathematical forms of language. If a student’s first language is different than the language of instruction, then the situation becomes more complex. The number and the quality of the transitions between the different forms of language raises issues also for all underprivileged language learners, as in their home the school and even the everyday register are under supported.

Table 1 shows an example of the transition between everyday, school and mathematical/technical language.


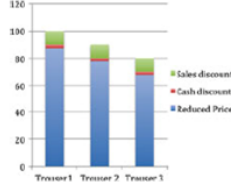
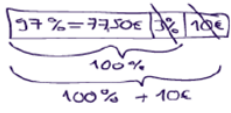
	Everyday register	School register	Technical register																																
Representation in words	Yesterday I was at a sale, in my favourite shop. The sale meant I received a 10€ discount for the trousers. Since I paid in cash, the sales clerk gave me another discount of 3%. In all I only paid 77.50€. How much was the original price?	In a sale, a pair of trousers was reduced by 10€, and further 3% discount was offered if you paid in cash. Hence, the final price was 77.50€. What was the original price of the trousers?	If the original value is reduced by 10€ and then by 3%, the new value is 77.50€. What was the original value?																																
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Table 1: Example of the transitions among mathematical representations and linguistic registers for a word problem involving the use of percentages.

Assignment. Discuss the following issues in your group and then open the discussion to the whole class:

1. Give one example following the model depicted in Fig. 2.2 concerning the different forms of representation of a mathematical or scientific idea.
2. Name the issues that worry you as a prospective teacher of mathematics or science when looking at the cartoon in Fig. 2.3.
3. Discuss about the transitions among the different forms of language depicted in table 1.
4. Provide your own examples to demonstrate the difference among the everyday, the school and the mathematical or scientific forms of language.

Prediger, S. & Wessel, L. (2013). Fostering German-language learners' constructions of meanings for fractions—design and effects of a language- and mathematics-integrated intervention. *Mathematics Education Research Journal*, 25, 435–456.

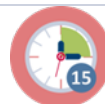
II. Considering pedagogical approaches to mathematics and science teaching in multicultural classrooms through the lens of research and theory



Activity 2.3: Addressing theoretical issues concerning multicultural science teaching



Work in groups



15 mins

Read the following passage (Braaten & Sheth, 2017, p. 138) and produce a text with the main issues (in bullets) relevant to multicultural science teaching.

What Does It Mean to Teach for Equity?

Equity pedagogies are characterized by *active involvement of students in constructing and producing their own knowledge and understandings* rather than passively acquiring information transmitted by authoritative sources (Banks, 1993). This alters epistemic authority in the classroom displacing teachers and curricula as sole knowledge authorities and centering youth as authorities—and authors—of their own understandings with *space made for multiple—rather than singular—ways of being “right”* (e.g., Carlone, Haun-Frank, & Webb, 2011; Esmonde, 2009; Hand, 2012; Rosebery et al., 2010). Teachers engaging in equity pedagogy use *critical reflection on their day-to-day practice* continually questioning and analyzing the subject matter, instructional practices, curricula, routines, and structures used in schools and society (Grant & Gillette, 2006; Zeichner & Liston, 1996).

Braaten, M., & Sheth, M. (2017). Tensions teaching science for equity: Lessons Learned from the case of Ms. Dawson. *Science Education*, 101, 134–164.

Further reading

Cobern, W.W. & Aikenhead, G. (1997). Cultural Aspects of Learning Science, Project 13. Scientific Literacy and Cultural Studies Project. Mallinson Institute for Science Education. WesternMichiganUniversity

http://scholarworks.wmich.edu/cgi/viewcontent.cgi?article=1012&context=science_slcsp

Meyer, X., & Crawford, B.A. (2011). Teaching science as a cultural way of knowing: Merging authentic inquiry, nature of science, and multicultural strategies. *Cultural Studies of Science Education*, 6, 525–547.

<http://www.bu.edu/hps-scied/files/2012/12/Crawford-HPS-Teaching-science-as-a-cultural-way-of-knowing.pdf>

Cobern, W. W. & Loving C.C. (2001). Defining “Science” in a Multicultural World: Implications for Science Education. *Science Education*, 85, 50– 67.

<http://lrc-ead.nutes.ufrrj.br/constructore/objetos/obj20452.pdf>



II. Considering pedagogical approaches to mathematics and science teaching in multicultural classrooms through the lens of research and theory



Activity 2.4: Readings from relevant research literature



Homework (individual)



30 mins

You are given a framework that describes what the teacher needs to take into account when teaching in multicultural and multilingual contexts (Fig. 2.3) and three extracts all taken from research papers.

