IncluSMe

Intercultural learning in Science and Mathematics initial teacher education

Module 2

CULTURE-RELATED CONTEXTS FOR MATHEMATICS AND SCIENCE

Worksheets

Co-funded by the Erasmus+ Programme of the European Union

IncluSMe
Intercultural learning in Science and Mathematics initial teacher education

This *worksheet* is based on the work within the project Intercultural 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.

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ICSE International Centre for STEM Education

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

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I. Introduction and background

Activity 1.1: warming up: an example

Duration: 30 minutes

Study the example and discuss the things you notice. Use these questions:

- Do you see this as an example of a *culture-related context* and why?
- Which topics, concepts or problems from mathematics or science relate to this context?
- For whom (which students in your class) can this context be of interest: Why do you think so?

First we collect old plastic bottles 	Fill them with sand 	Make foundations with rocks 
And start to build 	And build 	Then plaster the walls 

Source: https://www.primas.mathshell.org/pd/modules/1_Student_led_inquiry/html/index.htm

Summarizing: What is your feeling and opinion on addressing culture-related aspects through the use of contexts?

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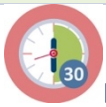
I. Introduction and background

Activity 1.3: Theoretical background on culture



Duration 30 minutes

Read the text about defining culture. Discuss the questions you find below the text.

Text 1: Defining culture

"Culture" is difficult 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 that 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 of these 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; Council of Europe, 2016a).

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 therefore 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 shaped by other cultures to which they also belong. In other words, cultural affiliations intersect, and each individual has a unique cultural positioning.

People's cultural affiliations are dynamic and fluid; what they think defines them culturally fluctuates as an individual moves from one situation to another. These fluctuations depend on the extent to which a social context focuses on a particular identity, and on the individual's needs, motivations, interests and expectations within that situation (Council of Europe, 2016a).

References:

- *OECD (2018). Preparing our youth for an inclusive and sustainable world. The OECD PISA global competence framework. OECD, Paris.*
- *Council of Europe (2016). Competences for Democratic Culture: Living Together as Equals in Culturally Diverse Democratic Societies, Council of Europe, Strasbourg*

Discuss in the group:

- What is new for you in this text about the meaning of culture?
- What are aspects of your *unique cultural positioning* (cultural identity)?
- How can this personal cultural identity influence your teaching?

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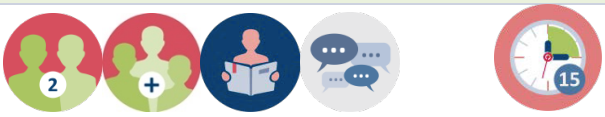
II. Culture-related contexts

Activity 2.1: Roles of (culture-related) contexts



Duration: 15 minutes

Read the excerpts below.

"In this study the definition of a context-based learning environment follows that of the context-based approach by Bennett et al. (2007) in their review of research into the subject:

> "Context-based approaches are approaches adopted in science teaching where contexts and applications of science are used as the starting point for the development of scientific ideas. This contrasts with more traditional approaches that cover scientific ideas first, before looking at applications" (p. 348).

"An important element of a context-based learning environment is active learning (Gilbert, 2006; Parchmann et al., 2006): the students are required to have a sense of ownership of the subject and are responsible for their own learning. The combination of self-directed learning and the use of contexts is consistent with a constructivist view of learning (Gilbert, 2006). As current research in science education points out: people construct their own meanings from their experiences, rather than acquiring knowledge from other sources (Bennett, 2003). "[p.9].

"The context should cause a need for students to explore and learn concepts and to apply them to different situations." [p.11]

"According to the joint statement on the context-based approach published by the Dutch innovation committees, contexts have on the one hand a pedagogic purpose and on the other hand they can be the connector to the social experience domain where science and mathematics are involved. It is however important to select contexts and relevant scientific concepts that are closely related. Also the contexts must be adapted to education in such a way students can acquire the intended scientific concepts (Boersma et al., 2006). "[p.43]

Source: Putter - Smits, de, L.G.A. (2012). Science teachers designing context-based curriculum materials: developing context-based teaching competence. Eindhoven: Technische Universiteit Eindhoven. Last retrieved on 20181212 from https://www.jstor.org/stable/pdf/40248079.pdf

Discuss in a small group:

- which of the roles and characteristics of contexts cited above, do you recognize in the example Building with bottles in Honduras and in your own teaching materials?
- which elements of a context-based approach do you find most valuable for your teaching?
- how important it is for you to use contexts that can contribute to addressing culture-related aspects in science and mathematics teaching.

