

Sámi Cultural Properties of the Numbers Three and Four

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Abstract

The mathematics curriculum for Sámi students in Norway is a mere translation of the national curriculum text. This article aims to contribute to the discussion of the need for a Sámi mathematics curriculum. The study identified cultural properties of numbers in Sámi traditional knowledge. Traditional school mathematics and the national mathematics curriculum do not discuss the cultural properties of numbers. Modern Sámi institutions aim at relating to traditional knowledge. We present founding documents and the logo of two Sámi institutions for education and research. The study investigated these documents with respect to how the numbers three and four occurred, and we describe cultural properties of these two numbers. We indicate that studies of other parts of Sámi traditional knowledge will reveal more cultural properties of the two numbers, and that investigations of other numbers will reveal further cultural properties. Thus, we conclude that there is a need for a Sámi mathematics curriculum that encompasses the cultural properties of numbers.

Čoahkkáigeassu

Matematihkka oahppoplána Sámi ohppiid várás lea dušše sámegillii jorgaluvvon našunála oahppoplána. Dán artihkkala áigumuš lea doarjut dárbbu sierra sámi matematihkka oahppoplána divaštallama. Dan dutkamis bohtet ovdan kultuvrralaš iešvuodát loguin mat gullet sámi árbedihtui. Dábálaš skuvla matematihkka ja našunála matematihkka oahppoplánain ii leat sáhka loguid kultuvrralaš iešvuodaid birra. Ođđaáigásaš sámi ásašusain lea ulbmil váldit vára sámi árbedieđus. Mii guorahallat guovtti Sámi oahppo- ja dutkaninstitušuvnna dokumeanttaid ja dovdomearkkaid (logo). Mii dutkat dokumeanttaid ja loguid dainna ulbmiliin movt logut golbma ja njeallje leat boahtán ovdan ja mii čilget dán guovtti logu kultuvrralaš iešvuoda. Mii mearkkašit ahte dutkat eará osiid sámi árbedieđuid fuomášahtášii eambo kultuvrralaš iešvuodaid. Danne mii loahpas árvalit dárbbu Sámi matematihkka oahppoplánii mii sisttisoalašii loguid kultuvrralaš iešvuodaid.

Introduction

This study intends to contribute to discussions about the need for a Sámi mathematics curriculum. The Sámi curriculum in Norway includes a Sámi learning poster (Ministry of Education [KD], 2007), which claims that schools that follow the Sámi curriculum have to provide the students with quality teaching based on Sámi language, culture and social life. The mathematics curriculum for Sámi students, however, is a mere translation of the national text, in contrast to several other subjects where separate Sámi curricula have been developed (KD, 2017). This study aims to identify cultural properties of numbers, an aspect of mathematics that is not considered in the national mathematics curriculum. In order to achieve this aim, we investigate how numbers are understood in Sámi traditional knowledge. For pragmatic reasons, we have chosen to limit our focus to the two numbers *three* and *four*. The main subject area *Numbers and algebra* in Norway's National Mathematics Curriculum (KD, 2013) reflects a perspective on numbers according to which they a) are part of systems and patterns, and b) are tools for measuring quantities and magnitudes. Norway's National Mathematics Curriculum reflects Western mathematics; it is not actively open for perspectives according to which numbers have any cultural properties. Our point of departure is the idea that cultural properties of numbers are important in Sámi traditional knowledge.

The Sámi is an Indigenous people of the Arctic who live in northern Scandinavia and on the Kola Peninsula in Russia. The Sámi is a heterogeneous group of people; there is a total of nine different Sámi languages and a multiversity of Sámi cultural expressions (Gaski & Berg-Nordli, 2017). The Sámi language borders typically reflect the traditional respective Sámi homeland areas that are crossed by nation state borders. For instance, the northern Sámi area, which is our main focus, covers Sámi homelands in Norway, Sweden and Finland, and the three countries have different school systems and modes of resolving Sámi education

challenges. Within the Sámi homeland area there is also a variety of socio-economic modes of adaptation, which include typical Sámi economies such as reindeer husbandry, small-scale farming, and fjord and coastal fisheries, often combined with a subsistence economy. As of present, Norway has officially recognized three Sámi languages, and two more Sámi languages are in a phase of revitalization (Sametinget, 2017).

Because modern Sámi institutions aim to connect to traditional knowledge, our analysis focuses on traditional knowledge that is reflected in the institutions' foundation documents and their logos. The research question is: How do the former foundation documents and the logos of the Nordic Sámi Institute and the Sámi University of Applied Sciences identify the cultural properties of the numbers *three* and *four*? The numbers' cultural properties are revealed by identifying how these numbers appear and are explained in the foundation documents and in the logo that is presented in Figure 1.