Read the extracts and identify issues related to the framework concerning classroom practices in multicultural and multilingual contexts. Then, write a short text (500 words) describing how you would take into account these issues while teaching in a multicultural and multilingual classroom and prepare two slides to communicate your ideas in the teacher education course.

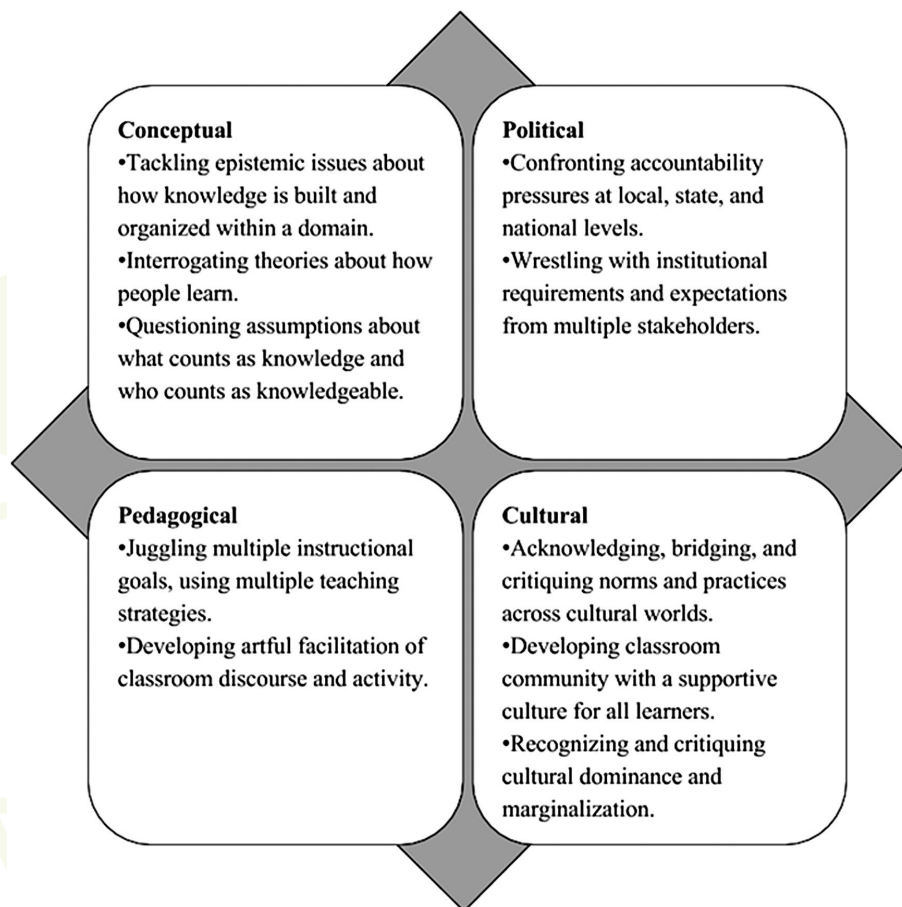


Figure 2.3. Four dimensions of dilemmas written by Windschitl (2002) (sited in Braaten & Sheth, 2017, p. 139)

Extract 1 (Adler, 1997)

Adler (1997) addresses tensions and dilemmas that the teacher faces in multilingual contexts. The dilemma she mentions concerns validating diverse pupil meanings vs developing mathematical communicative competence. This is particularly difficult for teaching when there is no zone for effective pupil-pupil interaction. Then the teacher needs to decide where to stay back and allow the different students' ideas to emerge and when to intervene to improve the mathematical and scientific communication.

Adler, J. (1997). A participatory-inquiry approach and the mediation of mathematical knowledge in a multilingual classroom. *Educational Studies in Mathematics*, 33, 235-258.

Extract 2 (Hand, 2012)

This notion of "taking up space" comes directly from one of the teachers with whom I have collaborated and is linked to a particular way that teachers who taught mathematics equitably were disposed to perceive the relations between individuals, mathematics learning, and broader sociopolitical processes. These perspectives are articulated in two quotes I provide from this teacher and are connected to a robust literature on equitable teaching, as discussed below.