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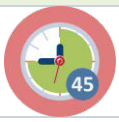
II. Culture related contexts

Activity 2.2: Examples of culture-related contexts

Duration 45 minutes

Eight examples of contexts are presented on the next pages. Some are specific, some are rather general. Note that they are just contexts, and not ready-made classroom activities. Some are clearly related to a specific culture or cultures, some you will be able to address from a 'personal' cultural perspective. Some will fit your subject, a specific domain from your subject or even a specific concept, some won't fit at all. Some you will like, or you expect your students to like. Some you won't connect to. Some will be clear, some will be fuzzy.

The contexts are:

- Patterns
- Water
- Building
- Food and Health
- Pascal's Triangle
- Energy
- Navigation
- Musical instruments

Note: Unless stated otherwise all pictures are copyright-free CC0 downloaded from https://pixabay.com or https://pixabay.com/nl

Your task as a small group is to select 2-4 examples and discuss and analyse these, focussing on the following aspects:

- Relation to STEM-subject, -content or – concepts
- Possibilities for intercultural teaching/learning
- Connection to all students' interests and backgrounds (cultural identities)
- Practical issues to deal with when using each context

Also reflect on the question:

- Is the example meaningful to you? does it relate to your cultural background and identity?

Write your findings (of at least one example) on a poster to present and share in the whole group.

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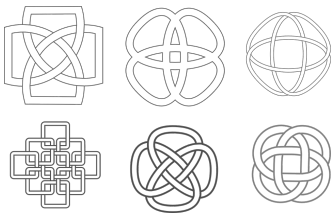
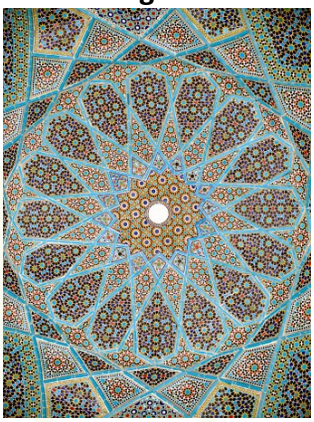
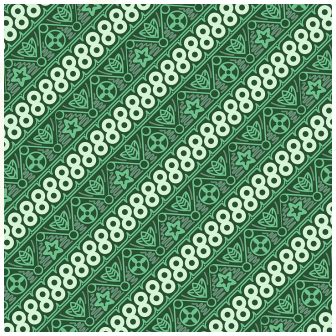
Example 1 Patterns

Patterns are all around us: patterns of nature and man-made patterns. Did you ever wonder: what is the use of patterns? What is their structure or how are they 'constructed', formed', 'grown'? What are their characteristic and properties? What makes it a pattern? Can we classify patterns, according to what criteria?

Celtic knots 	**Aboriginal painting** 	**Bridge** 
Islamic tiling 	**Zebra** 	**Muqarnas**  Source: Tom Goris
Pineapple 	**Batik Indonesia** 	**Native American weaving** 