Figure 1 The Nordic Sámi institute's logo. (Nordic Sámi Institute, 1975, front cover)

The first author, Jan Henry, was the first and founding rector at the Sámi allaskuvla/Sámi College, today the Sámi University of Applied Sciences¹. He started as a Sámi language teacher in 1968, worked with Sámi education and research challenges from a variety of positions, including international work on Indigenous education cooperation, all his

¹ The English name of the Sámi allaskuvla has changed over the years: 1989–2000: Sámi College; 2000–2015: Sámi University College; 2016–today: Sámi University of Applied Sciences.

professional life until retirement in 2013. Kristine was engaged in the work with the first Sami curriculum in the mid-1990s. She has later been assistant professor and vice rector at the Sámi allaskuvla/Sámi University College, and has been engaged in lecturing on teacher education and in research. She holds a PhD that focuses on resilience. Culturally responsive mathematics teaching will undoubtedly contribute to positive ethnic identity development and ethnic pride. Ethnic pride is considered a potential resilience factor (Nystad, Spein, Balto & Ingstad, 2017). Anne is a North Norwegian researcher from the field of mathematics education. Her grandfather was born and raised in a traditional Coast Sámi community. She has seven years of experience teaching mathematics to Sámi students in a rural community.

Jan Henry introduced Kristine to Anne in 2005, when Kristine was vice rector at the Sámi University College. Kristine explained to Anne how the institution was organized in three “poles”, which represented the three stabilizing basis poles of the *lávvu*, the traditional Sámi tent. Figure 2 shows an example of this traditional three-pole construction. Twelve years later, Anne suggested carrying out this study. Jan Henry’s first-hand knowledge of foundation documents for Sámi education and research institutions made this study possible.

We present Sámi traditional knowledge and Western mathematics before we present tensions between the two forms of knowledge. Then we describe perspectives of mathematics as a cultural phenomenon, before we introduce some foundation documents for the Nordic Sámi Institute and the Sámi University College.

The logo is an old Sámi symbol for the sun (Nordic Sámi Institute, 1975). Today’s institution, the Sámi University of Applied Sciences, has assumed the duties of both the Sámi University College and the Nordic Sámi Institute, and the logo represents the Sámi University of Applied Sciences. The cultural properties of the numbers *three* and *four* are revealed by identifying how the numbers appear and are explained in the documents and in the logo.



Figure 2 *Válddahagat*, traditional Sámi constructions with three poles with a y-shaped top. Left: Drawing by Buljo, 2017. Middle and right: Photo by Nystad

Sámi Traditional Knowledge Versus Western Mathematics

Sámi traditional knowledge is based on perspectives that differ from those of Western mathematics. This causes a tension between the two kinds of knowledge. Turi and E. C. H. Keskitalo (2014) show that reindeer herders' traditional knowledge is de-prioritized in relation to scientific knowledge in local-level policy implementation. This asymmetric relation has caused damage. As Reinert (2006) explains, a unique blend of government mismanagement and non-Indigenous interests destroyed the profitable Indigenous reindeer meat industry in Norway, while at the same time destroying the herders' traditional entrepreneurship.

Traditional knowledge has an asymmetrical relation to scientific knowledge. Mathematics, however, is a well-established university subject throughout the world. In Norway and many other countries, you have to study at least one mathematics course to be allowed to study science subjects like physics and chemistry. All universities in Norway offer a PhD in mathematics. The Sámi University of Applied Sciences offers a 30 ECTS study in Sámi traditional knowledge, *árbediehtu*. No other university offers this subject.

Sámi Traditional Knowledge

Sámi traditional knowledge is "... the collective wisdom and skills that the Sámi people used to enhance their livelihood for centuries. It has been passed down from generation to generation both orally and through work and practical experiences" (Porsanger & Guttorm 2011, p. 18). Traditional knowledge is experience-based, relies on long-term observations, and is often focused on practical applications (Turi, 2013). Fishman (1996) argues that traditional knowledge like joik lyrics and narratives, is often fully available only through the language used to express it. People who do Sámi handicraft, *duodji*, work with cultural expressions that arise out of the culture's traditional knowledge (Guttorm, 2007). Ornamentation is important in *duodji*, because a product is not treated as complete if it lacks ornamentation or symbolic use of colors (Dunfjeld, 2001/2006). Sámi ornamentations and visual patterns complement and replace verbal language. A premise for understanding this knowledge is knowing the culture, codes and underlying phenomena behind the ornaments, symbols and patterns. Dunfjeld emphasizes that ornaments are reservoirs of meaning and hidden knowledge; they cannot be treated as pure decorations. The logo in Figure 1 is an example of Sámi ornamentation; the figure has cultural properties in addition to geometrical properties.

Western Mathematics

Mathematics is an invention of Western societies. According to Russell (1946/2006), mathematics in the sense of a demonstrative deductive system, begins with Pythagoras, for whom it is intimately connected with a peculiar form of mysticism. Pythagoras combined theology and mathematics, and this combination characterized the religious philosophy in Europe up to Kant. Russell points out that in the works by Plato, Descartes, Leibnitz and others there is "... an intimate blending of religion and reasoning, of moral aspiration with logical admiration of what is timeless, which comes from Pythagoras" (p. 45). This distinguishes Europe's theology from Asia's more straightforward mysticism.