"I'm her teacher [and] I have to find something that will help me interact with her in order for to her to understand mathematics...not necessarily as a teacher, but more of a human...It's more going out there and taking up their space. I don't mean that everybody should choose to become a neurosurgeon...But, it's like, being able to have the tools to say, "If I could do this, I will become anything. I will get out there and take up my space."

(Interview, secondary mathematics teacher, May 2002)

In this quote, the teacher orients her classroom instruction at a basic human level, focusing first on helping students to utilize their capacity to "take up space" in society. From her perspective, taking up space is about realizing one's potential to contribute to society. ...

Mathematics instruction with this aim was marked by three features: (1) supporting dialogic space in classroom interaction, (2) blurring distinctions between mathematical and cultural activity, and (3) reframing the system of mathematics education. These features are reflected elsewhere in the research on equity in mathematics education and are by no means exhaustive. (pp.237-238)

Mathematics instruction with this aim was marked by three features: (1) supporting dialogic space in classroom interaction, (2) blurring distinctions between mathematical and cultural activity, and (3) reframing the system of mathematics education. These features are reflected elsewhere in the research on equity in mathematics education and are by no means exhaustive. (pp.237-238)

Hand, V. (2012). Seeing culture and power in mathematical learning: toward a model of equitable instruction. *Educational Studies in Mathematics*, 80, 233-247.

Extract 3 (Gorgorio & Planas, 2001)

Many teachers consider that once they can communicate with their students, in a social sense, there will be no further problems, because mathematics is 'a universal language'. We want to expose the negative implications of the widely accepted myth that associates the extent of language acquisition with academic achievement and academic potential. Minority language learners are often supposed to be handicapped academically. However, the insights we got through developing our project, lead us to note that the greatest effect language may have on the academic achievement has essentially to do with "the way in which teachers and schools view students' language" (Nieto, 1999, p. 195). We support an approach that assumes that the students' languages and different cultural backgrounds can be seen as a resource in their learning." (p. 29)

Gorgorio, N. & Planas, N. (2001). Teaching Mathematics in Multilingual Classrooms. *Educational Studies in Mathematics*, 47, 7-33.

Further reading

Barwell, R., & Kaiser, G. (2005). Mathematics education in culturally diverse classrooms, *ZDM*, 37(2). 61-63.

Boaler, J. (2016). Designing mathematics classes to promote equity and engagement. *The Journal of Mathematical Behavior*, 41, pp 172-178.

Molyneux-Hodgson, S., Rojano, T., Sutherland, R. & Ursini, S. (1999). Mathematical modeling: The interaction of culture and practice. *Educational Studies in Mathematics*, 39, 167-183.

Parker, F., Bartell, T. G. & Novak, J. C. (2016). Developing culturally responsive mathematics teachers: secondary teachers' evolving conceptions of knowing students. *Journal of Mathematics Teacher Education*. DOI: 10.1007/s10857-015-9328-5.

Setati, M. (2005). Teaching mathematics in a primary multilingual classroom. *Journal for Research in Mathematics Education*, 36(5), 447-466.

III. Designing mathematics and science teaching for multicultural and multilingual classrooms



Activity 3.1: Reporting on the activity 2.4



Whole class discussion



10 mins

Two or three students present their slides from the homework in the class and share ideas with their peers.

III. Designing mathematics and science teaching for multicultural and multilingual classrooms



Activity 3.2: Observing and analyzing video clips from multicultural and multilingual classrooms



Work in groups



20 mins

Observe the following video and identify one critical incident related to culturally responsive teaching. On the basis of your prior readings interpret this incident and propose how you would handle the situation. Discuss in the classroom your ideas.

Resource: <https://www.youtube.com/watch?v=nQCitldgzW0>



III. Designing mathematics and science teaching for multicultural and multilingual classrooms



Activity 3.3: Designing a culturally responsive mathematics lesson



Work in groups



40 mins (20'+20')

Below you are given a text about how to design a culturally responsive mathematics lesson and examples of culturally responsive tasks (Smile, 1993).

Text

Instruction is culturally responsive when it incorporates and integrates diverse ways of knowing, understanding, and representing information.

As seen in previous sessions, instruction and learning should take place in an environment that encourages multicultural viewpoints and allows for inclusion of knowledge that is relevant to the students.

Students need to understand that there is more than one way to interpret a statement, event, or action. By being allowed to learn in different ways or to share perspectives based on their own cultural and social experiences, students become active participants in their learning.

