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Cultural Identity Promoting Pre-Service Math Educators in Israel

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Abstract: *In this research we study possibilities to enhance motivation of math teacher students by relating to their cultural background. The study was carried out in a college in Israel, where students of mainly Jewish and Arabic backgrounds joined a seminar during their last year of studies. Flexibility in the choice of seminar topics made it possible to connect between math and culture. We will show that a culturally-enriched view of mathematics enhances the manner in which future math teachers see mathematics and boosts their motivation. To address our research questions, we distributed questionnaires and collected mind-maps. We also started a pilot of interviewing students and reviewing math books in the Hebrew and Arabic languages. Mind maps revealed that at the end of the seminar, more students were aware of the many aspects of our lives to which math are relevant. In text books in both languages, there are some references made to cultural symbols or objects (such as garments, tents, or the star of David), but the only historical references are those to Greeks. The interviews, particularly, revealed that putting math into the social context of the student has a very strong positive impact on motivation. The interview participants demonstrated an awareness of the relationship between their own culture and math, but less awareness of the relationship between other cultures and math. Therefore, lecturers should not miss opportunities to show the rich breeding ground offered by the many cultures which have fostered the development of mathematics in the past and wherein they continue to evolve today.*

Keywords: Culturally relevant teaching; mathematics education; mind maps; ethnomathematics; motivation; pre-service math teachers

Introduction

The research project which we will describe herewith started with a very interesting and culturally-diverse group of seminar students participating in a professional retraining course to become math teachers, some of whom had background in practical engineering. A third of this group were native Arabic speakers, some of them Bedouins, and another third were early Israeli military retirees. The students in this group demonstrated a high degree of willingness to collaborate and a desire to help each other and learn from each other. Upon reviewing the seminar topics chosen and presented, the importance of putting math into a cultural context

became evident. It seemed that math seminars could serve as a platform for teaching how to motivate students by establishing a basis for learning math on cultural background.

The math seminars to which we refer in this research are final year courses for math teacher students, and for many students the first experience of doing some kind of literature research. Students are very free in choosing topics of various mathematical fields. They present the topic of their choice first in the classroom and later in a faculty study day. They also have to write a seminar work of about 30 pages including proper citations and a bibliography. Please refer to table 2 for examples of seminar topics.

Due to the freedom in the choice of argument these seminars usually cover a very large spectrum of topics. On the one hand, students learn to explore a topic in depth, and on the other hand they learn a lot from their peers.

The research objective

The study presented here was conducted to show that

a) a variety of culturally-relevant math topics in a multicultural classroom enriches the way future math teachers see mathematics, and
b) a culturally-enriched view of mathematics enhances motivation.

Theoretical Background

The fact that Robert Davis's 1955 article, Emotion and Thought, was reprinted in honor of the 100th anniversary of the Journal of Mathematics Teacher Education (2007) reflects upon the importance of the matter: positive emotion improves the study of mathematics. Positive emotion and motivation are more likely to increase when an individual's cultural background and field of studies coexist harmoniously (Altugan, 2015). Altugan analyzed the learning of Turkish Cypriots and concluded that touching upon cultural diversity in the classroom encourages minorities to engage, while ignoring cultural differences creates an atmosphere of insecurity and silences students. Incongruity between the world of studies and the learner's cultural background, on the other hand, can hinder studies (Burton, 1994).

Ladson-Billings (1995a), known for popularizing culturally relevant teaching, brought evidence which showed that students study successfully what is important to them. Ladson-Billings reported on cases of failure which ultimately became successful due to learners recognizing the topic of studies as relevant. Milner (2010), continuing Ladson-Billing's work, collected many case studies which underlined that addressing diversity in education can help to close opportunity gaps.

White, Zion and Kozlesk (2005) show that when teachers make their cultural background part of their teaching, it promotes engagement in the classroom. Since education students are likely, in the future, to project their attitudes towards mathematics on their pupils (Burton,

2012), it is important to show ways in which to generate positive emotion by integrating individual cultural backgrounds into the field of study (Gurgel, Pietrocola and Watanabe, 2014). The importance of preparing education students for responsive teaching in a multicultural classroom has been pointed out by, amongst others, Ladson-Billings (1995b), Koellner and Jacobs (2002) and Ukpokodu (2011), both in mathematics and in other fields. Ukpokodu cites the US National Assessment for Educational Progress (NAEP) in displaying how, due to growing awareness and efforts, minority students have achieved some gains over the last two decades. Bennison (2015) reports on the benefits of putting the material into a cultural context, particularly in mathematics. Gerdes (1996) shows that many calculation techniques have culturally-rooted alternatives which should be taught. D'Ambrosio (1985) and later Gerdes (1988) entitled the relationship between culture and mathematics "ethnomathematics". Borba (1990) stressed this discipline's value for education.