Bishop (1990) claims that Western mathematics is one of the most powerful weapons for the imposition of Western culture on non-Western cultures. Until the 1970s, mathematics had the status of being a culturally neutral phenomenon. Before the 18th century, it was commonly assumed in Europe that numbers and geometrical figures had cultural properties. According to Russell (2006), Plato was strongly influenced by Pythagoras and Plato claimed that God was a geometrician. Goethe's famous play Faust illustrates the importance of cultural properties of geometry in those days; because Faust had not drawn the protecting pentagram correctly by the door, the devil in disguise was able to enter his room. "Look carefully! It's not completed: One angle, if you inspect it closely, has, as you see, been left a little open" (Goethe, 2003/1831, lines 1400–1402). According to the last book of the Bible, 666 is the number, or name, of the wild beast with seven heads and ten horns that comes out of the sea (Revelation, 13:1).

According to von Wright (1990/1997), the creation of a new concept of nature after Descartes changed the relationship between nature and human beings². Nature became object

² Von Wright refers to Western Science, but he calls it just "science".

while human beings were subjects. Mathematical physics has been the modeling norm for the development of science since the 16th century. The new perspective of science lived side by side with the old traditions for centuries, because these perspectives were incommensurable. During the 18th century, Western Science and mathematics departed from the old perspectives, and perspectives like the one in Goethe's Faust were deemed non-scientific.

Mathematics as a Cultural Phenomenon

Mathematical ideas, like other ideas, are human constructions, constructed within a cultural context with a history. According to D'Ambrosio (1999), each culture has developed its own ways, styles and techniques for doing and responding to the search for explanations, understanding and learning. Western mathematics can be considered to be just one such system. According to Sriraman (2013), mathematics is one of the symbol languages we have invented for helping us organize our lives and surroundings; mathematics consists of systems of expressed ideas that are shared and exchanged between human beings in different parts of the world over time. He also points at a human dimension of the notion of mathematical proofs: several mathematicians have found errors and shortcomings in the probably most significant book of Western mathematics, Euclid's *Elements*.

Barton (1999) describes mathematics as a system that is used to make meaning of *quantities, relations, and space* – a “QRS system”. When you raise a traditional Sámi tent, *lávvu*, you start out with three basic poles, *válddahagat*, that are split like “Y”s at the top and put together like the traditional *goadádas* in Figure 2. The *goadádas* is used for hanging and storing things. According to Nielsen (1979), a *goadádas* consists of three tree trunks with short-cut branches at the top, leaning against each other in the same way as the three tent-poles that form the main support for the *lávvu* framework, namely *lávvu-válddahat*. The number of poles, *Q*, is *three*, and the poles have approximately the same length. The poles meet in the top of the *lávvu*, where their tips are twisted into each other so that they are

“locked”. The poles are spread evenly like a triangular pyramid; relations between the poles, R , can be described by how they are organized to shape a structure. The poles generate two- and three-dimensional spaces, S ; the area of the floor and the volume of the space beneath the poles.

Bishop (1988) claims that just as all human cultures generate language, religious beliefs, food-producing techniques, rituals, and so on, so it seems that they are able to generate their own mathematics. According to his perspective, mathematics is a cultural product that has developed from six various activities: *counting*, *locating*, *measuring*, *designing*, *playing* and *explaining*. *Counting* refers to the use of a systematic strategy for comparing and ordering discrete phenomena. *Locating* means exploring, conceptualizing and symbolizing one’s spatial environment. *Measuring* includes quantifying qualities for comparison and ordering, and measure-words. *Designing* means creating a shape or design for an object, making the object itself, or symbolizing it in some conventional way.

One example of *designing* is creating the logo of the Sámi University of Applied Sciences, and the act of raising the three *válddahagat* is another example. *Playing* means devising or engaging in games and leisure activities with more or less formalized rules. *Explaining* means finding ways to account for the existence of a phenomenon, from religious and animistic phenomena to scientific ones. These activities occur in every cultural group, and they are both necessary and sufficient for the development of mathematical knowledge.

Bishop (1988) points out that the activities take place on the culture’s premises, not on the premises of Western mathematics. The sun and the cardinal directions exist in Sámi culture. Raising a traditional *lávvu* is a human activity. These are categorized as *locating* by Bishop (1988) and as *Space* by Barton (1999). D’Ambrosio (1999) has no such category. We have chosen Bishop’s perspective and not Barton’s (1999), because Bishop’s six activities is a framework that includes cultural issues as a necessary aspect of mathematics education

through the activity *explaining*, while Barton's QRS-system can be applied without implementation of any distinct cultural issues.

Sámi Education and Research

J. H. Keskitalo (1997) elaborates on the multifaceted concept of Sámi education and research. The concept is not straightforward; there are many Sámi communities, including north-, lule-, and south, with significant varieties in language, culture and livelihood. One must also consider both tradition and contemporary challenges, and intra-group and inter-group ethnicity as well as general academic challenges. In addition, one has to consider aspects of individual-level, group-level and system-level solutions. Stordahl (2008) interprets A. I. Keskitalo (2005) as arguing for a separate Sámi research paradigm built on the Sámi theory of knowledge – a Sámi epistemology. A. I. Keskitalo defines Sámi research as a culture-bound phenomenon.