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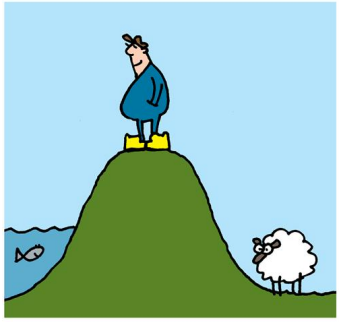
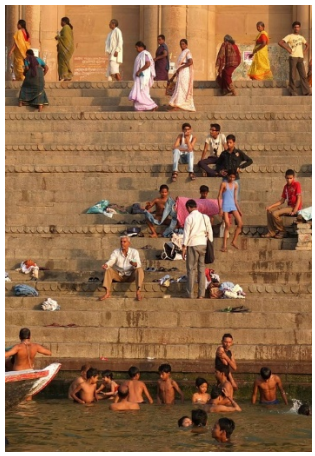
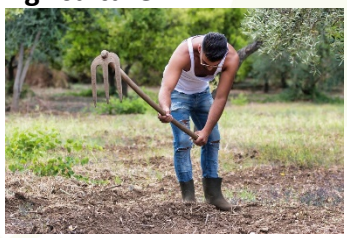
Example 2: Water, friend and foe

Water is one of the most important resources for all live on earth. Each country, ecosystem and/or culture struggles with the demand for fresh water and the dangers water brings differently.

Dike  Source: https://www.aaenmaas.nl/pagina/leren-over-water/leerkrachten/leerkrachten.html	**Bath** 	**Well** 
Ice 	**Food** 	**Dam** 
Landslide 	**Agriculture** 	**Rice field** 

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Example 3: Building

Constructing houses, towers and other buildings can be done in a lot of different ways. Different material can be used and different constructions can be made. Circumstances (location, weather, costs, available materials, sustainability etc.) may determine possibilities and constraints.









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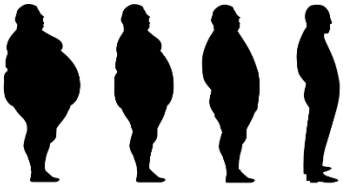
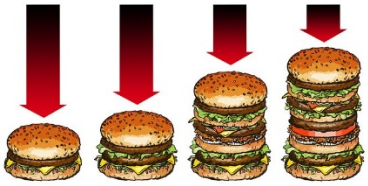
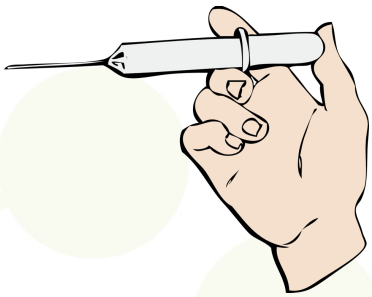
Example 4: Food and Health

Food and Health traditions are very different amongst different cultures.
We do use plants (and animals) for meals, but also for healing. The use of plants as healing agents is ancient. We also know that sport is good for our bodies (and mind). Who do we stay healthy? How do we produce enough food?




You may watch one or more videos about food around the word:
What does the world eat for breakfast: https://www.youtube.com/watch?v=ry1E1uzPSU0
School lunches around the world:
https://www.youtube.com/watch?v=Po0O9tRXCyA&t=4s
Or the pictures of the project Hungry planet: what the world eats.
http://www.nobelpeacecenter.org/en/exhibitions/hungry-planet/

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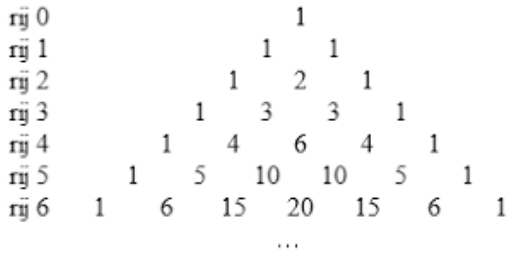
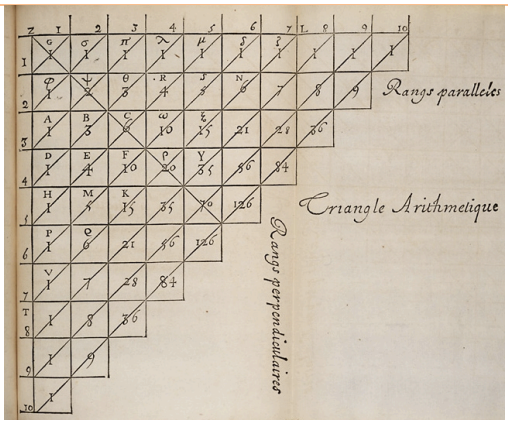
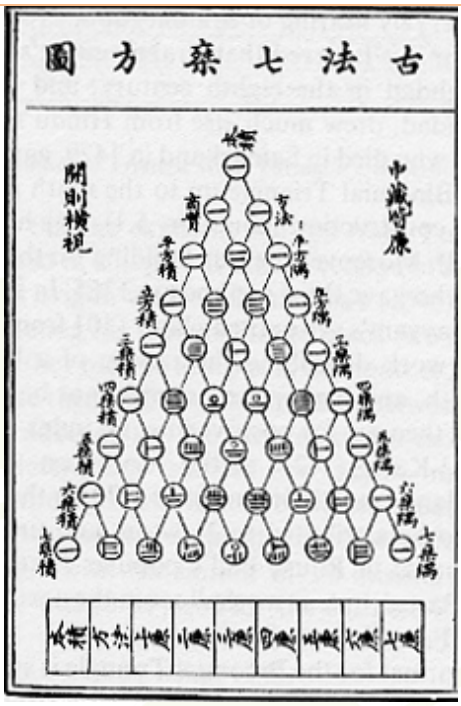
Example 5: Pascal's triangle