The importance of preparing education students for culturally-diverse classrooms has been stressed in many articles written in the United States, where teachers from the cultural mainstream are faced with immigrant students: Bryan and Atwater (2002) examine teachers' beliefs and their impact on teaching science. Anderson (1994) examines teaching styles. The situation is different in Israel, with Arabic-speaking students studying in colleges where relevant sections of the courses are taught in Hebrew, while their future students are most likely to be Arab Israelis. Teaching content and attitudes need to be addressed. Education amongst the Bedouin sector, as a common case study, is different from Western education. Ismael Abu-Saad (1991) underlines the importance of knowledge which correlates directly to daily life and tradition in the Bedouin educational system. Karnieli (2006) emphasizes that when preparing students to teach within the Bedouin community, the ability to relate to the existing culture responds to a need and can help close gaps without imposing Western values.

So, how do pre-service teachers perceive math, to what extent are they able to put math in a cultural context, and can study alter their attitudes?

In addition to classical research methods such as questionnaires and interviews, we used mind mapping to analyze our students' attitudes towards mathematics. The introduction of mind maps is usually attributed to popular author Buzan (1984), though Serig (2011) shows that they go as far back as Leonardo da Vinci's sketch books.

To our knowledge, there are no studies demonstrating – with mind mapping or similar association-revealing techniques – how broad or deep the views of education students' are or can become, with regards to mathematics, when studying relevant and adequate topics. Rubin, Bar and Cohen (2003) carried out a similar study for science in general and observed that education students' views of both science and scientists can be very traditional and quite limited. Most of the Arabic-speaking students participating in their study put Classical Islamic scientists near the top of their lists, and the study showed that they associated the term "scientist" with a male Arab, while for the Hebrew-speaking students' "scientist" was as a typical Western male. Concluding, Rubin, Bar and Cohen suggest bringing a broader

spectrum of research into the curriculum, including that conducted by women, and touching upon the role of scientists in society.

The research hypotheses

We hypothesized that choosing culturally-relevant topics in math seminars can:

1) Enhance education students' motivation to study and deliver mathematical content
2) Motivate future teachers to incorporate culturally-relevant topics into their lessons
3) Fight math anxiety and avoidance by meeting students and pupils at eye-level,
4) Foster mutual understanding in culturally diverse classrooms.

These hypotheses cannot be tested in a single one-year study. They will be tested in a long-term study during which we will screen students' attitudes towards culture and mathematics and their motivation to study and to deliver mathematical contents. For the first phase of the study we formulated the research questions below. In a pilot that we carried out during summer after the first year of the study, we interviewed a small number of students. In these preliminary interviews we started addressing the research hypotheses as will be outlined further below.

The research questions

The here presented research was designed to answer the following questions:

1) To which degree is it important to students to relate to their cultural background when studying mathematics?
2) Do math seminars with a variety of culture-related topics broaden the students' view of mathematics?

Research Methods

To address the above-mentioned research questions, we distributed and evaluated questionnaires, and collected and analyzed mind-maps. In a follow-up pilot we conducted a small number of interviews, and reviewed elementary school books in both Hebrew and Arabic. The study was carried out at the beginning of the academic year 2016-2017 (delivering questionnaires and collecting mind maps), and at the end of the academic year 2016-2017 (delivering questionnaires and collecting mind maps). The pilot studies were conducted during the summer thereafter (interviewing students and confronting school books).

Questionnaires

We distributed questionnaires to four seminar classes of a total of 97 final-year math education students during the 2016-2017 academic year, both at the beginning and at the end

of the year. The questionnaires contained two control questions, i.e. the same question worded slightly differently, to check that the participants were answering consistently.