Formal Sámi education was introduced in the first half of 18th century by the missionary Thomas von Westen. Since then, over the years, there have been tensions in Sámi education at all levels (J. H. Keskitalo, 1997) between those who consider education to be an instrument for strengthening and building a Sámi society and those who consider education to be an instrument for assimilating the Sámi into Norwegian society.

Traditional Sámi Knowledge Transfer

Children and young people gain knowledge by observing, by listening to instructions or stories, and by trying things out (Balto, 2005; Sara, 2004; Jannok Nutti, 2007). Storytelling is important for passing on knowledge to younger generations (Balto, 2005; Nergård, 2006; Jannok Nutti, 2007). Through stories, Sámi children indirectly learn norms and values. Sámi stories present rules for individuals' relations with other humans, animals and nature, and express cultural knowledge about life and survival in vulnerable situations. According to Balto (2005), the approach to learning in a Sámi context is holistic, in which a great variety

of indirect communication and indirect approaches rule or guide the young ones. The main goal is to develop self-reliant individuals.

Sámi School Mathematics

The first Sámi curriculum in Norway was applied in 1997 (KUF, 1997). Some years later, Hirvonen and J. H. Keskitalo (2004) pointed out a need for Sámi culture to become the basis and the premise for the teaching and not just an appendix. The 2006 Sámi curriculum's Quality Framework (KD, 2007) highlights Sámi traditional knowledge and maintains that Sámi culture, language and social life must be the basis for the teaching. However, it is up to individual teachers, who are often left to themselves, to implement Sámi culture and social life in the classroom (Solstad et al., 2009). Regarding mathematics, the result is that usually no cultural implementation takes place (Jannok Nutti, 2010; 2013).

According to J. H. Keskitalo (2009), the Sámi school system, in its present state in Norway, is based on ideas of the national Norwegian school system. This is an obstacle for the Sámi school system, which is thereby prevented from implementing traditional knowledge as an integrated part of the teaching. As a result, the teaching has to reflect a Western perspective of mathematics, and cultural properties of numbers are hence not taught.

Place-Based Education

The top priorities and concerns among Sámi and other Indigenous peoples have to do with decolonization and transformation of their societies (Kuokkanen, 2006). Decolonization and transformation among Indigenous peoples mean restoring Indigenous communities and recovering control over their lives according to their own priorities and premises.

Gruenewald (2003) takes the perspective of decolonizing a step further and introduces the term "critical pedagogy of place". This pedagogy is guided by the twin objectives of decolonization and "reinhabitation" through synthesizing critical and place-based approaches.

Place-based education lacks a specific theoretical framework. This education includes the

value of learning from and nurturing specific places, communities and regions; it leads the way to ecological “reinhabitation”. Local cultural competence is a central ingredient in this type of education.

Gay (2013) defines “culturally responsive teaching” as teaching that relies on students’ cultural knowledge, prior experiences, frames of reference, and performance styles to make learning encounters more relevant to and effective for them. Culturally responsive teaching is a means for improving achievement by teaching students through their own cultural filters, and is specifically designed to perpetuate and enrich people’s culture. Averill et al. (2009) claim that in order for mathematics teaching to be culturally responsive, the development of cultural competence has to be a key goal. Including cultural properties of numbers into the mathematics curriculum may facilitate students’ investigation of culture, development of cultural competence and ethnic pride.

According to the framework adopted by central authorities, Sámi student education must be based on Sámi culture, language and social life (KD, 2007). This means that the curriculum must support a place-based mathematics education. Balto (2005) underlines the importance of trial and error in the learning process; the Sámi child is allowed to try something out and to fail. This supportive perspective on children’ trial and error is in line with investigative approaches to mathematics education. Investigative perspectives contrast with traditional deductive mathematics teaching, as described by for instance Skovsmose (2001) and Fyhn et al. (2015). The traditional deductive approach to mathematics in Western societies is the remains of a Pythagorean heritage. No wonder Russell (2006) claims that Pythagoras is the most influential philosopher in the West. The intended mathematics curriculum opens up for investigative and more inductive approaches: “The teaching must switch between explorative, playful, creative and problem-solving activities and training in skills” (KD, 2013, p. 2).

Sámi Education and Research Institutions

The Nordic Sámi Institute was established by the Nordic Council of Ministers in 1973 (Solbakk, 2006), and its mission was to strengthen and develop Sámi languages, culture and social life. According to the statutes, §2, the Nordic Sámi Institute's goal is to serve the Sámi population in the Nordic countries by, among other things, creating an understanding for, strengthening and developing Sámi languages and cultural life, built on Sámi traditions and values (Hoëm, Kuhmunen & Magga, 1987). This means that Sámi traditions, culture and values have been central to this research institution. The Sámi allaskuvla/Sámi University of Applied Sciences was established in 1989 in order to strengthen Sámi language and culture in Sámi teacher training. The first English name of the institution was Sámi College, but it was changed to Sámi University College in 2000. In 2005, the Nordic Sámi Institute merged with the Sámi University College. Since 2009, the institutions have been located in the campus complex of Diehtosiida in Kautokeino/Guovdageaidnu, Norway. The Ministry of Education (2015) encouraged the institution to change its English name to Sámi University of Applied Sciences, and the name was changed in accordance with this request.

