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Intangible Cultural Heritage as a Resource for a Sámi Mathematics Curriculum

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Abstract

Northern Norway's population comprises many different cultural groups. According to the Norwegian Education Act, education must give students insight into and a firm foundation in history and culture. This paper aims to present a proposal for how to start working with the creation of local rural mathematics curricula for which Sámi culture in particular, and Northern Norwegian culture in general, is the basis and foundation. It examines three activities that are examples of intangible cultural heritage from different non-urban Northern Norwegian cultures: i) Sámi traditional measuring, ii) fishermen's traditional navigation at sea and iii) *ruvden* (a Sámi way of braiding). The activities are analysed with respect to the framework cultural symmetry, which was developed in research in Māori mathematics education. The analysis shows that the three activities are of great significance to local cultural reasoning to such an extent that they should be included in local rural mathematics education. Each of the three activities provides opportunities for developing a culture-based mathematics teaching that values the language and culture in which the activities are embedded. We conclude that cultural symmetry seems to function as a tool for developing a Sámi mathematics curriculum.

Keywords: *measuring, navigation, braiding, Indigenous, mathematics education, Sámi languages*

Introduction

When Norway gained its Constitution in 1814, Northern Norway was a geographically and culturally rural area. The population comprised the Indigenous Sámi, the Qven minority, and Norwegians. Most people lived on smallholdings in combination with fisheries, and in addition the reindeer herding families moved around with their herds. The area was rich in resources, and people in many of the areas had to pay taxes to more than one country before the borders became clear in 1791 (Aarseth, 1989). Rokkan (1995) pointed out that for hundreds of years, privileged traders (Norwegian: '*nessekonger*') had bought people's products, decided their credit, and thereby controlled their lives. During the 20th century, Norway as a national state moved towards a stronger concentration of 'elite' arenas in the capital Oslo area in the south. Rokkan claimed Northern Norway to be a polarised periphery. Hellevik (2010) points out that the centre-periphery polarities in Norway also include cultural polarities between an urban, internationally oriented elite and a locally oriented rural population. In 1972, Northern Norway gained a university, but north-south centre-periphery polarities still exist. The Coastal Rebellion (Kystopprøret, 2023) was established in 2017 with the message that the resources should belong to the people, and that the fish in the ocean has to cause activity in Norway instead of abroad. The Sámi parliament in Norway was established in 1989. In February 2023, there was a breakdown of negotiations between the Sámi parliament and the Norwegian government regarding consultations about the new Education Act (Sámediggi, 2023). This breakdown shows that cultural center-periphery polarities still exist.

The Sámi are an Indigenous people of the Arctic who inhabit northern parts of Norway, Sweden and Finland, and the Kola peninsula of Russia. Sápmi is the name of the area where the Sámi historically live. Traditional Sámi livelihoods are reindeer herding and combinations of smallholdings and fisheries. *Meahcceealáhus* (hunting, fishing and gathering) and *duodji* (Sámi handicraft) have strong traditions. In Sámi traditional knowledge, the term *knowledge* means knowledge as a process, not just as the outcome of a process. The Sámi people and their culture have had very limited space in Norwegian schooling. The Sámi curriculum was established in 1995 (Ministry of Education, Research and Church Affairs, 1997). It is based on Sámi culture and values, which are peripheral to the culture and values of the decision makers at the Ministry of Education. From our perspective, this was a rural curriculum, with one exception: The mathematics curriculum was a mere translation of the national curriculum text. The reason for the exception is most likely the idea of mathematics being considered cultureless. This idea is engraved in people's views about the nature of mathematics, due to its long history (Meaney, Trinick, et al., 2022). Despite the Sámi curriculum, Keskitalo (2009) points out that the Sámi school system in its present state in Norway is based on the ideas of the national Norwegian school system.

To recognise and reinforce living cultural heritage, Norway ratified the Convention for the Safeguarding of the Intangible Cultural Heritage (The United Nations Educational, Scientific and Cultural Organization [UNESCO], 2020) in 2007, with a special commitment towards the Sámi people. In the Convention, the phrase 'intangible cultural heritage' means practices, representations, expressions, knowledge and skills—as well as the instruments, objects, artefacts and cultural spaces associated with them—that communities, groups and, in some cases, individuals recognise as part of their cultural heritage. The aim of our article is to provide examples of how to contribute to safeguarding Sámi intangible cultural heritage as well as intangible cultural heritage of the coastal Northern Norway.

Centre-periphery tensions influence the teaching of mathematics, as well as other subjects. For instance, Fyhn and Nystad's (2013) study of one national mathematics exam found that more than one sixth of the exam's first part concerned contexts that are absent in the north. Contexts and activities must be taught with due regard for the culture and the language in which they are embedded. This is not always the case when examples from the local rural culture are introduced into school mathematics. If culture is reduced to just a tool for teaching mathematics, there is a risk that the well-meaning mathematics teacher contributes to misrecognition of culture, instead of the opposite. The research question is: How may illumination of tensions between intangible cultural heritage from the north and Western mathematics contribute to a future Sámi mathematics curriculum?