The questionnaires contained grading questions to evaluate the students' attitudes towards math and culture as well as open questions. Students were asked to indicate their mother tongue which we used as an (not exact but approximate) indicator for the responder's cultural background. We checked for correlations between the students' cultural backgrounds and their interest in linking math with culture, and for changes in the students' attitudes during the course of the seminar. The questionnaires were designed to answer to research question no. 1 ("To which degree is it important to students to related to their cultural background when studying mathematics?").

Mind maps

Mind maps are commonly used in teaching (Tanriseven, 2014). They are created by visualizing associations and are closely related to brain-storming. In our case, the central term was "math". Students were asked to list all the ideas and concepts which they considered to be associated with this term.

Mind maps are different from concept maps in the sense that there is more freedom in design. Therefore, they are more "artistic" and more adequate for expressing people's attitudes. Whereas concept maps are typically used to organize knowledge, mind maps are more personal.

Burton (2012) used a method similar to drawing mind maps. She asked 62 pre-service elementary teachers "to draw math". Burton analyzed the drawings using open coding from grounded theory (Strauss and Corbin, 1994), i.e. ideas or concepts appearing frequently were tagged with codes. She grouped specific codes by concepts and then by categories. In a similar manner, we categorized the concepts appearing in the mind maps. We chose mind maps, since skipping the coding step that pictures require makes analysis easier and requires less interpretation.

We used mind maps as a tool to reveal the students' perceptions of mathematics by asking them at the beginning and end of the year to illustrate what they associate with the term "math".

To analyze these mind maps, we counted and evaluated the average number of ideas and concepts that students associated with math. Additionally, we categorized these concepts, and checked the frequency with which each of these categories appeared both at the beginning and at the end of the year. The categories are:

Issues and Topics in Math
Science and Nature
Technology and Computers

Human Sciences and Art
Ways of Thinking
Studying and Teaching
Games and Challenges
Positive Emotions and Success
Negative Emotions – Failure and Fear

Mind maps were used to answer research question no. 2 ("Do math seminars with a variety of culture-related topics broaden the students' view of mathematics?**").**

For our study we collected 51 mind maps in the beginning of the academic year 2016/17, and 48 mind maps in the end of the year.

Pilot studies

Reviewing elementary school math books

To get a better idea of the status quo of cultural relevance in current study material, we checked (with the help of native speakers) four elementary school math books for culturally-relevant content.

Interviews

Since it is difficult to evaluate the degree of motivation or a change in motivation using questionnaires, we conducted 4 interviews, 2 of them with Arabs and two of them with Jews. The interview questions reviewed motivation, experiences during the math seminar, and the importance of relating to culture when teaching math.

Results

Questionnaires

Of the 97 students invited to participate in the survey, 66 filled out questionnaires at both the beginning and end of the year, in a manner that allowed matching the individual's questionnaires (using a secret code comprised of the mother's maiden name initials, the student's elementary school name, and digits from his or her date of birth).

The distribution of mother tongue between the students participating in the study was as follows: 53 (80%) Hebrew speakers, 11 (17%) Arabic speakers and 2 (3%) Russian speakers. We used language as an indicator of culture, though this might not be exact. For further analysis, the small number of Russian mother tongue speakers were added to the group of non-Arabic speakers. Their culture is usually closer to Jewish culture, since they or their ancestors immigrated to Israel under the right of return.

The first question of the survey addressed the matter of finding a topic for the seminar thesis: *How did you choose the topic of your seminar thesis?* The answers from which to choose were as follows (in brackets the number of times the respective answer was chosen):

a) I asked the lecturer to choose a topic for me. (1)
b) I chose the topic from a list that the lecturer provided. (25)
c) I chose the topic during a meeting with the lecturer. (11)
d) I suggested the topic, and the lecturer approved it. (29)
e) I chose the topic according to the availability of material in my mother tongue. (0)
f) Other (students were invited to specify). (0)

The results show that slightly more than half of the students (those who chose options a, b, or c) needed some guidance when choosing a seminar topic.

The following question addressed the degree to which students saw an overlap between math and culture, the degree to which their perceptions changed during the seminar, and if there were differences between cultural groups: *In your opinion, how important is it that the seminar thesis be connected to the student's culture?* The following table, summarizing the results, reflects that native Arabic speakers demonstrate more concern about choosing a seminar topic related to their culture. This shows that identity development in relation to math is indeed interlinked with the sociocultural perspective, as stressed by Aydeniz and Hodge (2011).