The Norwegian government's white paper (KUF, 1993) about research considers Sámi research to be research aimed to produce more knowledge about areas that are of special interest for Sámi society. According to the Sámi University of Applied sciences' strategy document for 2012–2016 (Sámi allaskuvla, 2011), the Sámi University of Applied Sciences shares the WINHEC³ institutions' vision: "We share the vision of the Indigenous Peoples in the world united in the collective synergy of self-determination through control of higher education." These documents show that even though Sámi education and research

³ WINHEC, World Indigenous Nations Higher Education Consortium <http://winhec.org/>

have developed over the years, the goals of the Nordic Sámi institute remain relevant even though they were formulated around forty years ago.

The Logo and the Foundation Documents

Our data consist of foundation documents of the Nordic Sámi Institute and the Sámi University College. The Nordic Sámi Institute's logo and the Sámi University College's professional profiles are central parts of these documents. The analysis focuses on how these documents deal with the numbers *three* and *four*.

The Nordic Sámi Institute's Logo

Pieti Näkkäljärvi and his father Ovlá Näkkäljärvi won the Nordic Sámi institute's logo competition in 1973 (Nordic Sámi Institute, 1975; Sámi University College, 2008). Their logo has been used since 1973–74. The Näkkäljärvis (Nordic Sámi Institute, 1975) explain their symbol the following way: The sun rules the complete ecosystem and is its source of energy. Ancient Sámi worshiped the sun like a God. The photosynthesis is as important today as it was before. Preservation of the ecosystem is especially important for the Sámi, who make their living from nature. The sun symbol is a useful symbol for the institution to remind us that if there is no photosynthesis, there will be no food; if there is no food there will be no human beings, and if there are no human beings there will not be any Sámi culture. So, as A. I. Keskitalo (2005) formulates it, the logo illustrates a sun that, through photosynthesis, releases food, life and culture. After the Nordic Sámi institute and the Sámi University College merged, the Nordic Sámi Institute's logo was chosen as the logo for the new institution, see Figure 3.



Figure 3 The Sámi University College's logo

A rhomboid sun symbol with rays departing from each of the four corners is the South Sámi shaman drums' fundament (Manker, 1950). Figure 4 shows similarities between this symbol and the logo. According to Reuterskiöld and Wiklund (2013), the four rays might refer to cardinal directions; the four directions north, east, south and west. Non-Sámi researchers with different backgrounds, such as the German Manker and the Swedish Reuterskiöld and Wiklund, have interpreted and re-interpreted the drum symbols for centuries. However, Rydving (1991) claims that the drums have been symbols of Sámi resistance since the 17th century. The drums represented a striving to preserve traditional values.

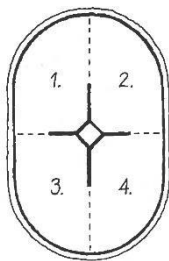


Figure 4a. Diagram of South Sámi drum (from Kjellström, 1991, p. 113)

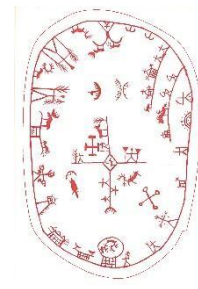


Figure 4b. Manker's (1965) tracing of a South Sámi drum

Three Main Elements, The *Válddahagat*

The Sámi University College's professional profile from 1994 (Sámi allaskuvla, 1994) identifies three main elements: i) Sámi language and language development, ii) sustainable development and management of the Sámi society's environment and basic resources, and iii) Sámi education and knowledge. Regarding these three main elements, the Sámi University College aims to establish programs for increased competence and

development of special competencies; «Ja dát oasis galget leat «sámi dutkama ja oahpahusa lávu» válddáhagat» (Sámi allaskuvla, 1994, p. 20), in English: These main elements will constitute the main structure for “the *lávvu* for Sámi knowledge and education.”

Válddáhagat, the main structure, is the three poles first erected when you raise a traditional *lávvu*, as presented in Figure 2. The *válddahagat* mesh and all three poles have to be present in order for the *lávvu* to stand.

Cultural Properties of the Numbers *Three* and *Four*

This section shows how the Nordic Sámi Institute’s logo reflects cultural properties of the number *four* and how the Sámi University College’s professional profile reflects cultural properties of the number *three*.

The Nordic Sámi Institute’s Logo

The Nordic Sámi Institute’s logo is still the logo of Sámi research. Figure 5 shows the complete logo of Sámi University of Applied Sciences. According to the 2017 – 2021 strategic plan for Sámi University of Applied Sciences (Sámi allaskuvla, 2016), the logo illustrates a sun, which is important in life of the Sámi. The sun symbol also explains that the Sámi live in four cardinals; north, south, east and west. The institution’s vision is to be a Sámi and Indigenous university.