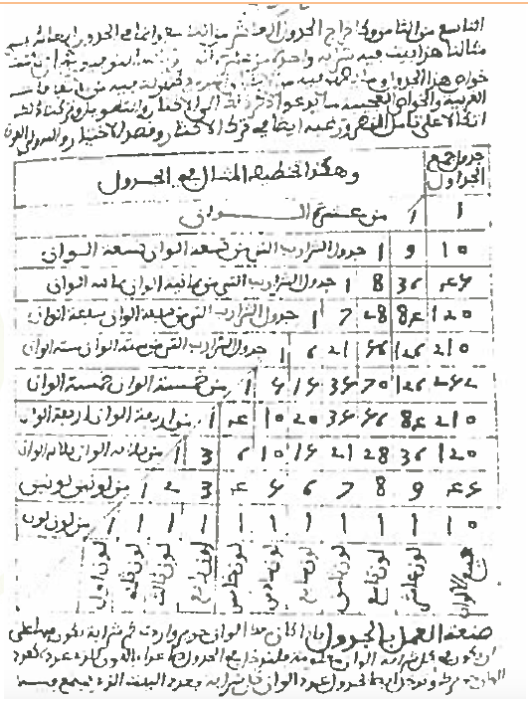
You may be familiar with Pascal's Triangle from your math lessons lessons. It is used in Mathematics for example for determining coefficients of polynomials and for combinatorics. It also has a lot of interesting number patterns in it. But how old is this idea? And did Pascal really invent it?



https://www.wiskundeleraar.nl/page3.asp?nummer=11720







https://www.maa.org/press/periodicals/convergence/combining-strands-of-many-colors-episodes-from-medieval-islam-for-the-mathematics-classroom-tassels

Source: Van den Bogaart, D. A. (2017). Wortels van de wiskunde. Euclides, 92(5), 11-12.

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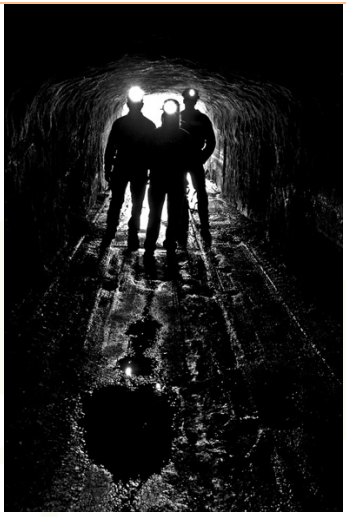
Example 6: Energy

There are a lot of ways to produce energy. Not all energy is ecological friendly. Not all energy is made in a people friendly way.

Find out the different fossil and non-fossil fuels. What kind of energy resources do you use yourself?

