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p-ISSN: 2086-4280 Fauzi, Ahyan, Supiyati, Hayati, & Satriawan e-ISSN: 2527-8827 An Analysis of Frieze Patterns, Crystallographic Patterns, and Philosophical Values on Subahnale Woven Motifs Sukarare Village Lalu Muhammad Fauzi1*, Shahibul Ahyan2, Sri Supiyati3, Nila Hayati4, Rody Satriawan5 Mathematics Education Study Program,

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, NTB, Indonesia 1*lmfauzi@hamzanwadi.ac.id; 2shahibulahyan@hamzanwadi.ac.id; 3sri.supiyati@hamzanwadi.ac.id; 4hayatisyahdani@hamzanwadi.ac.id; 5rodysatriawan@hamzanwadi.ac.id Article accepted: 28-04-2023, revised: 19-07-2023, published: 31-07-2023 Abstrak Budaya dengan keberagaman dan keunikan adat istiadat, kesenian dan kerajinannya, memberikan identitas bagi suatu daerah. Keunikan-keunikan budaya ini dapat dikaji untuk dijadikan sebagai bagian dari sumber belajar. Etnomatematika merupakan jembatan untuk mengeksplorasi matematika yang berkembang di masyarakat. Dengan demikian penelitian ini berupaya untuk menganalisis pola frieze, pola kristalografi dan nilai-nilai filosofis yang terdapat pada motif kain tenun subahnale Desa Sukarare.

Metode yang digunakan dalam Penelitian ini adalah metode etnografi. Data penelitian dikumpulkan **melalui observasi** , studi pustaka, **dan wawancara** 1

dengan praktisi budaya, tokoh adat, pengerajin kain tenun dan budayawan. Hasil penelitian menunjukkan bahwa motif (reragian) kain tenun subahnale terbentuk dengan perpaduan bentuk-bentuk geometri yakni garis, segi tiga, segi empat dan segi enam. Bentuk geometri tersebut tersusun menggunakan model matematika yakni translasi, rotasi da refleksi. Adapun pola-pola yang terbentuk berupa 4 buah pola frieze yaitu pola 3, 4 ,6 dan 7.

Selain itu terdapat juga pola Kristalografi yaitu pola p1, pm, dan p4m 4

. Kata Kunci: filosofis; frieze; Kain Tenun; kristalografi. Abstract Culture, with its diversity and unique customs, arts, and crafts, provides an identity for a region. This cultural uniqueness can be studied as part of learning resources. Ethnomathematics is a bridge to exploring mathematics that develops in society. Thus, this study seeks to analyze the frieze patterns, crystallographic patterns, and philosophical values in the subahnale woven fabric motifs in Sukarare Village. The method used in this research is the ethnographic method. Research data were collected through observation, literature study, and interviews with cultural practitioners, traditional leaders, woven cloth artisans, and humanists. The results showed that the motif (reragian) of the subahnale woven fabric was formed by a combination of geometric shapes: lines, triangles, rectangles, and hexagons. The geometric shapes are arranged using a mathematical model: translation, rotation, and reflection. The patterns formed are 4 frieze patterns, namely patterns 3, 4, 6, and 7. In addition, there are also crystallographic patterns, namely patterns p1, pm, and p4m. Keywords: philosophical; frieze; Woven Fabrics; crystallography. Mosharafa: Jurnal Pendidikan Matematika 505 Volume 12, Number 3, July 2023 Copyright © 2023 Mosharafa: Jurnal Pendidikan Matematika I. INTRODUCTION Travel and notes on the emergence and presence of something is an event. When the process gives rise to an event that developed before then, we are faced with a history (Nemeth, 2016). When dealing with a phenomenon, cultural groups try to respond and seek explanations about that phenomenon in unique ways and techniques. This kind of activity is the origin of human knowledge. In responding to their environment, a group of cultures in each region in patterns and styles are found as part of building a knowledge system (D'Ambrosio, 2016; Rosa & Orey, 2016). The activity of comparing, classifying, evaluating, quantifying, measuring, and calculating through observation tries to explain and understand the knowledge of that culture (Rosa & Orey, 2016). Cultural diversity with all forms of customs as part of historical heritage provides opportunities for improving the education system, which is the mathematics education system which seeks to bring the realities of life and culture closer through ethnomathematics (Abdullah, 2017). Cultural identity positively reflects a society's equality and socio-cultural level. Originality and uniqueness reflected in various activities, artifacts, and customs in

culture can be used as a source of mathematics , including **the** culture **of the** 3