Figure 5. The logo as it appears on the institution’s 2017 website <http://sammas.no/se>

Sámi University of Applied Sciences has four strategic areas of priority:

1. Leading environment for learning and working in Sámi language and with Sámi language.
2. Maintaining a close dialogue and cooperation with Sámi societies.
3. Being an effective, actual and attractive institution.
4. Maintaining transboundary higher education and research.

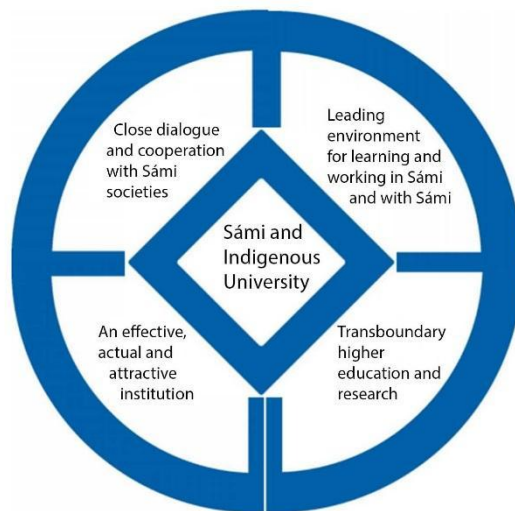


Figure 6. Four strategic priorities and their implementations. How the logo appears in the institution's vision. (Sámi allaskuvla, 2016, authors' translation)

The four strategic priorities and their implementation in the logo in Figure 6 show that the number *four* has a meaning beyond being just a random number. This is in line with the Sámi tradition explained by Dunfjeld (2001/2006): Sámi ornaments express a meaning and cannot be treated as pure decorations.

Applying Bishop's (1988) six activities on the logo reveals its mathematical properties as well as its cultural properties. *Counting* here refers to the use of a systematic way to order the four strategic priorities. When the priorities are presented in a numbered list, it may appear that the priorities are ordered according to importance. When the priorities are organized in the logo, it becomes clear that each priority is an essential part of a holistic image. *Locating* includes position, change in position, and reflection, as well as orientation,

journey, rotation, and angles. The symmetric properties of the logo ornament can be treated as outcomes of reflection as well as rotation. The logo is a figure with the geometrical property of 4-fold rotational symmetry; you can turn it a quarter of a turn around and it still keeps its shape. This means that the four spaces that represent the strategic areas in Figure 6, are equal.

Measuring is the way one uses eye measuring to make sure that each of the four regions inside the figure are equal. Eye measuring is an activity that is common in the application of Sámi traditional knowledge (Jannok Nutti, 2010; Fyhn et al., 2016). *Designing* means creating a shape or design; making the logo itself and choosing appropriate materials for making the logo. *Playing* means devising or engaging in games and leisure activities with more or less formalized rules, like reflecting or rotating the logo to find that the figure remains unchanged. Bishop lists several outcomes of playing; some of these are *procedures*, *strategies*, *guessing*, *game analysis* and *hypothetical reasoning*. The logo is constituted by a rhomboid and four equal spaces around it, and when making this logo you have to find a proper *strategy* for drawing a symmetrical figure. When drawing this logo, you will probably have to start out *guessing* and *analyzing* your mistakes before you are able to make an acceptable drawing. The symmetrical properties of this logo figure are based on properties of rhomboids.

Explaining highlights the logo's cultural properties. It concerns finding ways to account for the logo's existence, why just this logo was originally chosen, why this logo is still in use, and what it symbolizes. *Explaining* the logo includes explaining what values are incorporated into the logo. It also includes *explaining* relations between the logo and ancient Sámi peoples' symbols like the South Sámi sun and how the South Sámi shaman drums featured a central sun with four cardinal directions, as shown in Figures 4a and 4b .

Explaining includes knowledge about how and why the sun is and has been important in the

life of the Sámi. Finally, explaining also includes knowledge about the four strategic areas of priority for the Sámi University of Applied Sciences.

The Sámi University College's Professional Profile

Bishop (1988) elaborates on the outcomes of the six activities, as they relate to the Western mathematics he himself has learned. *Properties of shapes* is one outcome of designing. One property of the three *válddahagat*, similar to the poles in Figure 2, is that they constitute a robust and stable structure. This property was carried over to the foundation documents for the Sámi University College. The Sámi University of Applied Sciences is today still constituted by three departments. One property of the departments is that they cooperate and that they together shape the institution. The Sámi University of Applied Sciences is still based around the original three main elements, the three *válddahagat*. The three poles or divisions are i) Division for Language Sciences, ii) Division for Social Sciences, and iii) Division for Duodji, Industry and Natural Sciences (Sámi University of Applied Sciences, 2017). The teacher education is organized together with *duodji* and natural sciences.

