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Binary Representation of the Weaving Motifs of Rumah Bubungan Tinggi: An Ethnomathematical Exploration for Discrete Mathematics Learning

Arifin Riadi[1*], Turmudi[2], Dadang Juandi[3], Jarnawi Afgani Dahlan[4], Rolina Amriyanti Ferita[5]

[1*]Department of Mathematics Education, Universitas PGRI Kalimantan
Komp. H Iyus No. 18 Banjarmasin Utara, Banjarmasin, South Kalimantan, Indonesia
[1*]arifinriadi@upk.ac.id

[2,3,4]Department of Mathematics Education, Universitas Pendidikan Indonesia
Jalan Dr. Setiabudi No. 229 Sukasari, Bandung, West Java, Indonesia
[2]turmudi@upi.edu; [3]dadang.juandi@upi.edu; [4]jarnawi@upi.edu

[5]Mathematics Education, Universitas Nahdlatul Ulama Kalimantan Selatan
Jalan A. Yani No. KM 12.5 Kertak Hanyar, Banjar, South Kalimantan, Indonesia
[5]rolina.amriyanti@unukase.ac.id

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Abstrak

Motif anyaman pada dinding anjung Rumah Bubungan Tinggi menampilkan pola berulang yang dapat dimodelkan sebagai barisan biner. Penelitian eksploratif kualitatif ini merepresentasikan orientasi bilah sebagai digit 1 dan 0, kemudian menganalisis periodisitas, memformulasikan aturan berbasis modulo, serta melakukan konversi biner–desimal–karakter untuk menautkan motif tradisional dengan struktur pengodean informasi digital. Hasil menunjukkan motif membentuk barisan biner deterministik berperiode tertentu yang dapat dijelaskan melalui fungsi modulo. Berdasarkan pemetaan digit–arah bilah, disusun pula model konseptual steganografi: penyisipan pesan biner melalui variasi orientasi bilah tanpa mengubah karakter visual motif. Temuan ini menegaskan potensi motif anyaman sebagai media representasi informasi sekaligus konteks budaya untuk pembelajaran matematika diskret melalui tugas bertahap (pengodean motif, identifikasi unit ulang/periode, penurunan aturan modulo, dan konversi bilangan).

***Kata Kunci**: etnomatematika; motif anyaman; barisan biner; matematika diskret; steganografi.*

Abstract

Motif weaving on the *anjung* wall of the *Rumah Bubungan Tinggi* exhibits repeating patterns that can be modeled as binary sequences. This qualitative exploratory study encodes strip orientation as 1 and 0, then examines periodicity, formulates modulo-based rules, and performs binary–decimal–character conversions to connect traditional motifs with the basic structure of digital information encoding. The results show that the motifs form deterministic binary sequences with specific periods that can be described using modulo functions. Based on digit-to-orientation mapping, the study also proposes a conceptual motif-based steganography model: embedding binary messages through variations in strip orientation without altering the motif's overall visual character. These findings highlight the potential of weaving motifs as both an information representation medium and a cultural context for discrete mathematics learning through stepwise tasks (motif encoding, identification of repeating units/periods, derivation of modulo rules, and number conversion).

Keywords: ethnomathematics; weaving patterns; binary sequences; discrete mathematics; steganography.

I. Introduction

The development of ethnomathematics over the last two decades has shown that cultural practices are a rich source for the construction of mathematical knowledge (Gerdes, 1999; Rosa & Orey, 2013; Riadi, Turmudi, & Juandi, 2024; Roesdiana et al., 2025). This perspective emphasizes that the patterns, symbols, and structures embedded in cultural artifacts are not merely aesthetic expressions, but reflect the cognitive activity of communities in solving problems and organizing everyday experience. Recent studies further reinforce that integrating cultural elements into mathematics instruction can support the development of mathematical literacy, conceptual understanding, reasoning ability, and learning motivation among both school and university students (Hunter, 2021; Sari et al., 2024; Putra, Novita, & Usman, 2025). These findings are consistent with the view that cultural patterns can function as conceptual bridges that help university students connect concrete experience with abstract mathematical representations (Amit & Abu Qouder, 2017; Lestari et al., 2022).

In the context of Banjar society, the Rumah Bubungan Tinggi is a cultural artifact that is particularly rich in mathematical value, especially in the bamboo weaving motifs used on the right and left anjung walls. These traditional woven motifs are composed of repeated vertical and horizontal strips that generate distinctive structural patterns. Studies of geometric patterns in weaving techniques across various cultures have shown that such recurring structures embody higher-level mathematical logic, especially with respect to sequences, symmetry, periodicity, and symbolic representation (Arribay, 2025; Rosa & Orey, 2011, 2019). Nevertheless, most ethnomathematics research has focused on primary and secondary education, while the use of cultural artifacts in university-level mathematics instruction, particularly in relation to discrete mathematics, remains relatively limited (Hidayati & Prahmana, 2022; Schüler-Meyer, 2019). This gap indicates the need for more innovative and relevant instructional models that connect local cultural heritage with core concepts underlying modern computation.