Literature supports that culturally responsive/mediated instruction provides the best learning conditions for all students. It may help decrease the number of students who are frustrated with instruction not meeting their needs.

In planning, implementing and evaluating a culturally responsive instruction, teachers are expected to:

- (a) devise and implement different ways for students to be successful in achieving learning goals by
 - setting realistic, yet rigorous, goals for individual students
 - allowing students to set their own goals for a project
 - welcoming the use of the student's first language to enhance learning
- (b) create an environment that encourages and embraces culture by
 - employing patterns of management familiar to students
 - allowing students ample opportunities to share their cultural knowledge
 - questioning and challenging students on their beliefs and actions
- (c) vary teaching approaches to accommodate diverse learning styles and language proficiency by
 - initiating cooperative learning groups
 - using student-directed discussion groups
 - communicating in ways that meet students' language needs

Examples of tasks

Task 1

Smile 1881

HINDI ADDITIONS

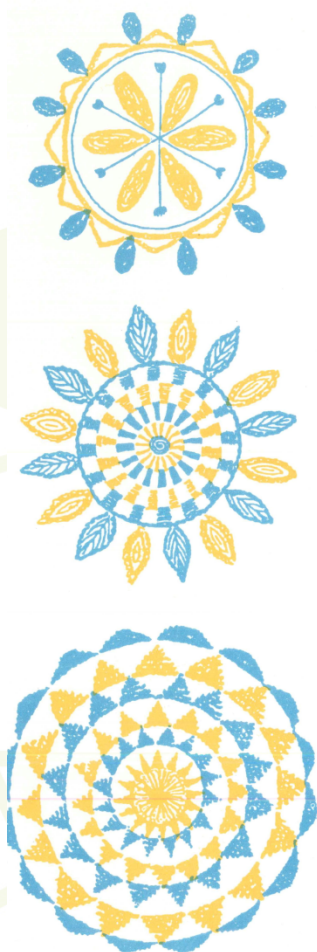
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These additions are in Hindi number script.

Can you work out what each numeral is
in your own number script ?

Task 2

Smile 2099



Naksha

Nakshi Kantha means "embroidered, patched cloth". Bangladeshi women make them by sewing together old saris and other cloths, then embroidering them with the coloured threads pulled from the saris.

They use many designs but they always put a circular design in the centre. The circular design represents the lotus flower with its very many petals. The women sew the outline of their designs, then fill them in by using different stitches, threads and colours.

Choose a number of petals and design a lotus for nakshikantha. When you have made some lotus designs you may like to try Smile 1731, (Rose) on the micro, or use LOGO to make your own designs.

Drawing by Mary Harris. This activity was originally part of the MW Cabbage Pack
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Assignment. Based on the text, the suggested tasks and other information from the resources provided below work in groups of 2-3 to address

1. In which ways these tasks can facilitate mathematics learning in a class with students of different cultural and language background.
2. Which classroom practices you could adopt in relation to (a) classroom interaction and communication and (b) the mathematics content at hand in the tasks.

You could use the following resources to get some ideas:

“Culturally Responsive Teaching – Lesson Analysis Tool”

<http://www.mathconnect.hs.iastate.edu/documents/CRMTLessonAnalysisTool.pdf>

“Enhancing the Common Core with Culturally Responsive Mathematics Teaching: Key Principles and Strategies”

https://www.nctm.org/uploadedFiles/Conferences_and_Professional_Development/Institutes/Grades_3-8_Mathematical_Practices/NCTM2015_Grade3-5Institute_Aguirre_Keynote_CRMT5.pdf

III. Designing mathematics and science teaching for multicultural and multilingual classrooms



Activity 3.4: Designing a culturally responsive science lesson



Homework in groups



45 mins

Work in groups of three. Read the following two teaching examples and think of possible uses of visual representations in teaching and learning in diverse classrooms.

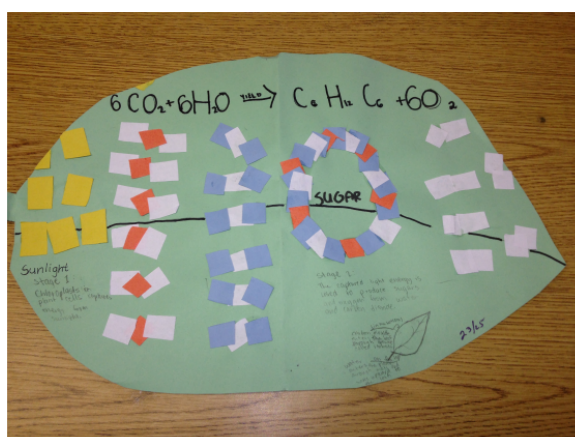
Specify a thematic unit and design your own scenario. Include details of the educational context and produce specific materials for classroom or out of classroom science learning. (Produce one slide with the description of the educational context, one slide with the thematic unit and your rationale for your choice, two slides with the design of your scenario, and one at least activity/task for the students).