Table 1 How important is it for students that their seminar thesis be connected to culture?

Answers	Native Arabic speakers	Native Hebrew (53) or Russian (2) speakers	Total
Important or very important	7	14	21
Slightly important or unimportant	4	41	45
	11	55	66

This observation is supported by the following list of seminar topics, which was created by asking students if they chose a seminar topic related to their cultural or professional background. To guarantee the anonymity of the questionnaires, we conducted this particular survey separately. Nine of the topics in this list are linked to the students' cultural background and three to their professional background as electrical or sound engineers. According to this table, more Arabs than Jews chose topics connected to their cultural background. This gives a refined answer to research question no. 1: to Arabs it is more important than to Jews to relate to their cultural background when studying mathematics.

Table 2 Topics related to individual students' background

Topic	*Background (mentioned by the student as relevant for choosing the topic)*
Al Khwarizmi and his methods for solving quadratic equations	Arabic
About Omar Khayyam and geometric solutions of the Cubic equation	Arabic
Magic squares in Islamic mathematics	Arabic
Thabit Ibn Qurra and his work	Arabic
Penrose tiling and tiling in Islamic architecture	Arabic
Famous Arabic mathematicians and their work	Arabic
Famous female mathematicians and their work	Jewish
Interesting properties of numbers in the bible	Jewish
Calendars (with emphasis on the Jewish calendar)	Jewish
Boolean logic	Electrical engineering
Electromagnetic wave defense systems	Electrical engineering
Math and music	Sound engineering

To see if, over the course of the seminar, students changed their minds regarding the possible relationship between math and culture, we compared the answers to the following questions from the beginning of the year with the answers from the end of the year: *In the beginning of the year, to which degree did you see an overlap between your future profession and your culture*, and later, *Now, at the end of the year, to which degree do you see an overlap between your future profession and your culture*? The possible answers are:

a) There is no overlap at all
b) There is a little overlap
c) There is some overlap
d) There is a large degree of overlap

In the following table, we marked changes: as positive (> 0) when students saw a higher degree of overlap between math and culture at the end of the year, as zero (0) when there was not any change, and as negative (< 0) when students saw less overlap between math and culture at the end of the year. The following table shows that there were more positive changes than negative.

Table 3 Changes over the duration of the academic year in views regarding the overlap between the profession of math teacher and culture

Positive changes	No changes	Negative changes	Total
11	54	1	66

Mind maps

Aydeniz and Hodge (2011) discuss ways to study the development of students' identity and their attitudes to culture in math and science classrooms. Mind maps, in fact, provide an additional way to observe identity development, especially when they are collected at the beginning and the end of the year. Our students arrived from very different social contexts, experienced very different classroom cultures, crossed borders and collaborated.

Analyzing the mind maps from the beginning and end of the year, we can see that those from the year's end showed more ideas related to math, with an average of 8.9 ideas (7.6 in the beginning of the year). After having heard the contributions of their classmates, more students were aware of the many aspects of our lives to which math is relevant. Thus, the answer to research question no. 2 is (at least slightly) positive ("Do math seminars with a variety of culture-related topics broaden the students' view of mathematics?"). See below (Figure 1), an example of a mind map from the end of the year. The terms appearing in the mind map were translated from Hebrew to English.

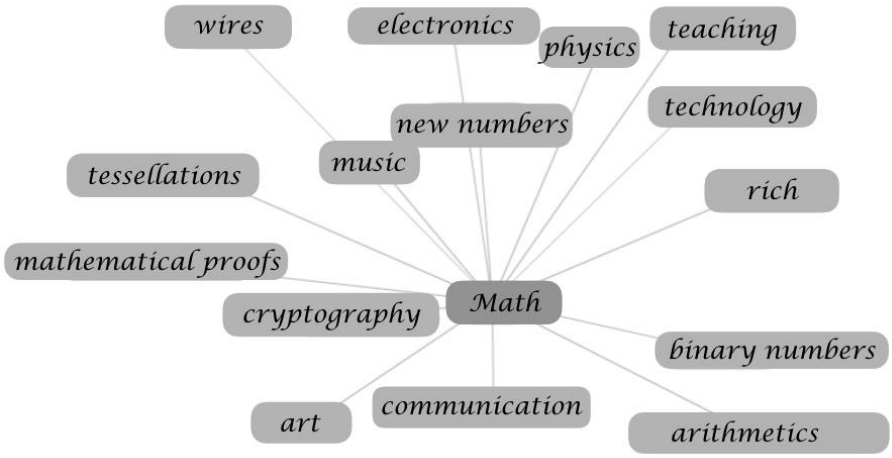

Figure 1 Example of a mind map from the end of the year (translated).