Discrete mathematics, particularly binary representation, modular operations, and the modelling of repeating patterns, constitutes a fundamental component of computational systems. Binary representation has long served as the basic language of computing machines (Patterson & Hennessy, 2016; Wang et al., 2025), while the ability to read patterns and formalize rules through modular functions is a key competence in algorithm development. When woven motifs that exhibit only two states—vertical and horizontal—are reduced to the digits 0 and 1, these cultural structures can be mapped directly onto the framework of discrete mathematics. Such an approach aligns with the notion of computational thinking, which emphasizes the ability to organize patterns, perform abstraction, and transform representations (Denning & Tedre, 2019; Wing, 2006). Through binary representation, woven motifs are no longer merely aesthetic objects, but become symbolic systems that can be mathematically processed and analyzed.

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Despite its foundational role in computing, discrete mathematics is often experienced by undergraduates as highly abstract and proof-intensive. Empirical and review-based evidence in discrete mathematics education indicates that students frequently perceive proof writing—particularly induction and related formal arguments—as one of the most challenging components of the course (Arnesen & Skartsæterhagen, 2025; Magda & Gardner-McCune, 2025; Polycarpou, 2006). Research on mathematical learning further suggests that these difficulties are closely associated with students' limited ability to coordinate and translate across representational systems; therefore, visualization and the use of multiple representations can serve as critical bridges from perceptible structures to formal symbolic reasoning (Arcavi, 2003; Duval, 2006; Mainali, 2021; Maulandani & Afriansyah, 2024). Accordingly, culturally familiar visual artifacts such as weaving motifs can be positioned not only as motivational contexts but also as representational resources that make binary states, periodicity, and modular rules observable before they are formalized into symbolic expressions.

Moreover, the potential of woven motifs to be used in modern steganographic techniques further extends their mathematical relevance. Recent research has shown that repetitive visual patterns such as traditional motifs are highly effective as media for hiding messages in information hiding schemes because of their consistent and redundant structure (Ho et al., 2009; Sajedi, 2016). The use of cultural motifs as cover media in steganography also aligns with current trends in integrating culture into digital technology that are widely discussed in contemporary literature (Li et al., 2022; Zhao, 2024; Septia, Handayani, & Ramadhan, 2024). Thus, the motifs of Rumah Bubungan Tinggi not only embody mathematical patterns but also hold applicative potential in the contexts of information security and digital literacy.

Integrating the analysis of traditional motifs into university-level mathematics instruction offers substantial opportunities to improve the quality of learning. Numerous studies have shown that ethnomathematics-based and culturally contextualized instruction can enhance higher-order mathematical understanding, including modelling ability, abstract reasoning, and problem-solving skills (Nur et al., 2020; Putri et al., 2024; Saironi, 2022). Through such approaches, students can perceive direct connections between culture, formal mathematics, and technology, thereby making learning experiences more meaningful and relevant. This approach also supports the direction of twenty-first-century curricula, which demand mathematical literacy, digital literacy, and appreciation of local culture as integral components of global competence (Qolbi & Afriansyah, 2024; Komalasari, 2021; Niemi et al., 2018).

In light of these findings, the present study aims to examine the mathematical structure of the woven motifs of Rumah Bubungan Tinggi and to develop a binary representation that can be linked to concepts of discrete mathematics and elementary steganographic techniques. The objectives of this study are to identify the mathematical patterns in the woven motifs, to construct formal rules that describe these patterns, to relate them to systems of digital information representation, and to develop a learning model that is pedagogically relevant for pre-service mathematics teachers. This research is expected to make a substantive contribution to the development of advanced ethnomathematics and to offer an innovative approach to mathematics instruction in higher education.

II. Method

This study employs a qualitative exploratory approach aimed at uncovering the mathematical structures embedded in the woven motifs of the Rumah Bubungan Tinggi and designing an instructional model that integrates these representations into discrete mathematics learning. This approach was selected because the research focuses on an in-depth analysis of cultural artifacts and their transformation into formal representations, rather than on testing empirical treatments in a classroom setting. The data consist of visual documentation of bamboo weaving motifs found on the anjung walls of the Rumah Bubungan Tinggi, which display authentic variations of tight, medium, and loose patterns that reflect the traditional weaving skills of the Banjar community.