The framework of cultural symmetry (Trinick et al., 2016; Meaney, Trinick et al., 2022) values intangible cultural heritage in mathematics education and serves as a tool to prevent situations where culture is reduced to just a tool for teaching mathematics. The framework deals with tensions between intangible cultural heritage and school mathematics. We show how cultural symmetry can serve as a tool for creating a Sámi mathematics curriculum. We analyse mathematical reasoning that is embedded in three different activities that belong to Sámi culture. The reason for the choice of activities is that we know them from own previous research: Jannok Nutti's (2007, 2010, 2013) study of Sámi traditional measuring of length, Fyhn et al.'s (2014, 2015, 2017) study of *ruvden*, a Sámi braiding, and Fyhn and Robertsen's (2020) study of a fisherman's traditional navigation.

The first author, Anne, grew up in Tromsø when it was a small rural town with no traffic lights, no TVs, and no university. Her grandfathers were fishermen who later became sailors. Her father taught her how to find and use a straight course while rowing a boat, before she learned any foreign language at school. Anne has cooperated with Sámi researchers and mathematics teachers since 2005 and she holds a professor II position at the Sámi University of Applied Sciences. The second author, Ylva, is a Sámi researcher and former Sámi primary school teacher, and since 2015 she has been associate professor for the Sámi teacher training programme at the Sámi University of Applied Sciences. She lives with her reindeer-herding family in the home village of Johkamohkki in the Swedish part of Sápmi. From 2010 to 2014, Anne and Ylva worked together with a Sámi lower secondary school on a research project about Sámi culture and mathematics.

Background

Norway's ratification of the Intangible Cultural Heritage Convention (UNESCO, 2020) supports the work towards including intangible cultural heritage in a future Sámi mathematics curriculum.

Northern Norway's Coastal Cultural Heritage

The fish in the ocean is the most important reason for permanent settlement in small communities along Northern Norway's coast. Edvardsen (1984/2011) studied schools and livelihoods in a Northern Norwegian coastal society in the last part of the 19th century, after Norway was freed from the Danish colonialists. He describes how the school fought against the coastal culture and its way of living; it was not the children of the coast who needed to be educated, but the culture itself.

> *The mission of the educational system is to mold one subculture to fit the specifications of another subculture. The manners and breeding of the upper classes are the source of the teacher lectern's general education: the uncultivated is to be cultivated, the primitive civilized. Norway is "a work in progress" that has to be made into one country. (Edvardsen, 1984/2011, p. 118)*

Edvardsen points out that local people's scepticism towards school and schooling was the wise and sensible individuals' resistance. The school encountered a way of living that was rich in knowledge that differed from the school's knowledge, but the schoolteachers did not consider the population's knowledge to be '*knowledge*'. Edvardsen furthermore claims that the Sámi population were exposed to double Norwegianization, because their language, as well as their culture, needed 'cultivation'. Trinick and Heaton (2020) describe a similar 'cultivation' in Aotearoa/New Zealand, where the function of the curriculum at that time was to assimilate and 'civilise' the Māori population. English language and cultural hegemony were used to build a nation state.

According to Maurstad (2010), small boats with one or two fishermen constituted the backbone of Norway's coastal societies. People rowed or sailed these boats. The small traditional boat 'spisse', is about to go out of use in the Sea-Sámi areas. The Sea-Sámi organisation Mearrasiida pass on knowledge about the construction of 'spisse' to ensure that such boats remain an important part of Sea-Sámi culture (Mearrasiida, 2019; Hætta Karlsen et al., 2023).

The Sámi's Need for a Sámi Mathematics Curriculum

The first Sámi curriculum claimed that teaching should provide basic cultural knowledge and include local culture and cultural heritage (Ministry of Education, Research and Church Affairs, 1997). Hirvonen and Keskitalo's (2004) evaluation of the 1997 curriculum revealed a need for a curriculum change in which Sámi culture would become the basis and premise for teaching, rather than just an appendix. Jannok Nutti (2010, 2013) studied Sámi mathematics teachers' work about including local Sámi culture in their teaching. She conducted her study in the Swedish part of Sápmi. As in Norway, there is no Sámi mathematics curriculum. Teachers themselves must adapt their teaching to the local culture, and as a result, usually no Sámi culture-based mathematics teaching takes place. She also found that the teachers' newly developed knowledge about ethnomathematics as a field of research seemed to enhance their work with Indigenous culture-based mathematics teaching.

The Core Curriculum (Ministry of Education and Research, 2017) claims that the Sámi school must ensure that pupils receive education and training based on Sámi values and language. Norway gained new curricula for all subjects in 2019. The Ministry of Education and Research (2018) stated beforehand that that the new curricula from 2020 should include Sámi issues in all subjects. It turned out to be no Sámi content in the mathematics curriculum, because "*... mathematics is a universal language, independent of culture*" (Ministry of Education and Research, as cited in Fyhn (2020), author's translation).