Table 4 Number of topics associated with math at the beginning and end of the year.

	Total number of mind maps	Concepts	Average number of concepts related to "math"	Standard Deviation
Beginning of the year	51	386	7.6	2.5
End of the year	48	429	8.9	2.7

To gain deeper insight, we categorized the ideas and concepts that students associated with math, and received the following:

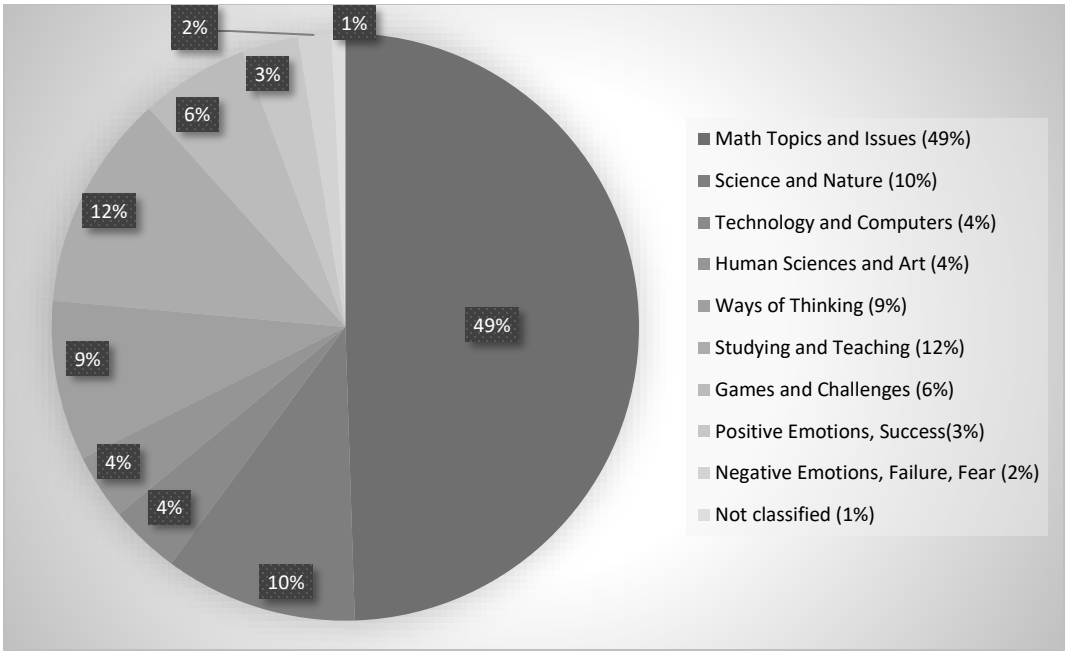

Figure 2 Categorized ideas related to math at the beginning of the year.