Observation Instrument and Selection Criteria. Data were collected using a structured non-participant observation sheet supported by photo documentation. The observation sheet recorded: (a) the panel location on the anjung wall, (b) motif characteristics and weaving density (e.g., rapat, liris, and longgar), (c) a sketch of the observed segment, (d) the sequential coding of strip orientation into binary digits, and (e) field notes on visibility and motif completeness. Because the study did not impose a fixed number of strips per segment, binary sequences were extracted from segments that clearly displayed one or more repeating units, allowing period identification and pattern verification. The anjung wall panels were selected purposively because they were physically intact (i.e., not significantly damaged), enabling reliable reading of strip orientations and pattern repetition. In addition, the selected weaving motif is commonly found across Rumah Bubungan Tinggi based on field observation, making it a representative cultural artifact for examining binary representation, periodicity, and modulo-based rules in a discrete mathematics learning context. Only panels with clear visibility, minimal deterioration, and sufficiently complete repeating segments were included for analysis.

The analytical process began with identifying the orientation of bamboo strips within each motif to determine the fundamental repeating unit that forms the structural basis of the weave. The two primary orientations—vertical and horizontal—were classified and represented using binary digits 1 and 0. This recoding process establishes a direct bridge between traditional visual patterns and the symbolic language of discrete mathematics. Once the motifs were reduced to binary sequences, the analysis continued by determining the period

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length of the pattern, constructing its minimal pattern block, and formulating the modulo function that characterizes its generative rule. Through this procedure, the repetitive structure of the motif can be interpreted within a more formal mathematical framework.

The resulting binary representations were then further analyzed through their conversion to decimal numbers and subsequent mapping to alphabetic characters or ASCII values. This stage was designed to illustrate how cultural patterns may be conceived as informational units compatible with digital representation systems. Such conversions also provide a conceptual foundation for understanding the relationship between binary structures and encoding principles in information technology.

The study then developed a conceptual model for employing woven motifs as media for steganography, a technique for embedding hidden information within visual patterns. This stage involved structuring a message into a binary sequence of a predetermined length and mapping the digits 1 and 0 to the vertical and horizontal strip orientations in the motif. The reconstruction procedure preserved the original visual character of the motif, ensuring that the embedded message remained imperceptible to casual observation. This development not only demonstrates the mathematical potential of cultural motifs but also highlights their connection to the foundational principles of digital information hiding. Accordingly, the research methodology encompasses structural motif analysis, the development of mathematical representations, and the conceptualization of binary-based steganography that positions culture as a mediating space between discrete mathematics and information technology.

III. RESULT AND DISCUSSION

Throughout the analysis, strip orientation was coded consistently as 1 for vertical strips and 0 for horizontal strips; all sequences, period analysis, and conversions in this section follow this fixed convention. The analysis of the woven motifs on the anjung walls of the Rumah Bubungan Tinggi shows that the visual patterns formed by the arrangement of bamboo strips possess structural characteristics that can be reduced to formal mathematical representations. The three motifs—rapat, liris, and longgar—each display a consistent repetition of vertical and horizontal orientations. In the rapat motif (Figure 1), for example, the bamboo strips alternate between vertical and horizontal positions, producing a rhythmic structure that can be mathematically represented as 1010 1010 1010 …. In the liris motif (Figure 2), two vertical strips are consistently followed by two horizontal strips, resulting in the pattern 1100 1100 1100 …. The longgar motif (Figure 3) features a more spaced arrangement, yet still maintains the two fundamental orientations that enable the construction of a binary structure.

Figure 1. Rapat Motif.

Figure 2. Liris Motif.

Figure 3. Longgar Motif.

By assigning the vertical strips the digit 1 and the horizontal strips the digit 0, the woven motifs can be represented as binary sequences that exhibit periodic properties. In the *liris* motif, the four-digit repeating unit 1100 serves as the fundamental block that generates the entire pattern. Analysis of this pattern indicates that the motif has a period length of four, allowing the value of the n-th term in the sequence to be expressed using a modulo function. This relationship can be formulated as follows:

$$f(n) = \begin{cases} 1, n \equiv 1, 2 \ (mod\ 4) \\ 0, n \ \equiv 3, 0 \ (mod\ 4) \end{cases}$$

This formula illustrates that the value of each digit in the binary sequence can be fully predicted based on the term's position and the modulo-four operation. These findings reinforce that traditional cultural motifs contain deterministic structures commonly encountered in discrete mathematics, particularly in the study of periodic sequences.