Example 1. The case of multimodal activity for Photosynthesis (Menon, 2015)

For the visual diagram task, the written prompt, “Please draw a picture of the plant which will explain the process of photosynthesis,” was created by the teachers to help the students engage in the visual drawing task. For the comic strip, the prompt given by the teachers was as follows: “Create a comic strip which will describe the process of photosynthesis. An example can be like The Magic School Bus, where you enter the plant in a bus and describe the process as you are going through the bus.”

- The teachers also provided a list of vocabulary words which was to be used in the comic strip.
- An example of a molecule visual model:

Molecule Model



Example 2: Ecological sustainability and the crosscutting concept ‘cause & effect’

Question for pupils: Look carefully at the following images. Can you discuss about causes and effects? Can you describe or draw more pictures to explain your ideas?

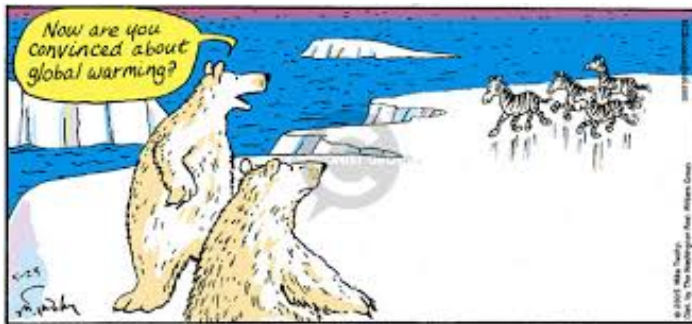


Image 1: The polar bears



Image 2: The case of Singapore

Further reading

Menon, P.K. (2015). Multimodal tasks to support science learning in linguistically diverse classrooms: three complementary perspectives, Doctor of Philosophy in Education, University of California, Santa Cruz.

http://media.proquest.com/media/pq/classic/doc/3767940321/fmt/ai/rep/NPDF?_s=5Z%2BYo59Lsel%2FEdZ0TaiLOsOetrA%3D

Ainsworth, S. (2006). DeFT: A conceptual framework for considering learning with multiple representations. *Learning and Instruction*, 16, 183–198.

Alvermann, D. E. & Wilson, A. A. (2011). Comprehension strategy instruction for multimodal texts in science. *Theory Into Practice*, 50, 116–124.

Jewitt, C., & Kress, G. (2003). *Multimodal literacy*. Pieterlen, Switzerland: Lang.

Meyer, X., & Crawford, B.A. (2011). Teaching science as a cultural way of knowing: merging authentic inquiry, nature of science, and multicultural strategies. *Cultural Studies of Science Education*, 6, 525–547.”

<http://www.bu.edu/hps-scied/files/2012/12/Crawford-HPS-Teaching-science-as-a-cultural-way-of-knowing.pdf>

Prain, V., & Waldrip, B. (2006). An exploratory study of teachers’ and students’ use of multi-modal representations of concepts in primary science. *International Journal of Science Education*, 28, 1843–1866.

IV. Reflecting on and synthesizing ideas from the module



Activity 4.1: Reflecting on lesson designs



Work in groups and whole class
discussion



45 mins

1. Exchange your scenario with another group's and evaluate each other's taking into account the Lesson Analysis Tool described in the following link:

The Culturally Responsive Mathematics Teaching –TM Lesson Analysis Tool

<http://www.mathconnect.hs.iastate.edu/documents/CRMTLessonAnalysisTool.pdf>

Prepare one slide with your reaction to the other group's scenario. Justify your opinion. All scenarios and reactions are presented in the whole class (25mins).

2. On the basis of the whole class discussion and the groups' evaluation, reflect on your group's scenario, propose changes and support them with arguments based on the knowledge you have developed throughout the module (1 slide). Whole class discussion will follow (20mins).