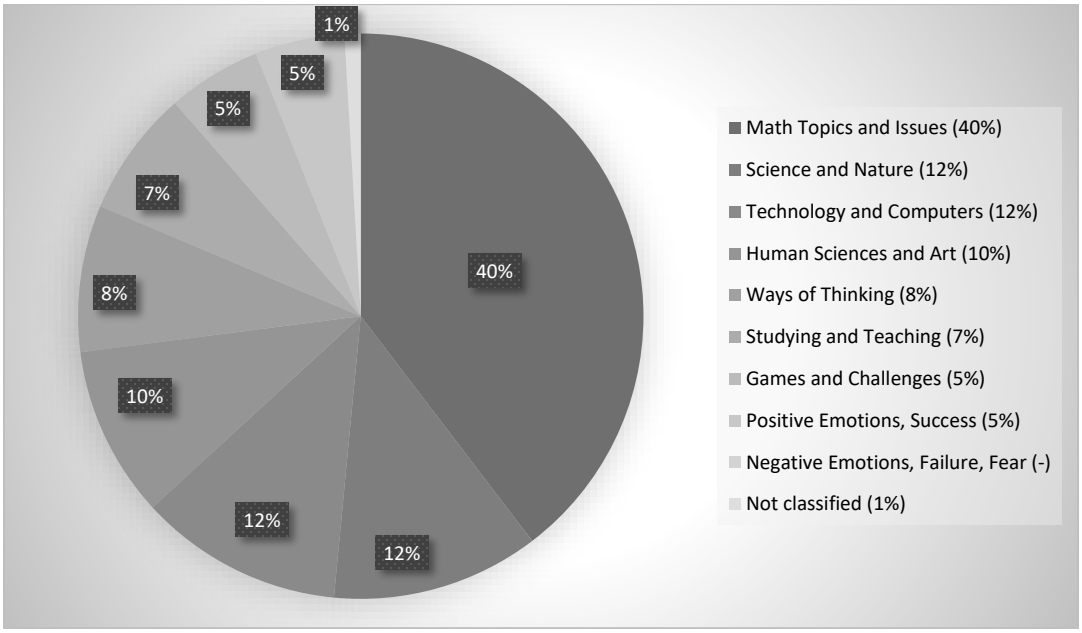

Figure 3 Categorized ideas related to math at the end of the year.

As can be seen from Figures 2 and 3, the portion of purely mathematical concepts perceived to be associated with math went from 49% to 40%, giving way to science, technology, and human sciences. It is remarkable that no negative feelings, such as fear or frustration, were mentioned in the mind maps at the end of the year, whereas they were mentioned seven times at the beginning of the year.

The minimal but existent presence of emotions in the mind maps triggered a discussion about the place of emotions in mathematics, and in studying mathematics. The students came up with the following points:

- There is plenty of literature indicating that fear hinders learning, as well as literature on how to fight math anxiety (e.g. Tobias, 1991).
- Very often, the abstract nature of math is considered an anxiety-inducing barrier, which may be an issue of curriculum as well as of pedagogy (Aydeniz and Hodge, 2011). However, the language of math is meant to be universal and cross-cultural, rather than exclusive, and independent of spoken languages. There are, indeed, mathematical proofs without words, which should be readable everywhere in the world (Doyle, Kutler, Miller and Schueller, 2014).
- Positive emotions arise for mainly two reasons – success and the discovery of beauty in math. Bertrand Russel formulated the latter as "Mathematics, rightly viewed, possesses not only truth, but supreme beauty." (Russel, 1919).
- The founder of set theory, Cantor (1845 - 1918) suffered from recurring depressions, which are at least partially attributed to the fact that his work was not adequately recognized and was even rejected by some known mathematicians (such as Kronecker).

Pilot Studies

Interviews

To address the question regarding the degree to which putting math into a cultural context can improve teaching and motivate students as well as pupils, we carried out interviews. All interview participants had gained some teaching experience during their hands-on training, internships, or while teaching math in the classroom.

All participants expressed the importance of being able to relate math to personal experiences and the roots of the society in which they live. One female student expressed particular frustration with not being able to relate to the topic of her seminar work, though she had chosen a topic that had fascinated her as a child. In this case, the lecturer had taken the topic from positive practical experiences (experiments with light) but applied it to very theoretical research questions. The same student gave many examples of how math lessons relate to daily life and of how to motivate students who find math daunting. She observed that studying the biography of the mathematician who had discovered the material they were learning helped motivate those pupils who usually disliked math. She did this because her

best memories of school were those of science lessons where she learned about the scientists behind the theories.

The creativity of Arab education students who were teaching in a Bedouin environment were most impressive, as can be seen in the following citation: "Every subject that we teach needs to be related to our pupils' background… If you teach math and you tell them about Europeans such as Gauss, who developed this theory or that theory, that doesn't tell them (your pupils) much… I'll give you an example, something that happened to me recently. I was trying to teach fractions and the addition of fractions with different denominators. Most of the kids added up numerators and denominators without any differentiation. But you can't add denominators or fractions having different denominators before converting them to fractions with a common denominator. They (my pupils) did not understand why halves are different from thirds and thirds are different from quarters, and so forth… So, I told them, 'Imagine your father has 5 cows and 3 goats. O.K., that means that your father has 8 cows…' Of course, they (my pupils) started to protest and then they got the point: halves are different from thirds in the same manner." The same student remembers only one lesson in school during which their teacher referred to his culture or history, when teaching about Al Khwarizmi.