Indigenous Mathematics Curricula outside Scandinavia

In the 1990s, New Zealand's Minister of Education agreed to the development of Māori medium curricula, and Pāngarau (mathematics) was one among three learning areas to be developed (Stewart et al., 2017). In 2007-8 this curriculum was redeveloped. The writers started from a different position compared with the original development, because most of them had been involved in the previous curriculum. In 2013, even the development and implementation of curricula of the more highly politicised Māori-medium sectors was funded by the state (Trinick & Heaton, 2020). The development of Māori-medium mathematics curricula actually represents a contrast to the Sámi mathematics curriculum in Norway, where the Ministry claims that mathematics is a universal language independent of culture. This also means that the Māori are approximately 25-30 years ahead of the Sámi when it comes to mathematics curriculum development. According to Trinick and May (2013) the development and modernisation of the Māori mathematics register has also resulted in discussions about standardisation versus dialect loyalty. As for the Sámi mathematics register, the 1990 mathematics dictionary has been renewed only once (Nystad et al., 2002), and there is a need for an improved version of it.

Math in a Cultural Context: Lessons Learned from Yup'ik Eskimo Elders (MCC) is a supplemental mathematics curriculum that is based on the traditional wisdom and practices of the Yup'ik people of southwest Alaska (Lipka et al., 2010). A group of elders, teachers and researchers cooperated on developing curriculum modules. MCC focuses on relations between pedagogy, mathematics and culture. The modules are published in English, the language of instruction is not considered.

Cultural Symmetry

Traditionally, the Māori were renowned for their navigational expertise, being able to navigate using traditional techniques across vast distances in the Pacific Ocean (Trinick et al., 2016; Barton, 2008). Meaney, Fyhn, et al. (2022) cite 'Peter', who is Indigenous,

> *Our people navigated across vast tracts of the Pacific Ocean without a sextant, without a compass, but they had the knowledge and their materials and tools to do that. But that was not the Western view of maths, so that was not considered mathematical knowledge. (p. 556)*

Based on their work on the revitalisation of Māori cultural practices in mathematics education, Trinick et al. (2016) and Meaney, Trinick, et al. (2022) developed the three-step approach called 'cultural symmetry'.

Even if Indigenous students do gain mathematical insights from interacting with familiar cultural practices, there is a risk that the intrinsic value of the cultural artefact is devalued if it is reduced to a tool for transmitting mathematical ideas. The idea of cultural symmetry is to prevent this risk. The framework differs from other approaches to culture-based mathematics teaching in the sense that cultural knowledge and language must be recognised and valued before any mathematics is introduced; intangible cultural heritage is highlighted and valued.

Step 1 in cultural symmetry is for the cultural knowledge and language to be identified and acknowledged as valuable. Regarding concepts of spatial orientation, it is important for the students to understand that location and direction are not just about finding one's way, since this also concerns cultural practices related to the landscape; as practices that are developed over a long period of time. Step 2 concerns examining the cultural practices and discussing them from a range of perspectives. Regarding location and direction, the Māori used a variety of spatial frameworks abstracted from landmark-based systems for their orientation. These references were derived from a mix of different phenomena, including the actions of the sun and the wind, and geographical land formations. Regarding the north-east-south-west orientation, they found that the hegemony of Western mathematics made it challenging for both teachers and learners to consider other means of orientation. Step 3 involves considering how mathematics can add value to cultural artefacts and practices, without detracting from the cultural understanding. This means discussing the origins and frameworks that underpin cultural knowledge in Western mathematics, as well as traditional Māori practices, and discussing the advantages and drawbacks of both. Functional use of cultural symmetry to analyse our three different examples of intangible cultural heritage may suggest how this framework can constitute the basis for a Sámi mathematics curriculum.

Analysis: Relations between Cultural Activities and Mathematics

Research on Indigenous Issues needs to be carried out in a way that is respectful and ethically sound from an Indigenous perspective (Louis, 2007). The three cultural activities in our study are presented from Indigenous and rural perspectives. Our study aims at showing how these activities can add value to Sámi mathematics education. For the activities bodily measuring and sea navigation, we also have included what we could find of available literature that present Sámi voices. However, there is not much literature about these issues. Ryd (2007/2022) and Birkely (1994) describe bodily measuring of snow depth. Ryd has interviewed the Sámi reindeer herder Rassa about snow, and the Sámi skier Birkely has studied the history of ski use from a Sámi perspective. The Sámi boat builders Hansen and Stødle present how they use traditional measuring in their work (Hætta Karlsen et al., 2023). The Sámi handicrafters Guttorm and Labba (2008) and Dunfjeld et al. (2018) explain how bodily measuring is used in Sámi handicraft *duodji* (south Sámi: *duedtie*). The Sámi boat builder Hansen (2021) describes Sea-Sámi landscape navigation at sea.