Sasak people (Fauzi et al., 2021; Fauzi, Hanum, et al., 2022; Fauzi & Gazali, 2022). Community activities in culture are seen as mere habits and contain historical and philosophical values that impact student character building, such as diligence, conscientiousness, economical, mutual respect, and social spirit (Widodo, 2019; Hartono & Putra, 2022). The Sasak people still maintain traditions and ancestral customs. Various remains in the form of artifacts, such as traditional villages and traditional arts and crafts, are still being preserved. One of them is conventional crafts in the form of traditional woven fabrics, which can be explored in learning mathematics. Several researchers have begun to look at the cultural uniqueness of the Sasak people through ethnomathematics studies, including (Fauzi, Hayati, et al., 2022; Fauzi & Gazali, 2022; Fitriyah & Syafi'i, 2022; Hardiani & Putrawangsa, 2019; Novitasari et al., 2022). Fauzi, Hayati, et al. (2022) conducted a study of the

exploration of mathematics and cultural values in the perisean **performing arts** 8

, Fauzi and Gazali (2022) ethnomathematics studies of residential characteristics based on crew elbows, Fitriyah and Syafi'i, (2022) examines the ethnomathematics contained in the bale lumbung, Hardiani and Putrawangsa (2019) Ethnomathematics: The

tradition of measuring **the Sasak people and its** integration **potential in mathematics learning** 5

and Novitasari et al. (2022) conducted an ethnomathematics study of mathematical exploration of the gendang beleq art (Iqrima, Zulkarnain, & Kamaliyah, 2023). In addition, several researchers conducted an exploratory study of the geometry of the traditional woven fabrics of the Sasak people, as was done by Fauzi et al. (2023) with a survey of geometric perceptions

and cultural values on traditional woven cloth **motifs** for **the Sasak people** 6

, Sutarto et al. (2021) an

exploration of the geometric transformation of the weaving geometry **of the** Sasak **Sukarara tribe** 2

, Fauzi and Setiawan (2020) conducted a study on ethnomathematics: The concept of geometry

in traditional Sasak crafts in teaching **mathematics in elementary schools** . From **the** 11

studies described above, no researcher has yet conducted a study to look at the frieze patterns, crystallographic patterns, and philosophical values of the subahnale woven fabric motifs in Sukarare Village. Various motifs are found on subahnale woven fabrics. Every motif or design in woven fabrics is related to aesthetics and contains local values. This provides an overview of spiritual, historical, and metaphysical principles, which can be felt, expressed, and applied in daily life. The motifs or reragian found on the traditional woven fabrics of the Sasak people generally use geometric patterns such as rectangles, squares, triangles, and other shapes. These geometric patterns are often found in mathematics learning related to frieze and crystallographic patterns. Frieze patterns or groups are symmetrical groups built by one-way translations to form a repeating linear pattern (Cooper, 2013). The Frieze pattern has a unique feature always created by translation (Rahmawati et al., 2018). The frieze pattern is a discrete group belonging to the plane symmetry group, a subgroup of isomorphic translations (Gallian, 2021). The symmetries formed in the frieze pattern consist of translation, rotation, reflection, or glide reflection. The Frieze pattern creates seven different patterns. The seven patterns are Pattern 1 only experiences translation in one direction; Pattern 2 has one-way translation and glide reflection; Pattern 3 has one-way translation and vertical reflection; Pattern 4 undergoes one-way translation, and there is a 180 o rotation; Pattern 5 has one- way translation, rotation, vertical reflection, and glide reflection; Pattern 6 experiences one-way translation and horizontal reflection; and Pattern 7 undergoes one-way translation, rotation, vertical and horizontal reflection . While the crystallographic pattern is a flat pattern in a two-dimensional plane that