The analysis was then extended by linking the binary sequences to digital representation systems through numerical conversion. Each binary block obtained from the motif—for example, 11001—can be converted into a decimal number using the standard formula:

$$\text{decimal number} = \sum_{i=0}^{k} b_i \cdot 2^i$$

For the example 11001, if the digit indices are counted from the right (with the rightmost digit as b_0), the conversion yields:

$$1 \cdot 2^4 + 1 \cdot 2^3 + 0 \cdot 2^2 + 0 \cdot 2^1 + 1 \cdot 2^0 = 25$$

These values can then be mapped to letters based on alphabetical order or ASCII codes, allowing traditional patterns to be interpreted as foundational structures for information encoding.

The results of this structural analysis subsequently serve as the basis for designing a conceptual steganographic model grounded in woven motifs. For illustration purposes, a word such as "MAKAN" can be reduced to its numerical representation through alphabetic mapping, and then converted into a five-

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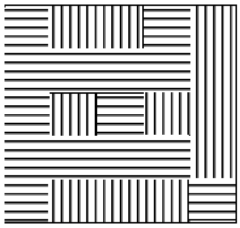
digit binary form for each letter. For example:

M ➔ 13 ➔ 01101
A ➔ 1 ➔ 00001
K ➔ 11 ➔ 01011 ➔
A ➔ 1 ➔ 00001
N ➔ 14 ➔ 01110



Each binary digit in the block is then mapped back onto the woven motif by assigning digit 1 to a vertical strip and digit 0 to a horizontal strip. In this way, the motif can be reconstructed in a manner that embeds a particular message without altering the overall visual appearance. This process demonstrates that traditional motifs have the potential to function as cover patterns in simple forms of steganography, as their repetitive characteristics naturally support the concealment of information bits.

This entire structural analysis is subsequently used to develop a culturally grounded instructional design for discrete mathematics. The design positions the woven motif as a contextual anchor for understanding binary representation, modular operations through the function $f(n)$, the analysis of sequence periodicity, and binary–decimal conversion using the formula $\sum b_i 2^i$. In addition, the steganographic concept developed from the motif creates opportunities to connect cultural structures with the fundamental principles of information hiding used in modern technology. This instructional design illustrates how traditional patterns can serve as epistemological bridges for conceptualizing abstract discrete mathematics ideas in more concrete and meaningful forms.

Accordingly, the results of the study encompass the identification of mathematical patterns within the woven motifs, the construction of binary representations and modulo functions, the demonstration of symbolic conversion from binary to decimal and character form, and the formulation of a conceptual steganography model utilizing traditional motifs. Taken together, these findings provide a solid foundation for developing a discrete mathematics instructional approach that integrates local cultural heritage with principles of digital representation.

The analysis of the woven motifs of the *Rumah Bubungan Tinggi* reveals that the visual patterns formed by the arrangement of bamboo strips contain mathematical structures that naturally align with concepts in discrete mathematics. These findings reinforce the view in modern ethnomathematics that the patterns, forms, and structures found in cultural artifacts are manifestations of mathematical practices embedded within a community (Gerdes, 2003; Sharma & Orey, 2017). In the context of the Banjar community, weaving techniques are not merely aesthetic or functional activities, but also representations of regularity and transformation that can be reduced into formal mathematical components.

The representation of strip orientations in the woven motif as binary digits 1 and 0 illustrates how cultural patterns can be directly translated into the symbolic systems used in digital technologies. This visual reduction process aligns with the concept of abstraction in computational thinking (Wing, 2006; Denning & Tedre, 2019), in which complex elements of the real world are transformed into simplified representations while preserving their essential underlying structure. When the woven patterns are translated into periodic binary sequences, the motifs exhibit deterministic characteristics commonly found in mathematical sequences. This reinforces previous research showing that cultural practices such as weaving, carving, and basketry contain repetitive patterns that can be formalized and analyzed mathematically (Enmufida et al., 2021; Medina et al., 2024).

Further analysis through the construction of modulo functions shows that the structure of the motif can be described using precise mathematical rules. The correspondence between the positions of the woven strips and the values of the binary function demonstrates that traditional motifs embody the concept of periodicity, which forms a mathematical foundation for various computational applications. Constructing a modulo function to describe the binary sequences derived from the motif illustrates that students can be guided to understand modular operations not merely through symbolic abstraction, but through cultural patterns that are familiar to them. This approach aligns with findings indicating that the use of concrete contexts helps university students develop a stronger understanding of mathematical structures in topics such as logic and foundational concepts in discrete mathematics (Lubis & Nasution, 2017).