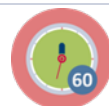
IV. Reflecting on and synthesizing ideas from the module



Activity 4.2: Preparing your final assignment of the module



Homework
(individual)



90 mins (60'+30')

Identify an issue that you would like to examine related to culturally responsive teaching on the basis of your personal experience or a discussion with a teacher in a multicultural and multilingual mathematics or science classroom, or any other resource related to a realistic setting related to culturally responsive teaching (e.g. teaching refugee students in your country). Read one of the following extracts and produce a text (500 words) indicated ways to handle the identified issues.

Extract 1 (Harper, 2017)

(Concluding thoughts from the study of Harper(2017). Karen refugees are refugees from Burma constituted the highest percentage of refugees resettling in the United States in 2015.)

In this research, an understanding of the use and production of scientific knowledge emerged from a learning terrain in which contextually authentic science learning was inextricably connected to the cultural knowledge of the students. Therefore, this research welcomed a wide terrain of cultural knowledge to inform science learning, and the epistemology of Karen students and the Karen teacher was privileged within the physical and political spaces of the after-school programme. In this way, the assumption that the culture of science exists only within institutionalised ways of knowing was challenged.

For Karen students in particular, the scientific practice of constructing explanations based on evidence gathered in science investigations proved to be a key characteristic of re-inhabiting their learning space. The science inquiry process enabled Karen students who had leveraged their understanding of the Karen language to claim higher academic status in the learning community and exercise agency in some of the inquiry projects.

Finally, for science educators and teacher educators, this research contributed to an understanding of how group formation and meaning generation within a decolonised and reconstituted learning space could impact the science learning identity of Karen refugee students. In after-school programmes, Saturday science programmes, and cultural immersion programmes, teachers engaged in science inquiry with culturally rich students and their families through the shared learning objectives of a community of practice seem to be able to crack the crusty outer layer of school culture to allow students access to multiple epistemologies as they engage with the epistemology of science. In our after-school programme, Karen and non-Karen students accepted Karen knowledge as legitimate and appropriate within a science classroom rather than 'other'. The construction of hybrid cultural knowledge and scientific knowledge within the context of a cross-cultural learning community allowed more complex meaning to emerge than would have been possible in a traditional science classroom. As a result, Karen students acted as stakeholders in science inquiry, challenging the scientific reasoning of non-Karen students, and claiming the right to argue their own reasoning. This enacted learning identity suggests a more complex understanding of scientific knowledge, one that begins to embrace the epistemology of science". (p. 373-374)

Harper, S. G. (2017). Engaging Karen refugee students in science learning through a cross-cultural learning community. *International Journal of Science Education*, 39(3), 358-376

Extract 2 (Moschkovich, 2002)

... several aspects of how bilingual students communicate mathematically that only become visible when a situated–sociocultural perspective is used... Classroom instruction should support bilingual students’ engagement in conversations about mathematics that go beyond the translation of vocabulary and involve students in communicating about mathematical concepts. A situated–sociocultural perspective on learning mathematics can help to shift the focus of mathematics instruction for English-language learners from language development to mathematical content.... One of the goals of mathematics instruction for bilingual students should be to support all students, regardless of their proficiency in English, in participating in discussions about mathematical ideas. Teachers can move toward this goal by providing opportunities for bilingual students to participate in mathematical discussions and by learning to recognize the resources that bilingual students use to express mathematical ideas.

Classroom conversations that include the use of gestures, concrete objects, and the student’s first language as legitimate resources can support students in learning to communicate mathematically. Instruction needs to support students’ use of resources from the situation or the everyday register, in which ever language students choose. Lastly, assessments of how well students communicate mathematically need to consider more than their use of vocabulary. These assessments should include how students use the situation, the everyday register, and their first language as resources as well as how they make comparisons, explain conclusions, specify claims, and use mathematical representations.

Understanding the mathematical aspects of what students say and do can be difficult when teaching, perhaps especially when working with students who are learning English. It may not be easy (or even possible) to sort out which aspects of a student’s utterance are the result of the student’s conceptual understanding or of a student’s English-language proficiency. However, if the goal is to support student participation in mathematical discussions, determining the origin of an error is not as important as listening to the students and uncovering the mathematical competence in what they are saying and doing. It is only possible to uncover students’ mathematical competence if we use a complex perspective of what it means to communicate mathematically.” (pp. 206-208)

Moschkovich, J. (2002). A Situated and Sociocultural Perspective on Bilingual Mathematics Learners. *Mathematical Thinking and Learning*, 4(2&3), 189–212.