forms a grid. In the crystallographic pattern there are 5 types of unit grid namely square, parallelogram, rhombus, and hexagonal where the two-dimensional plane has four types of symmetry namely translation, reflection, rotation, and shear reflection (Liu & Collins, 1998). Patterns formed in flat shapes that are contained in woven cloth motifs like this can be used in learning mathematics. Figure 1. Crystallographic Pattern (Liu & Collins, 1998) This classification has several notations, including 1) The letters p and c denote primitive cells (unit grid) or centered cells. In general, primitive cells have centers with the highest rotational order located at grid points, while centralized cells have a reflection axis that is vertical to one or two sides of the cell; 2) An integer n indicates a high order or turnover rate; 3) The symbols indicating that the axis of symmetry is vertical to the x-axis of the cell (i.e., the left side of the cell) are m (mirror) denoting the reflection axis, g indicates no reflection but the glide reflection axis; and 4) A symbol denoting an axis of symmetry at an angle α to the x-axis, with α depending on n, the highest order or degree of rotation: α = 180 o for n = 1 or n = 2, α = 45 o for n = 4, α = 60 o for n = 3 or n = 6 Mathematics learning becomes more meaningful by constructing knowledge, involving culture through artifacts and students' everyday experiences as basic knowledge (Bonotto, 2017; Halini, et al., 2023). In addition to utilizing the right artifacts, the teaching and learning environment is also designed according to student culture and implemented into mathematics learning activities through new socio-mathematics norms (Bonotto, 2017). Ethnomathematics provides an opportunity to connect mathematics with culture. Ethnomathematics applications can be found in the environment where children grow and develop (D'Ambrusio & Rosa, 2016; Nuqthy, Nityana, & Navia, 2022). Ethnomathematics can be defined from its pedagogical aspect, namely the relationship between mathematics content and student culture (Amit & Qouder, 2017; Meilina, Mariana, & Rahmawati, 2023). However, most mathematics learning in schools does not involve culture in exploring students' initial knowledge obtained from their environment. This is because the teacher's teaching is formal, only presenting the material in abstract mathematics. This study aims to find frieze patterns, crystallographic patterns, and philosophical values in subahnale woven fabric motifs in Sukarare Village, which can be used as a source of learning mathematics in Lombok. In addition, the independent curriculum currently being developed emphasizes that learning must integrate each learning content with culture and everyday life, especially in the form of local wisdom. II.

METHOD The research method used in this study **is the** ethnographic **method**

, which examines and describes a society's culture. (Spradley, 2016) . This research method was chosen because it is consistent with the goals of ethnomathematics, which is to study mathematical ideas, processes, and techniques in culture from a societal perspective. The interpretation of phenomena in the ethnographic method describes, analyzes, and interprets cultural group elements, such as patterns of behavior, beliefs, and language that develop over time. (Spradley, 2016). Subahnale woven fabric artisans on the island of Lombok create different motifs and names. Data collection was carried out by field surveys and interviews with specially selected informants. The procedure for choosing informants was conducted to determine the criteria for informants according to the data to be collected. The source person was Lalu Damsiah, a traditional figure from Sukarara Village, Central Lombok, who was used as an informant to find comprehensive information on the origins of subahnale woven fabrics in Sukarara Village. Mrs. Manggis, a songket woven fabric maker in Sukarara Village, was used as an informant in comprehensively exploring the meaning of the symbols and forms of subahnale woven fabric motifs in Sukarara Village. Mr. Gesum, a traditional figure from Sukarara Village, was used as an informant to find comprehensive information about the development of subahnale woven fabrics. Inaq Umi, a subahnale cloth weaver in Sukarara Village, was used as an informant to find complete details about the shape and meaning of each woven cloth motif. Lalu Agus Fathurrahman, a Sasak humanist, was used as an informant to find information about the philosophy and cultural importance of symbols on traditional Sasak woven cloth, and Moch Yamin, a West Nusa Tenggara humanist, was used as an informant to find comprehensive information about the philosophy and symbolic meanings of motifs from cloth Subahnale weaving. To complement the results of observations and interviews, researchers conducted a literature review on subahnale woven fabrics. The data collection results were analyzed using a triangulation technique to comprehensively explore the relationship between the mathematical knowledge system in the form of frieze patterns and crystallographic patterns with the philosophical values contained in other subahnale weaving motifs. The data collected is then reduced by data reduction to select raw data, simplify, abstract, and transform field data. After data reduction, the next step is data presentation, namely data separation based on content so that conclusions can be drawn later. III. RESULT AND DISCUSSION Weaving or nyensek is a hereditary tradition passed down by the ancestors of the Sasak people from generation to generation. Activities nyensek carried out by women take advantage of the rest time on the sidelines of farming activities. The resulting woven fabric motifs are pretty diverse. The motifs show not only sheer beauty but every motif contained has a philosophical meaning. Many types of subahnale woven fabric motifs have been developed. Apart from being used as daily clothing, the woven cloth produced is also used in traditional activities and rituals designed by the Sasak people. The motif or reragian subahnale woven fabric in Sukarara Village is formed from geometric patterns such as rectangles, squares, and triangles. The resulting design is determined when cutting the pakan using traditional tools. A geometric pattern is formed from the crossing of pakan and twine lungsin. Pakan thread is a thread that is arranged in the same direction as the length of the cloth, while the lungsin thread is a thread that follows the width of the fabric. Subahnale woven cloth did not have a parian, but in its development, subahnale woven fabric made motifs (reragian) with names depending on the shape of the motif. There are many subahnale woven fabric motifs, including the wayang