We chose cultural symmetry as the tool for our analysis because the framework is designed to prevent the risk of devaluation of the culture. Our paper focuses on Sámi intangible cultural heritage. However, there are not watertight bulkheads between Sea-Sámi culture and Northern Norwegian coastal culture. Different cultures may have activities in common; being different does not mean that nothing is shared. New Year is for instance celebrated in many different cultures. The 6th century historian Prokopios denoted the Sámi as '*Skrithifinoi*', which means 'skiing Sámis' in Early Norwegian language (Birkely, 1994). The verb '*skriđa*' means to go skiing. Nowadays, skiing is declared as Norwegian culture, but it is definitely Sámi culture, too. Coastal fishery in small boats belongs to Northern Norwegian culture, but it also belongs to Sea-Sámi culture.

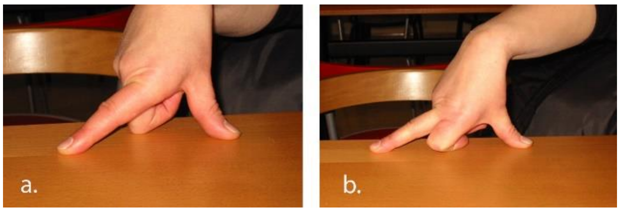
We argue that the chosen activities are of such considerable importance that they should be considered for inclusion in a future Sámi mathematics curriculum. Since all three activities belong to intangible cultural heritage, they obviously have value. Acknowledgement of value is included in cultural symmetry's first step.

Activity 1: Sámi Traditional Measuring of Length

The first published text about Sámi mathematics was Nystad's (2002) book chapter about geometry and traditional Sámi measuring. Some years later, Jannok Nutti (2007) published a study of reindeer herders and *duojars'* Sámi mathematical reasoning. A *duojar* is a skilled individual who works with Sámi handicraft, *duodji*. Jannok Nutti describes how the herders and *duojárs* use traditional Sámi measuring, counting, and estimation of large numbers in their everyday work. She analyses interviews with skilled individuals who practice two different culture-dependent activities.

We delimit our study to focus mainly on the traditional measure *goartil* (short for *čuvdegoartil*/pointing finger *goartil),* which is the distance from the thumb tip to the pointing finger's tip, as shown in Figure 1a. To measure by *goartil* is called *goartilastit*, which directly translated into English means to *goartil*-measure. This relation between noun and verb is a Sámi way of speaking that is not found in the Norwegian and Swedish (nor English) languages. *Goartil* is widely used for measuring snow depth. This is important for reindeer herders, because six *goartil* is the maximum snow depth a reindeer can dig through to find food (Jannok Nutti, 2007). To measure snow depth, reindeer herders traditionally turn a ski pole upside down and push it through the snow, to the ground. Next, they mark or check where on the pole the snow surface is, before pulling the pole back up again. Then they can *goartilastit* the length of the ski pole that was below the snow surface. Nowadays, the herders use snow scooters instead of skis, but they bring their hands and a pole with them. *Goartil* is also used in Sea-Sámi boat building (Hætta Karlsen et al., 2023) and in leather sewing and *gákti* (a traditional Sámi garment) sewing (Guttorm & Labba, 2008). The use of *goartil* and other measurings have survived the introduction of the SI system. We interpret this to mean these measurings are useful, and thus have value.

Figure 1a: The Sámi Measure of *Goartil* (*Čuvdegoartil*) and Figure 1b: *Gaskasuorbmagoartil (*Long finger *goartil)*. Photos: Kristine Nystad. Reprinted from "*Geometri og tradisjonelle måleenheter*" (p. 94), by K. Nystad (2002). Reprinted with permission.



Step 2 in cultural symmetry concerns different perspectives of *goartilastit* and *goartil.* One more *goartil* measure is *gaskasuorbmagoartil,* which is the distance from the thumb tip to the long finger's tip (Guttorm & Labba, 2008; Nielsen, 1979), as shown in Figure 1b. This measure is a bit longer than a (*čuvde)goartil* and is used when sewing *gákti* for men (Fyhn, Eira & Sriraman, 2011). Nielsen (1979) distinguishes between *goartil* and *čuvdegoartil*; he explains *goartil* as a quarter of an ell. This is similar to Ryd's (2007/2022) explanation of a 'kvarter', *goartta.* Based on interviews with the Lule Sámi reindeer herder Johan Rassa, Ryd explains that Rassa measures snow depth by 'kvarter'. A supporting photo shows Rassa measuring snow depth by *čuvdegoartil*, similar to the North Sámi reindeer herders in Jannok Nutti's (2007) study. Ryd adds that "*[w]hen the 'kvarter' is not measured by folding rule but by fingers [as in Figure 1a], it is a bit longer, maybe 18-19 cm*" (p. 22, author's translation). One reason why Ryd has two different explanations of this measuring unit might be due to the influence of the Swedish language. However, it could also be that the *goartil* unit was used in two ways, depending on the context. Birkely (1994) refers to the skilled Sámi skier Apmut Ahrman, who knew some Swedish language. Ahrman measured snow depth by '*kvarter*' when he referred from the 1884 ski race in Johkamohkki (maybe the longest ski race ever). Birkely interprets Ahrman to use the *čuvdegoartil* measure shown in Figure 1a. Dunfjeld et al. (2018) present three different South Sámi words for *goartil: vuepsie, vuemsie* and *voemse,* while a quarter of an ell is called *goerhte* or *goerhtere* in South Sámi.