Summarizing, we observed much readiness on behalf of the (future) teacher to meet pupils at eye-level and to include their cultural background. Only one Jewish education student participating in the interview remembered mention being made of biographies when she was a student, and was thus motivated to grant her pupils the same positive experience. The Arabic-speaking participants had fewer experiences of this kind, but stressed very much the need to put math into a cultural context. This could be due to accumulated experience from years of studies, and perhaps because native Arabic speakers, being a minority in Israel, feel more of a need to foster cultural awareness.

Reviewing elementary school math books

To what degree do elementary school math books relate to cultural context? In approaching this question, we analyzed three books.

In "Shvilim" (The Matah Math Team, 2015a) for the 5th grade, and its translation to the Arabic language "مسارات" (The Matah Math Team, 2015b) we found one reference to an historical figure: Carl Friedrich Gauss.

In "Bawakir" (بواكير) (Haibi, 2011) for the 6th grade, we found one reference to an historical figure: Plato. The presented material did refer to cultural background, mentioning such things as traditional garments and tents. Names given were typical Arabic ones, such as Mahmoud and Hassan. Female Arabic names did appear, but less frequently.

In "Haisabi" (حسابي) (Haibi, 2013) for the 5th grade, we did not find any reference to historical persons or cultural symbols.

In summary, we found that in all books, the names used were typical for the respective language. In Arabic elementary school math books, more male than female names appear. In both languages, there is some reference to cultural symbols or objects (such as garments, tents, or the star of David). The only historical references are those to Greeks – neither to Jews nor to Arabs.
The school books we checked did not, of course, cover the vast range of elementary school math books being available in Israel. However, the pilot shows that more research of this kind should be done.

Conclusions

The analysis of the questionnaires showed that over half of the students required some guidance when choosing a seminar topic. This means that the lecturer had considerable influence in terms of the topics to be presented at the end of the year. Helping students choose and work on culturally-relevant topics can enhance motivation. Moreover, it contributes to broadening students' horizons and allowing them to learn about other cultures and about the roots of others around them, and in this way, to the fostering of mutual understanding.

Arabs were more concerned than Jews about choosing seminar topics related to their culture. This can be explained by the fact that Arabs are a minority in Israel and therefore more concerned with passing their culture on and keeping it alive.

The small number of interviews suggests that putting math into the student's social context has a very strong positive impact on motivation. More interviews should be carried out to support this hypothesis.

All of the interview participants were very much aware of the motivational effect of relating math to culture, and all of them had been taught about the significance of putting math into the context of daily life when teaching. However, they were less aware of the fact that cultural context can be instrumental in fighting math anxiety and math avoidance. Therefore, stronger emphasis should be put on teaching math through a cultural lens both in teacher's education and in educational material, such as textbooks. Teaching math through cultural context should involve references to biographies, mention of cultural symbols, giving examples from daily life, and finding math in the pupils' physical environment (e.g., patterns or symmetries in decorations of public buildings or places of worship).

Cultural re-contextualization of math in Israel must be seen on two different levels – the cultural past and the cultural present and future. Historically the roots exist and only need to be remembered; so-called Western mathematics has profound roots in the Islamic golden age. For example, our numerical system is Indo-Arabic, and Al Khwarizmi is known as the founder of Algebra. The list of Jewish mathematicians is long, among them Noether (an

example of a woman famous for achievements in math). We just need to remember these roots.

The other level of cultural re-contextualization, which means reimagining math in a modern context while relating to symbols, pictures and experiences drawn from cultural context requires creativity and imagination.

Culturally diverse math seminars definitely succeed in challenging the Euro-centric "universal" math and in promoting a culturally inclusive concept of mathematics. For example, students understood that Descartes (1596-1650) was not the only father of analytic geometry, and that similar ideas were developed by Khayyam (1048-1131) in his geometric approach to solving the cubic equation, as stated by Rashed and Vahabzadeh (2000).

The interview participants demonstrated awareness of the relationship between their own culture and math, but less awareness of the relationship between other cultures and math.

Thus, lecturers, and especially those in a culturally-diverse classroom, should not miss opportunities to show the rich breeding ground offered by the many cultures which have fostered the development of mathematics in the past and wherein they continue to evolve today.

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