Regarding *locating*, the three *válddahagat* represent a symmetrical figure with the property of being such that it can be shifted a third of a full turn and still keep its shape. This means that the three poles that represent the institution's professional profile have equal importance; each of them are needed and necessary in order to maintain the institution.

Procedures is one expected outcome of Bishop's (1988) activity *playing*. One part of the *procedure* for raising a *lávvu* is to raise the three *válddahagat* properly before the rest of the poles. The other poles are added as required for the cloth to cover the *lávvu*. The number of *válddahagat* is not arbitrary. A similar triangular construction is *soarremuorrat*, three poles, that is common in Sámi frameworks for *suonjir*, hanger racks, and *luovvi*, scaffoldings (Buljo, 1994), as shown in Figure 6. These constructions are also used today.



Figure 7. *Suonjir* (left) and *luovvi* (right). From Buljo (1994, pp. 14–15)

While Barton's (1999) QRS system has no explicit reference to the 'meaning' of numbers or other mathematical entities beyond pure mathematics, Bishop (1988) includes the 'meaning' aspect as a separate category, *explaining*. *Explaining* includes finding ways to account for the existence of a phenomenon, either religious, animistic or scientific. From Bishop's perspective, the existence of the three *válddahagat* has to be recognized and described. From a Sámi traditional knowledge perspective, it is common knowledge that the three *válddahagat* make a stable structure. The professional profile of the Sámi University College explained the number of three basic elements by referring to the three *válddahagat*.

The *lávvu* technology is so functional that it has survived until the present. New materials cannot beat birch and aspen for the poles. The *lávvu* is easy to transport, easy to raise, easy to construct, and it can be repaired while in place. Most materials have survived locally through generations. The *lávvu* is still a popular construction, and in daily use in many areas. When the teachers at *Guovdageainnu nuoraidskuvla*, Kautokeino Lower Secondary School, were asked to choose one cultural issue for developing their mathematics teaching, they chose the traditional *lávvu* (Fyhn et al., 2016). The *válddahagat* played an important role in their teaching unit about *lávvu*.

Discussion

The numbers *three* and *four* have important properties in other Sámi traditional contexts as well. In addition, other numbers than *three* and *four* have cultural properties in Sámi traditional contexts.

Further Cultural Properties of Numbers

The four *áhkut* (grandmothers), goddesses, are central in Sámi mythology. *Máttaráhkká* (foremother) and her three daughters *Sáráhkká*, *Uksáhkká* and *Juoksáhkká* assist women (Reuterskiöld, 1912). *Sáráhkká* was the nearest and most beloved of the goddesses, and was important when a child was born. *Uksáhkká* protects the door, while *Juoksáhkká* is a hunting goddess who may make an unborn baby girl become a boy.

Symbols for the four goddesses occur on South Sámi drums, but not on drums in other areas. This is an example of how the multiversity of Sámi cultural expressions is reflected on the drums. In addition, the sun symbols on the drums are less dominant further north, where they appear more circular or round-shaped, and may occur with or without rays.

Reuterskiöld (1928; 1912) refers to Friis' suggestion that the figures on the South Sámi drums are organized in a manner similar to their organization of *gåetie*, the traditional dwelling. Like the fireplace is in the center of the *gåetie*, the sun is drawn on the center of the drum. The space behind the fireplace is the place of pride, and thus the highest ranked gods are portrayed on the upper part of the drum. The spaces on each side of the fireplace should be working places and sleeping spaces. At the bottom part of the drum, corresponding to the door, we find goddesses, the reindeer fence and sometimes a fishing lake. More recent researchers, like Sommarström (1991), suggest that the illustrations on the Sámi drums rather may refer to stellar constellations.

During winter time, three stars in a line occur on the lower southern part of the sky. These are known as *Gallabártnit*. In Greek mythology these stars are called Orion's belt. The

Gallabártnit are close relatives of the sun, and these four celestial bodies play an important role in Sámi mythology. Gaski (2003) describes the myth as follows:

Gallabartnit, the Sami ancestors, were elevated to the heavens after death because they had established such a positive reputation for themselves on earth. They were highly accomplished moose hunters and the inventors of skis and, therefore, instead of being buried in the traditional Sami fashion--wrapped in birch bark and laid in flagstone graves--they were taken up to the night sky where they are found today in the constellation Orion's Belt. The Gallabartnit are the direct descendants of the Son of the Sun and the Giant's Daughter, and the Sami can, therefore, trace their ancestry directly back to the most powerful force in the universe, the sun! (p. 149)

Just below the three stars there are three more diffuse stars pointing downwards. According to Nystad (1999) these are known as *Gallabártnit's* knife, spear and pot. In other areas they are known as *Gallabártnit vadđu*, *Gallabártnit's* fishing net or fishing line (Qvigstad, 1921). In earlier days, *Gallabártnit* had properties that were useful for the reindeer herders' work. When these three stars appeared above the eastern horizon, herders would know that their herd would settle down to rest (Nystad, 1999). According to North-Norwegian coastal traditions, the season for cod fishery in Lofoten started when *the three fishermen* rose into the sky.