The measure of *salla* (fathom) is often used to measure depths in lakes and in the ocean, and for the length of a *suohpan*, lasso. Wool frieze fabric was traditionally measured in *salla*. Usually, a *suohpan* is somewhere between 10-15 *salla*, depending on its use (Fyhn & Nystad, 2021). *Suohpan* length is related to body size. For that purpose, it is useful to have an individual *salla* measure. The International System of Units (SI system) belongs to Western mathematics, while *goartil, salla* and traditional *use of* these measures belong to the Sámi intangible cultural heritage. Nielsen (1979) only refers to a standardised use of *goartil* and not to the individual *goartil* measure. The SI system is taking over more and more and even some *duodji* books of today use metre and centimetre instead of *goartil* and *salla*.

The use of individual body measurements is used by other Indigenous peoples, too. Lipka et al. (2013) describe how the Yup'ik people in Alaska use body-related, non-standardised measuring units. Their point is that the ratio between individuals' footlength and other body parts, such as arm's length, is the same. Yup'ik elders use body-proportional measuring as a generative solution to solve everyday problems. The aim is to use a proportional measure and not a universal unit of measuring like the metre.

In Step 3, we refer to Jannok Nutti's (2010) description of how primary school students experienced the transition from their own personal *goartil* as an individual unit of measurement to the grown-up reindeer herder's standardised *goartil* as a tool for measuring snow depth. The individual unit of measurement was intuitive to grasp and work with for the children. The transition from individual to standardised units for measuring would most likely also contribute to an understanding of mathematics for non-Sámi primary schoolchildren.

Activity 2: Ruvden – A Sámi Braiding

The lower secondary school in Guovdageaidnu/Kautokeino participated in a research project about the round-shaped Sámi braiding, *ruvden,* and how to perform the braiding procedure. The project developed a short video that starts with two schoolgirls presenting what *ruvden* is, what ruvden cords are used for and how to perform the braiding (Fyhn et al., 2014). This is directly related to Step 1, identification of knowledge. The verb *ruvdet* means to braid *ruvden* cords. The word *ruvden* is used for braiding with 4, 8, 12 or 16 threads. So, the generalization of the term *ruvden* becomes apparent, as *ruvdet* with different numbers of threads follows the same procedure (Fyhn et al., 2017). The use of colours tells a story about the individual who wears the cord: gender, marital status and family belonging, so rules for the use of colours are embedded in the culture. Yellow yarn is for instance less used in the Norwegian part of Sápmi, while being quite common on the Swedish and Finnish sides. Ancient Sámi worshipped the sun like a God. According to Dunfjeld (2001/2007), the missionaries considered yellow to be a sinful colour, because it symbolised the sun. This caused the yellow colour to almost disappear from South Sámi clothes. Shoe bands were the only items that kept the yellow tradition. The strongest among the elders were the only individuals who maintained the tradition with the yellow colour in other parts of their clothes.

At the first meeting between mathematics teachers and researchers, two teachers presented their approaches to the *ruvden* procedure (Fyhn et al., 2017). One was a narrative that describes rules of behaviour when you visit your neighbour's *lávvu* (a traditional Sámi dwelling), while the second was a detailed and stepwise description of how to move the threads. The two different approaches caused a move to Step 2. The teachers discussed the braiding from different perspectives. They found the narrative approach easier to remember, but maybe rather childish for lower secondary students (Fyhn et al., 2015). Jannok Nutti presented a third approach from her schoolwork; analytical drawings of how the threads move. Her presentation included *ruvden* with 4, 8, 12 and 16 threads. The teachers met at workshops, where the discussions considered how to express the braiding procedure through mathematics and why the number of threads had to be divisible by four to get a round-shaped cord.