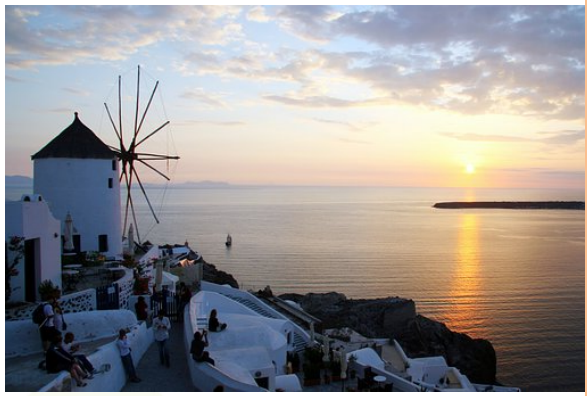
Solar cells in the desert

Windmills



Coal mining

Windmill in Greece



Nuclear power

Reservoir lake

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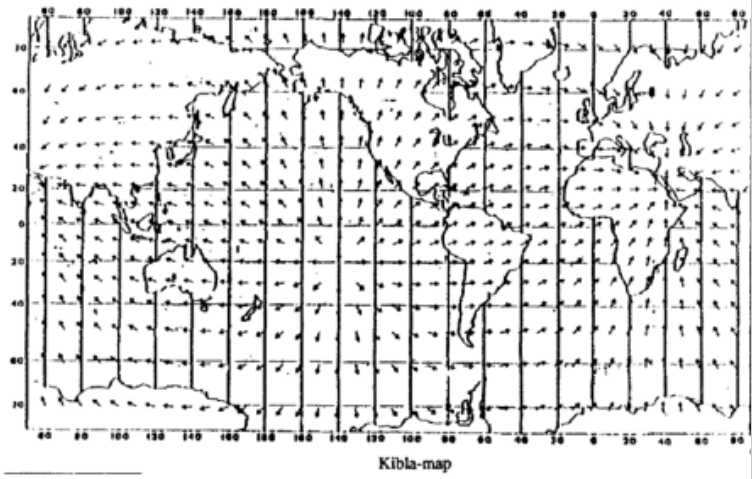
Example 7: Navigation: where is Mecca?

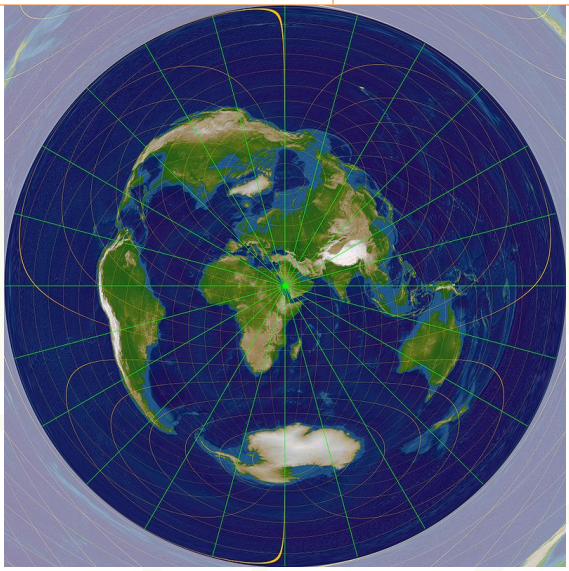
All over the world Muslims pray five times a day. They do so in the direction of Mecca. But how can they find this direction? And how would you do this?

Study this link for 5 methods of finding Mecca:

https://www.wikihow.com/Find-the-Qibla-for-Prayer

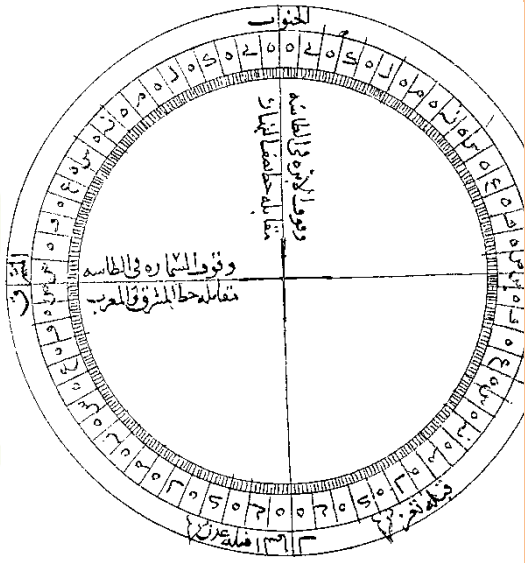


Source: Team W12-16, Mekka (1992)



Equidistant azimuthal projection, centered to Mecca and green lines showing the Qibla (shortest direction to Kaaba in Mecca, 21° 25′ 21″ N, 39° 49′ 34″ E).