. Subahnale woven fabric is one of the fabrics that has existed since the reign of Datu Panji Sukarare and Dende Terong Kuning. This cloth has a geometric motif with a lotus flower decoration inside. Taking the lotus flower as a motif symbolizes prosperity. The edge of the fabric is also decorated with many patterns that combine many forms. The primary colors used are dark colors such as blue, maroon, and black. The color of the motif uses contrasting colors such as white, light blue, or bright yellow. A noble daughter did this woven cloth with various rituals and special conditions for quite a long time. After the fabric was finished, it was shown to the public. The whole community was amazed by the material's beauty and said Subhanallah, so in the end, the cloth was named subahnale. A. Subahnale woven fabric pattern Woven fabric subahnale is a songket cloth with the highest level of complexity. That said, not everyone can weave this type of songket. Only people of blue blood or nobility can weave songket subahnale (Damsiah, 2022). If someone not belonging to the nobility class incorporates this type of songket, he will fall ill. This is because the people of Sukarara Village still believe that songket weaving is sacred. This subahnale songket is a very famous songket. Not only the level of complexity during the manufacturing process, but the aesthetic beauty both in terms of motifs and colors has made this subahnale songket cloth has its charm. In addition, songket subahnale also has a meaning related to the spiritual and sacred world. Figure 2. The motif on the top subahnale woven fabric The motif on the top of the subahnale woven cloth is decorated with a series of lotus flower motifs which symbolize fertility and prosperity. These motifs are arranged neatly in the same pattern and shape using gold thread. Figure 3. Basic sketch of the motif on the top of the subahnale woven fabric Figure 3 above shows that the primary form of the subahnale woven fabric motif at the top is a geometric shape, namely a rhombus and a hexagon. Y Y X X Figure 4. Reflection of subahnale woven fabric motifs Figure 4 above shows that the motifs arranged on the subahnale woven fabric use the concept of geometric transformation, namely reflection, where the motif is reflected on the Y axis. As shown in the picture above, the top motif of the subahnale woven fabric has vertical reflections but no horizontal reflections. Furthermore, based on the flowchart, it can be seen that the pattern has half turns. So, the geometric pattern in the motif on the subahnale woven fabric is pattern 6: experiencing one-way translation and horizontal reflection. Figure 5. The motif in the middle of the subahnale woven fabric The motif pattern shown in Figure 5. of the subahnale woven cloth, the middle part is a hexagon shape with a lotus flower in it. Geometry shapes also look like rhombuses, triangles, and squares that fill any empty spaces in the same direction. Figure 6. Basic sketch of the motif for the middle part of the subahnale woven fabric Figure 6. above shows that this pattern has a rhombus lattice and a rotation of 90o. In addition, there are 4-way reflections. So, the crystallography found is a p4m pattern. Besides that, the motif in the middle of the subahnale woven fabric is part of the lotus flower motif. The design has a rhombus and hexagonal lattice but not the smallest degree of rotation, nor does it have reflection and glide reflection. So, in this pattern, we found a crystallographic p1 way. Y Y Figure 7. Reflection of subahnale woven fabric motifs Subahnale motif pattern There is a one- B. Philosophical Values way translation with a 180° rotation and a A noblewoman makes subahnale woven horizontal reflection. So, pattern four is fabric with a unique selection of materials found in the freeze pattern. and colors, which takes a long time to make Y Y (Damsiah, 2022). Furthermore, at that time, there was not much production of x x woven cloth because it was only used by certain people (Gesum, 2022). The philosophical values contained in Figure 8. Reflection of subahnale woven fabric subahnale woven fabric motifs are as motifs follows: Figure 8. above shows reflections on Table 1. both axes on the x-axis and y-axis, The philosophical values contained in subahnale experiencing one-way translation, rotation, woven fabric motifs and vertical and horizontal reflection. The Dimensions Philosophical value pattern found is pattern 7 in the frieze Black base Most of the primary colors of color woven fabrics, traditional pattern. clothing, and other accessories from the Sasak people are black (dark). This is taken because black is a neutral color, Figure 9. The motif of the subahnale woven fabric reflecting togetherness, The pattern on the bottom of the strength, and courage subahnale woven fabric is a triangular (Damsiah, 2022) Triangle According to the Sasak people, shape that repeats itself in the long the triangular symbol is the direction of the material. The motif used is alignment of three elements: the relationship between the motif of the lotus flower shape. humans and nature, humans and humans, and humans and God. Rectangular The quadrilateral consists of Figure 10. Basic sketch of the motif on the bottom three directions. To realize the of the subahnale woven fabric prosperity of a nation, it must Figure 10. above shows the pattern of synergize between four the subahnale woven fabric motif at the components, namely pandite bottom. It can be seen that the pattern only (government), nyake (scholars/intellectual), guru has vertical reflections and also does not (religious leaders), and kire have a 180° rotation. So, the bottom (people) (Fathurrahman, 2022) Hexagon The form of belief in Islam is the pattern of the subahnale woven fabric can pillars of faith (Fathurrahman, be categorized as pattern 3 in the Frieze 2022) pattern. Based on the philosophical values of the colors and shapes of the motifs contained in the subahnale woven fabric above, it gives a meaning that can be used as part of advice and as a lifeline for the next generation. IV. CONCLUSION Subahnale woven fabric is the oldest woven fabric in Sukarare Village. The motifs and colors of the threads that adorn this woven fabric, besides having an aesthetic meaning and containing philosophical values, can also be used as a source of learning mathematics. Various geometric shapes adorn this subahnale woven fabric, including hexagons, triangles, squares, and rhombuses. The figures are placed based on geometric transformation patterns: translation, rotation, and reflection. This study has observed ethnomathematics elements of subahnale woven fabric motifs based on Frieze and Crystallography patterns and analyzed Frieze patterns or Crystallographic patterns in one woven fabric pattern. These patterns are found by cutting the motifs vertically and horizontally and then rotating them to find Frieze or Crystallographic ways. The study found that there were 4 Frieze patterns in subahnale woven fabric motifs. The Frieze patterns are patterns 3, 4, 6, and 7. In addition, there are also crystallographic patterns. The crystallographic ways are p1, pm, and p4m patterns. Subahnale woven fabric motifs are the result of development. The variant name of the woven fabric depends on the form

of the motif used. These variants include subahnale woven fabric with wayang motifs, subahnale woven fabrics with nanas motifs, subahnale woven fabrics with benang empat motifs, etc. For this reason, it is suggested that future researchers export forms of mathematics through ethnomathematics studies to make the sources of learning mathematics more culturally related. REFERENCES Abdullah, A. S. (2017). Ethnomathematics in perspective of sundanese culture. Journal on Mathematics Education, 8(1), 1–16. https://doi.org/10.22342/jme.8.1.387 7.1-15 Amit, M., & Qouder, F. A. (2017). Weaving Culture and Mathematics in the Classroom: The Case of Bedouin Ethnomathematics. In M. Rosa, L. Shirley, M. E. Gavarrete, & W. V. Alangui (Eds.), Ethnomathematics and its diverse approaches for mathematics education (pp. 23–50). Cham: Springer Nature. https://doi.org/ 10.1007/978-3-319- 59220-6_2 Andriani, L., & Muchyidin, A. (2020). Pola Frieze Group Pada Gerakan Tari Buyung Kuningan. 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