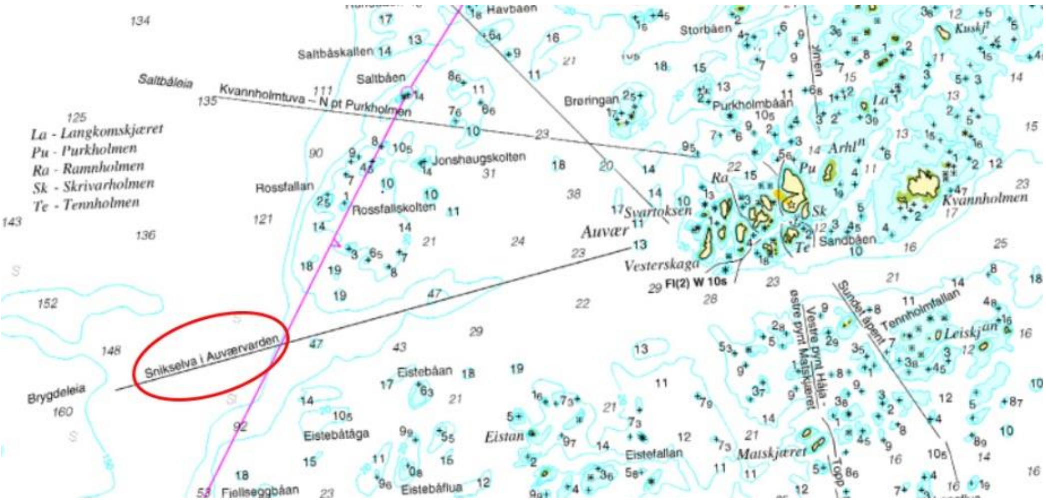
Step 3 was clearly apparent when one of the teachers conducted a teaching unit about ruvden in his class (Fyhn et al., 2015). The students started out by braiding with different numbers of threads, to investigate which number of threads would give a round-shaped cord. They found that the number of threads had to be divisible by four. In the language of Western mathematics, the generalisation of the ruvden procedure may be described as an example of an algorithm. This indicates that ruvden may function as basis for teaching about programming. At the workshops, teachers identified the moves of each thread in the braiding procedure. Each step included a move past a given number of other threads, which was presented as an algebraic expression (Fyhn et al., 2017). Teachers and researchers expected beforehand that the transition from numbers to letter symbols would cause the most challenges for the students, but this was easy for them to grasp. The students' challenge was grasping the content of compound expressions with letters and number symbols. The emergence of programming as part of the national mathematics curriculum (Ministry of Education and Research, 2019) opens up more possibilities, because for those who are familiar with the ruvden procedure, the algebraic expression of it can add value to students' grasp of algorithmic reasoning.

A closer look at what happens in Step 2 made the researchers see that while the research project focused on the braiding procedure, the girls who participated in the video focused on the different cords you could make (Fyhn et al., 2017). This presentation of different possibilities revealed mathematical reasoning that was categorized as enumeration, sorting and organising elements in a set. This is combinatorics and not algebra. It turned out that, with access to yarn in four distinct colours, you can *ruvdet* 31 different cords with four threads. As pointed out by Fyhn and Steinfjell (2023), there is no need to calculate this exact number, but the enumeration per se is useful to gain an overview of different possibilities.

Activity 3: Coastal Fishermen's Navigation

The coastal fishermen' s traditional navigation at sea is related to knowledge of the tides and the local landscape both above and below sea level. Fyhn and Robertsen (2020) analyse the fisherman Håkon's navigation practice. He is the skipper on a 12.16-metre-long fishing vessel. He represents the oldest generation of active coastal fishermen, and the last generation that learned navigation without technological artefacts such as GPS and marine chart plotters.

Figure 2: ***Part of Sea Map from Håkon's Local Area. Screenshot from Norgeskart.no***



When people travel by car or bus, they follow a road. A *lei* (shipping lane) at sea is like a *road* on dry land. Figure 2 shows the *leis* named Saltbåleia and Brygdeleia. Brygdeleia is presented as 'Snikselva i Auværsvarden' (Sniks creek in Auvær's cairn), marked with a circle on the map. To find

Brygdeleia when you arrive at these islands landwards, you follow a sightline through the island of Auvær's cairn, which ends up in the waterfall from the Snikselva creek (this creek is far behind to the right and not included on the map). A sightline like this one is called *méd. Méds* are important navigation tools for fishermen's work at sea, to find fishing spots and to use safe shipping lanes. Sea-Sámi words for *méd* are *vihtá* and *mearka* (Meron, 2023). According to Hansen (2021), *mearka* is used nowadays, while *vihtá* is an old term. The importance of language in *méds/mearkkat* come to surface in the use of local names. The fishing spots are often intertwined with a rich cultural history where you need to know mountains, rivers and valleys, and even small hilltops and plains in order to orient yourself (Maurstad, 2010). Hansen (2021) provides some examples of *mearkkat* in Sámi language, for instance, *Guovdesuolu luovvana Jágánis* (The Guovdesuolu island is loosened from the island Jágána). Sámi language and coastal Northern Norwegian dialects express *méds/mearkkat* by less words than the language of Western mathematics does.