Source: RokerHRO - Eigen werk, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=7325404



Source: https://en.wikipedia.org/wiki/Qibla

Al-Ashraf's diagram of the compass and Qibla. From MS Cairo TR 105, copied in Yemen, 1293.

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Example 8: Music and musical instruments

People like to play music. It makes people happy. You have traditional music, classical music, modern music, experimental music, digital music, etc. Can you play an instrument? What kind of instrument? Do you play together with other people? Do you play by heart? Are there any rituals where music plays an important role?

II. Culture-related contexts

Activity 2.3: Back to the theoretical background

1 or 2 | Duration 30 minutes

You will be assigned two texts (in English) by your educator that provide background on concepts and theory used in this module. These texts are on this worksheet.
Note: you can you also find these texts online at http://www.fi.uu.nl/toepassingen/28593/

Topics of the texts are:

1. Contributions from indigenous science
2. White teachers in Urban classrooms
3. Concepts and contexts in engineering and technology
4. The history on mathematics
5. Multicultural mathematics

- Read the two texts you are assigned to by your course educator.
- For each text you read formulate (in your small group) one statement that you want to debate in a whole group discussion (in the next session).
- Hand in your statement on a ppt-slide.

Text 1: Contributions of indigenous science

"Numerous traditional peoples' scientific and technological contributions have been incorporated in modern applied sciences such as medicine, architecture, engineering, pharmacology, agronomy, animal husbandry, fish and wildlife management, nautical design, plant breeding, and military and political science (Weatherford, 1988, 1991). In the Americas, traditional scientists developed food plants that feed some three-fifths of humanity. They also developed thousands of varieties of potatoes, grain, oilseed, squashes, and hot peppers, as well as corn, pumpkins, sunflowers, and beans. They first discovered the use of rubber, vulcanizing, and also platinum metallurgy (Weatherford, 1988, 1991). Meso-American mathematicians and astronomers used base 20 numeracy to calculate calendars more accurate than those used by Europeans at the time of contact, even after the Gregorian correction (Kidwell, 1991; Leon-Portilla, 1980). Native Americans developed highly articulated and effective approaches to grassland management (Turner, 1991) and salmon [p.13] production (Pinkerton, 1989). Traditional Native American healers discovered and used quinine, Aspirin, and ipecac (a drug still

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used in traumatic medicine to expel stomach contents), as well as some 500 other important drugs (Weatherford, 1988, 1991)". [p.14]

[Indigenous Science] "Provides time-tested in-depth knowledge of the local area which results in more accurate environmental assessment and impact statements. People who depend on local resources for their livelihood are often able to access the true costs and benefits of development better than any evaluator from the outside. Involvement of the local peoples improves the chance of successful development (Johannes, 1993; Warren et al., 1993, 1997)". [p.18]

Text 2: White teachers in Urban Classrooms

"Christopher Emdin (2010b) has successfully interwoven hiphop and popular culture into urban science classrooms, embracing students' culture and the traditional science curriculum (see also Emdin, 2010a). During his work in a Bronx school, before every class, Emdin would look at pictures that represent hip-hop culture and deconstruct them scientifically; if a picture happened to be of a rapper with an array of "chains" hanging from his neck, then students would think about the physics of this chain and the chemical components of the metal. Emdin's (2008) work has focused on finding "effective approaches to science instruction in urban schools that will allow students and teachers to have shared positive experiences" (p. 773)". [p.128]

"Ensign (2003) specifically examined how fifth grade students were more engaged when teachers used math problems that directly related to specific costs and issues that were relevant to their lives, such as living expenses. As previously discussed, because "urban students were acutely aware of how much their rent and other necessities cost," the students were more engaged in the math problems that seemed important to their lives (Ensign, 2003, p. 419)." [p.129].