Other numbers than *three* and *four* also have meaning in Sámi contexts. For instance, Manker (1975) called the Sámi the "eight season's people". This refers to the Sámi organization of the year. Reindeer husbandry families and the sea Sámi organize the year slightly differently, but both groups have eight seasons.

Critical Pedagogy of Place

Fyhn, Jannok Nutti, Nystad, Eira and Hætta (2016) use Smith's (1999/2006) four levels of development to describe teachers' move toward self-determination. The teachers

developed a culturally responsive mathematics exam. Sámi mathematics teachers who base their teaching on textbooks and exams that are translated from Norwegian are stuck in a state of recovery where no cultural implementation takes place. Each time they create and try out culturally based mathematics teaching, they visit a state of development. When teachers' autonomy is controlled by national rules, guidelines and textbooks, almost no culturally responsive mathematics takes place. By contrast, when teachers experience supported autonomy, they experience investigating culturally responsive mathematics as something exciting. Factors that contribute to supported autonomy are: cooperation with researchers, feedback from their students and studies in implementation of Sámi curriculum at the Sámi University of Applied Sciences. Adding critical pedagogy of place (Gruenewald, 2003) to their work would clarify the importance of including the value of learning from the particular local culture of their municipality.

Proofs and Cultural Claims

As opposed to traditional school mathematics, there are no formal proofs in Sámi traditional knowledge. It is well-known in Sámi traditional knowledge that the three-pole structure shaped by the *válddahagat* and the structures in Figures 2 and 7 are stable. It is an accepted truth among craftsmen that a framework made out of three poles is stiff and stable. Craftsmen know this by experience and tradition.

According to Sriraman (2013), mathematical proofs played different roles in the old cultures in Babylon and China compared to Western mathematics. Several Western mathematicians have suggested explanations of the Babylonians' mathematics, but most of their suggestions failed because they did not take into consideration that ancient Babylon was a non-Western culture. It turned out that the Babylonians worked with non-deductive approaches to Pythagorean triples. Their work is less formal than today's standards prescribe, but is still both interesting and powerful. The Babylonians' work is probably more in line

with Balto's (2005) descriptions of trial-and-error in traditional Sámi child rearing, than with the Western deductive approach to mathematics.

According to Sriraman (2013), the Chinese used methods to find approaches to π by inscribing polygons in a unit circle. These methods were hundreds of years older than the methods of Archimedes and Euclid. The Chinese had theorems and formulas, but unlike the ancient Greek they did not prove any of their claims. In Sámi traditional knowledge there are numerous examples of knowledge, such as the knowledge that the number of *válddahagat* has to be three. Everyone who is familiar with raising a traditional *lávvu* knows that the stable construction of the three *válddahagat* has to be in place before you add the rest of the poles (Buljo, 1994). It is not questioned *why* the number has to be three; as in ancient China the Sámi do not prove their cultural claims. Sriraman's (2013) examples from Babylonian and Chinese cultures show that there are other well-recognized mathematics cultures that differ from the Western deductive approach. These mathematics cultures may be considered in the further development of a Sámi mathematics curriculum.

Conclusion

Norway's national mathematics curriculum (KD, 2013) is based on a Western perspective of mathematics in which there is no room for mathematical entities to have cultural properties. This curriculum also applies to Sámi schools. The Sámi learning poster (KD, 2007) claims that the teaching shall be based on Sámi culture, language and social life. This study shows that Sámi traditional knowledge includes several examples of numbers having cultural properties. These come to surface in foundation documents for the Sámi institutions for research and education. Thus, the hypothesis that a translation of the national mathematics curriculum can *function as a Sámi mathematics curriculum*, is falsified. The responsibility for integrating Sámi culture into the teaching still belongs to each individual teacher. A future Sámi mathematics curriculum needs to be based on a foundation and

perspective of mathematics that aims to increase students' cultural knowledge. This needs to be implemented into an improvement strategy for Sámi education.

One outcome of Bishop's activity *explaining*, is *generalizations*. The choice of the south Sámi sun ornament as logo motive and the choice of *válddahagat* in the foundation documents are examples of generalizations of well-known properties of phenomena in Sámi culture. The present study reveals how these properties are generalized to include the numbers *three* and *four*. As we also have indicated, other parts of Sámi traditional knowledge are expected to reveal more cultural properties of numbers than those on which we have focused here.

One aim of the national mathematics curriculum is to guide textbook authors, curriculum material authors, school owners and teachers in their work. If the aim should also include guidance toward developing culturally responsive teaching for Sámi students, then the curriculum has to consider properties of numbers within Sámi traditional knowledge. A follow-up study could focus on possible ways of implementing cultural properties of numbers in the mathematics education for Sámi students. The study would probably benefit from including Sámi perspectives on verification or proofs as well.

An improvement strategy as the one described above cannot be carried out by individual teachers, but would require a throughout implementation in institutional teaching cultures in an innovative way. School authorities and school owners need to assume an investment responsibility in this respect, including training of teachers and preparing for adequate quality measures.

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