Fyhn and Robertsen (2020) reveal that lexical descriptions of *méd* are usually presented in the language of Western mathematics, as variations of the theme that a *méd* is a straight line that is given by two points. Pais (2011) and Meaney, Trinick, et al. (2022) warn against this, that traditional knowledge of a phenomenon is interpreted and expressed in the language of Western mathematics. Lexica and Wikipedia contribute to devaluing the traditional knowledge by omitting the traditional way of putting *méd/mearka* into language. The precision of fishermen's navigation by *méds/mearkkat* shows that this precision does not depend on Western mathematics' language.

When Håkon follows Brygdeleia in Figure 2 on his way home from fishing banks in the ocean, he does not need to include any mathematical terminology such as 'point' or 'straight line' to understand exactly where he is. As long as his eyes are OK and the weather is clear, he can find his way using *méds.* The value of *méd* is obvious, because it is an important part of the fishermen's life insurance.

Step 2 is about examining fishermen's navigation competences and their practice from other perspectives. The lexica descriptions that use the language of Western mathematics solely refer to the phenomenon of *méd/mearka* and not to the cultural practices. Håkon uses modern technology in his everyday work at sea because it is functional. When asked, Håkon tells a true story from when the electricity stopped working on his boat out at sea on a dark winter's day. Then he uses his watch, a compass and knowledge of the tides to navigate his boat all the way to the shipyard in Tromsø more than 40 kilometres away, through uncertain waters and in complete darkness. The fishermen's challenge is to face what they have to do on the day the chart plotter and GPS stop working.

Step 3 concerns how Euclidean geometry might add value without detracting from the fishermen's cultural knowledge about navigation. The knowledge that two straight lines intersect at one and only one point is part of Euclidean geometry. This knowledge is so central to the coastal fishermen that it is expressed through the concept of '*tverrméd*' (*across méd*, our translation), *doaresmearka* in Sámi. Håkon explains this as *méding* in two directions *(å méde to veier,* our translation*).* Knowledge of tverr*méd/doaresmearka* is necessary for the fisherman's ability to navigate at sea in demanding conditions and for precise localisation of fishing spots. Hansen (2021) provides examples of fishing spots, presented by one *mearka* in the direction of inward/outward the fjord, and another *mearka* in crosswise direction.

Discussion

The analysis of three different cultural activities with respect to cultural symmetry shows clear tensions between Western mathematics and two of the activities, measuring and navigation. We have shown how Sámi traditional measuring is replaced by the SI system and coastal fishermen's navigation language is replaced by the language of Euclidean geometry. Because GPS systems and chart plotters are replacing landscape navigation, many local place names will be out of use. Place names, which are intangible cultural heritage, vanish if they are not in use (Pedersen, 1991). Sámi and coastal Northern Norwegian belong to different language groups, but their expressions of *méds*/*mearkkat* are shorter than the standardised formal Norwegian's. Norwegian lexica literature explains *méd*/*mearka* in the language of Western mathematics but does not refer how these are expressed in the fishermen's language (Fyhn & Robertsen, 2020).

Guttorm (2011) distinguishes between two Sámi concepts of knowing, *máhttit* (knowing something as bodily knowledge) and *diehtit* (knowing about something). *Máhttit* and *diehtit* are mostly connected with practical and theoretical knowledge, respectively, but there are not sharp borders between them. Regarding bodily measuring and landscape navigation, our study shows that the *máhttit* part (the ability to perform the action) is less in use nowadays, because the *diehtit* part (to know something) is replaced by Western mathematics. The braiding *ruvden* and the *ruvden* procedure are not influenced similarly by Western mathematics, because the *máhttit* part is *duodji* with less visible mathematics content.

D'Ambrosio (1999) introduces the term *ethnomathematics*. He points out that each culture has developed its own ways, styles and techniques for performing and responding to the search for explanations, understanding and learning. Bishop (1988) presents six fundamental activities which, he argues, are universal in that they appear to be carried out by every cultural group ever studied. These activities: counting, measuring, playing, locating, designing, and explaining, are necessary and sufficient for the development of mathematical knowledge. From Bishop's perspective, the three activities in our study show examples of mathematical ideas: bodily units of measuring, generalisation of a braiding procedure, and use of the landscape in sea navigation. Like other ideas, these are human constructions, created within a cultural context with a history. Opposed to the cultural symmetry framework by Meaney, Trinick et al. (2022), Bishop back in 1988 did not consider language as crucial for his six basic activities. Language and relations between language and cultural practice is important for the three activities in our study, because it is through language mathematical thinking is expressed and described. The use of Sámi language for expressing bodily measuring, and Sámi as well as Norwegian fishermen's landscape navigation, reveals a way of thinking that differs from how Western mathematics is expressed in Norwegian. This is one important reason why a future Sámi mathematics curriculum should be written in Sámi language instead of being translated from Norwegian as the situation is today.