Text 3: Concepts and Contexts in Engineering and Technology Education

"We have asked not only for concepts but also for contexts in which the concepts can be taught. This should be seen against the background of recent developments in educational research. Such research has led to the insight that concepts are not learned easily in a top-down approach (i.e., learning the concepts at a general, abstract level first and then applying them to different contexts). Even an approach in which concepts are first learned in a specific context and then transferred to a different context has proved unfruitful (Pilot and Bulte 2006). The most recent insights developed reveal that concepts should be learned in a variety of contexts so that generic insights can grow gradually (Westra et al. 2007). This growth leads to the ability to apply the concepts in

new contexts. In this approach, it is important to identify the concepts that should be learned as well as the contexts that are suitable for learning those concepts." [p.411]

"Analyzing the comments, the proposed contexts and the general remarks on the context part, we find roughly nine approaches, each with a different view on what the main criteria for suitable contexts should be. In random order, they state the following:

''The contexts should…'':

1. Be truly relevant to students' lives

2. Exemplify enduring human concerns, being fundamental to human nature and relevant in a variety of cultures and societies

3. Be situated around societal issues/problems

4. Encompass the Human-Made World

5. Be big examples, like the development of the paper clip, as described by Petroski

6. Be local (culturally, geographically)

7. Cover the technological domains

8. Use the ''Designed World Standards'' in ''Standards for Technological Literacy''

9. Best fit three considerations:

(a) fit to the concepts;

(b) familiarity to the learner;

(c) ability for the instructor or curriculum designer to provide more and less complex versions of the contexts that help make salient the critical feathers and relationships." [p.419]

Text 4: History of mathematics

The study of mathematics as a demonstrative discipline begins in the 6th century BC with the Pythagoreans, who coined the term "mathematics" from the ancient Greek *mathema*, meaning "subject of instruction". Greek mathematics greatly refined the methods (especially through the introduction of deductive reasoning and mathematical rigor in proofs) and expanded the subject matter of mathematics. Chinese mathematics made early contributions, including a place value system. The Hindu–Arabic numeral systemand the rules for the use of its operations, in use throughout the world today, likely evolved over the course of the first millennium AD in India and were transmitted to the west via Islamic mathematics through the work of Muḥammad ibn Mūsā al-Khwārizmī. Islamic mathematics, in turn, developed and

expanded the mathematics known to these civilizations. Many Greek and Arabic texts on mathematics were then translated into Latin, which led to further development of mathematics in medieval Europe.
From ancient times through the Middle Ages, periods of mathematical discovery were often followed by centuries of stagnation. Beginning in Renaissance Italy in the 16th century, new mathematical developments, interacting with new scientific discoveries, were made at an increasing pace that continues through the present day.

Text 5: Multicultural Mathematics: A More Inclusive Mathematics.

"Knowledge construction." This component refers not only to group consensus within a discipline but also to the process whereby individual students construct knowledge for themselves. In mathematics classes, teachers can help students understand that even though there are certain elements of mathematics that are universal--such as counting, locating, measuring, designing, playing, and explaining (Bishop, 1988) there are differences in the ways diverse cultural groups view some of the major aspects of mathematics. For example, Indians and Chinese believe that a result in mathematics can be validated by any method, including visual demonstration, whereas Europeans expect a conjecture to be proven step by step, starting with self-evident axioms.

Teachers can help students see that mathematics is derived from real-life situations by exposing them to ethnomathematics, the mathematics "practiced among identifiable cultural groups, such as national-tribal societies, labor groups, children of certain age brackets, professional classes, and so on" (D'Ambrosio, 1985, p. 45). Ethnomathematical methods vary according to interest, motivation, and certain codes and jargons that do not belong to the realm of academic mathematics.

An example is the "case price technique" developed and used by milk drivers to compute delivery charges. Suppose a driver has an order of 32 quarts of milk at $.68 per quart. Instead of computing 32 x $.68, which is hard to do mentally, the driver might take the case price (a case holds 16 quarts) and double it. If a case costs $10.88, the driver can compute the cost mentally as $10.88 x 2 (Scribner, 1984).

Discussion of ethnomathematical procedures can prompt the exploration of methods that students bring with them into the classroom. The validation of student-invented algorithms is important for self-esteem and belief in their ability to do mathematics. Moreover, these invented algorithms are grounded in real-life experiences and students' own construction of knowledge, thereby making the mathematics more meaningful.

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The sources of these texts are:

- **Text 1**: Snively, G. and Corsiglia, J. (2001), Discovering indigenous science: Implications for science education. Sci. Ed., 85: 6–34.
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  http://blogs.nwic.edu/briansblog/files/2011/02/Discovering-Indigenous-TEK-Implications-for-Science.pdf

- **Text 2**: Goldenberg, B.M., (2013) Embracing Non-White Students' Cultural Capital For Better Teaching and Learning, Urban Education, vol. 49, 1: pp. 111-144.
  Retrieved from (last access 20181212)
  https://static1.squarespace.com/static/537a4bcbe4b0c4a5e913ec47/t/590749fa6b8f5b60839f6c98/1493649915480/Urban+Education-2014-Goldenberg-111-44%281%29.pdf

- **Text 3**: Rossouw, A., Hacker, M., & de Vries, M. J. (2011). Concepts and contexts in engineering and technology education. International Journal of Technology & Design Education, 21, 409-424
  Retrieved from (last access 20181212)
  https://link.springer.com/content/pdf/10.1007%2Fs10798-010-9129-1.pdf

- **Text 4**: https://en.wikipedia.org/wiki/History_of_mathematics
  (last access 20181212)

- **Text 5**: Strutchens, M. (1995). Multicultural Mathematics: A More Inclusive Mathematics. ERIC Digest. ED380295.
  Retrieved from (last access 20181212)
  https://www.ericdigests.org/1996-1/more.htm

III. Connecting to practice

Activity 3.2 Analyse a textbook and design a lesson

1 or 3 optional | Duration 60 mins

Part A

Work in single-subject groups and analyse your textbooks for the occurrence of culture-related contexts, the role of these contexts and the opportunities to connect to your students (personal) cultures.

Part B

Prepare – in your small group- a lesson or a teaching activity for your subject using a context and addressing culture in some way. Base your design on a textbook example and be inspired by the context-examples you studied in the previous activities). In your design you may:

- use one or more culture-related context(s)
- connect to your students (personal) cultural identities
- make your students become aware of cultural aspects connected to mathematics and science.

Include a lesson-plan (including learning goals) and all teaching and student materials in your design.

Fill in the assessment evaluation form on worksheet 3.3.

Prepare a 1-2 minute pitch about your lesson/activity to present the end of this session. Be sure to address the way you activity/lesson relates to culture.

Homework (optional - ask you educator about this)

Finish the design of the teaching activity and plan how to use it in a lesson.

If possible: Try-out this activity with your students and ask them for feedback.

For the next session. Prepare a 5 minute presentation on the design of your activity, the way you address cultural aspects and connect to your students (personal) culture and the 'lessons learned' from the try-out.

Fill in the assessment evaluation form on worksheet 3.3.

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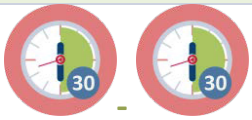
III. Connections to practice

Activity 3.3: presentation and assessment



Duration: 30-60 minutes

Name			
School			
Subject		grade	
Which activity was used (short description of resources, characteristics of the context and of the teaching method(s))			
How does your activity address cultural aspects? What is the role of the context?			
How and why do you think that your activity connects to your students (personal) cultures?			
Experiences during the lesson: what student behavior did you observe (different than normal)? How did your students react to the context? What did you observe with respect to cultural aspects?			

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