Future Sámi Mathematics Curriculum

Step 2 in Cultural symmetry highlights the cultural practice, this is what Guttorm (2011) explains as the *máhttit* aspect of cultural knowledge. *Máhttit* measuring using individual bodily measures is relevant for early years in primary school and so is *diehtit* the transition from individual to standardised *goartil* and *salla* measures. *Máhttit* navigation by *mearka*/*méd* is an activity that is relevant for geometry in the second half of primary school, in Sámi schools and in other schools in the North. Fyhn and Robertsen's (2020) study of the fisherman Håkon's language showed that he uses verbs and refers to activity, which is similar to the *máhttit* aspect of landscape navigation.

The results from our study show that it is relevant to distinguish between the *máhttit* and *diehtit* aspects of cultural knowledge in a future Sámi mathematics curriculum. In addition, valuing students' *máhttit* in mathematics education opens for a new perspective of mathematics education.

In Fyhn's (2015) study, the teacher who conducted *ruvden* in his mathematics class claimed that he would cooperate with a *duodji* teacher if he were to repeat the project. His students needed to *máhttit* the braiding before they could elaborate on the *diehtit* part of knowledge. *Máhttit* the *ruvden* procedure with a different number of threads includes knowledge of generalisation, which in turn can be used as a basis for students' approach to algorithms (Fyhn et al., 2017). *Diehtit ruvden* is relevant for algebra and combinatorics in Sámi mathematics education.

Juuso (2022) analysed the Ministry of Education's (2015) national report on renewal of school subjects from her Sámi perspective. She elaborates on how and why a Sámi mathematics curriculum needs to be based on Sámi interpretations of competence, whereby Sámi values come to the surface. Fyhn, Hætta Siri and Juuso (2023) investigated possible North Sámi translations of the curriculum sentence that describes what the curriculum interprets 'algebra' to mean. Given the difficulties encountered in that process, they concluded that a curriculum originally written in a Sámi language would probably be less time-consuming to create and easier to understand. They also concluded that a Sámi mathematics curriculum based on Sámi culture, reasoning and values would probably require fewer resources than continuing the established tradition of merely translating national curriculum texts from Norwegian to the Sámi languages. A Sámi mathematics curriculum would have to include suggestions for local adaptations, because Sámi culture is not homogeneous and the different Sámi languages express things differently.

Intangible Cultural Heritage in a Future National Mathematics Curriculum

The context-less national mathematics curriculum contrasts with the Core Curriculum (Ministry of Education and Research, 2017), about identity and cultural diversity: "*School shall give pupils historical and cultural insight that will give them a good foundation in their lives and help each pupil to preserve and develop her or his identity in an inclusive and diverse environment*" (pp. 5-6). The 1997 curriculum (Ministry of Education, Research and Church Affairs, 1997) introduced thematic and project work as a new way of working. Evaluation of this reform revealed that many of the issues in the Core Curriculum were approached through thematic and project work. The students learned, among other things, to cooperate, to be flexible, to search for information, to be independent, and to adapt to new requirements and new conditions (Rønning, 2004). Teachers reported that mathematics was usually excluded from thematic and project work, because mathematics has high status, a fixed structure, and a strong progression. Rønning's findings together with the ingrained idea of mathematics as a culture-free subject (Meaney, Trinick, et al. 2022; Fyhn, 2020) indicate that if rural culture from the north should is to be included in the national mathematics curriculum, politicians must change their attitude towards mathematics as a subject. However, Sámi traditional measuring might be included in early years of primary school because of the *máhtt*it part. To start with each child's individual bodily measures and proceed to standardised measures, is in line with how mathematics is taught. As long as national tests and national exams strongly influence the way mathematics is taught, there is reason to believe that no Sámi intangible cultural heritage will be included in secondary school mathematics.

Conclusion

Our study focuses on three examples of intangible cultural heritage that are embedded in Sámi culture. Landscape navigation at sea, bodily units of measuring and traditional braiding are activities that can serve as a basis for a Sámi mathematics curriculum. Our study shows that *máhttit* and *diehtit* as two aspects of knowledge needs to be highlighted in a future Sámi mathematics curriculum. Cultural tensions between the government and the Sámi as well as tensions between Northern Norwegian coastal societies and the 'elites' nearby the capital Oslo, needs consideration in order to achieve a Sámi mathematics curriculum. Awareness of these tensions show that Sámi measuring and sea navigation are being gradually replaced by Western mathematics (the Sámi are not to decide the content of their mathematics education). Other countries have their own intangible cultural heritages that might be more successfully included in mathematics curricula. The Māori have 30 years' experience with mathematics curricula. Research in Māori mathematics education has resulted in the development of cultural symmetry. Our study shows how cultural symmetry together with a focus on *máhttit* and *diehtit* as two aspects of knowledge can serve as a functional tool to create a Sámi mathematics curriculum in Norway. Future studies can provide better insight into how a focus on *máhttit* and *diehtit* as two aspects of mathematical knowledge can contribute to a Sámi mathematics curriculum.

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