The transformation of binary sequences into decimal numbers and subsequently into characters illustrates the connection between cultural motifs and the fundamental principles of data encoding in digital systems. The stepwise conversion from binary to decimal and then to characters reflects the basic mechanism of computer encoding used to map raw data into symbols that are readable by humans. (Rayuwati et al., 2019). When woven motifs can be mapped onto alphabetic sequences through their binary structure, this opens a new perspective in which traditional visual artifacts may function as symbolic containers for information. This finding is relevant to contemporary discussions on digital literacy, which emphasize the ability to understand how information is represented through both mathematical and cultural forms within technological ecosystems (diSessa, 2018; Hoyles et al., 2020).

The integration of steganographic concepts into the woven motifs expands the cultural interpretive dimension of the analysis. By structuring a message in binary form and mapping it back onto the weaving pattern, the traditional motif functions as an invisible medium for information storage. The fundamental principle of steganography in information security asserts that embedded messages must minimize distortion so that alterations to the medium remain visually imperceptible and statistically difficult to detect (Evsutin et al., 2020; Holub & Fridrich, 2013). Traditional woven motifs—rich in repetitive structure—serve as an ideal medium for this purpose. Recent studies also show that recurring patterns in images—including repetitive visual structures such as cultural motifs—are effective as cover media in steganography because of their ability to conceal information bits in a harmoniously integrated manner (Bailey & Curran, 2006; Thiyagarajan et al., 2010). Thus, the woven motifs of the *Rumah Bubungan Tinggi* not only embody aesthetic value but also serve as potential pathways for information encoding within digital technology contexts.

This structural analysis provides a strong conceptual foundation for developing an instructional design that integrates local culture with university-level mathematics content. The learning design formulated in this study demonstrates that woven motifs can serve as an effective context for understanding binary representation, the periodic nature of sequences, modular operations, number conversion, and the basic principles of steganography. Culturally grounded instructional approaches have been shown to enhance students' mathematical understanding through meaningful local contexts (Mardia et al., 2025; Madruga, 2022; Rosa & Orey, 2024; Samo et al., 2017). By providing analytical experiences grounded in authentic cultural contexts, this design has the potential to enrich students' mathematical and digital literacy while simultaneously fostering an awareness of the relevance of local culture within higher education.

The motif-to-binary transformation can be translated into a short instructional sequence for pre-service mathematics teachers in discrete mathematics courses. First, students observe a motif segment (*rapat/liris/longgar*) and produce a binary string using the fixed convention (1 = vertical, 0 = horizontal). Second, students identify the minimal repeating block and determine the period, then justify the pattern structure using positional reasoning. Third, students formulate a modulo-based rule (e.g., for period 4) and use it to predict any n-th term, connecting the motif structure to modular operations and algorithmic thinking.

As an extension linking discrete mathematics to digital literacy, students convert selected binary blocks into decimal values and then map them to alphabetic/ASCII representations, followed by a guided discussion on how encoding systems represent information. Finally, the steganography illustration can be used as a design task: students propose a short binary message, embed it into a motif segment through digit–orientation mapping, and explain how the visual character is preserved. This activity emphasizes representation, abstraction, and rule-based reasoning while maintaining cultural relevance, and it can be assessed through students' written justifications (period identification, modulo rule derivation, and conversion accuracy) and reflective notes on the cultural–digital connection.

Overall, this discussion demonstrates that the woven motifs of the *Rumah Bubungan Tinggi* can function as an epistemological bridge between culture, formal mathematics, and information technology. The mathematical structures embedded within these motifs provide a foundation for developing innovative instructional models that not only strengthen students' understanding of discrete mathematics concepts but also broaden their awareness of the connections between traditional knowledge and modern technology. This aligns with the notion of local–global relations in mathematics education, which emphasizes the importance of linking culturally grounded mathematical experiences and practices with global demands through a reflective and equitable learning framework (Le Roux & Swanson, 2021.

IV. CONCLUSION

This study demonstrates that the woven motifs on the *anjung* walls of the *Rumah Bubungan Tinggi* contain mathematical structures that can be formalized using discrete mathematics. Encoding strip orientation as binary digits (1 and 0) reveals deterministic sequences with identifiable period lengths. The derived modulo functions for the n-th term, together with binary-to-decimal and character conversions, indicate a logical connection between traditional motifs and the foundational principles of digital information representation. In addition, the proposed motif-based steganography scheme illustrates—at a conceptual level—how binary messages could be embedded through digit-to-orientation mapping while preserving the overall visual character of the motif.

From a mathematics education perspective, these findings provide a culturally grounded representation pathway for teaching core topics in discrete mathematics, including binary representation, periodic sequences, modulo operations, number conversion, and introductory ideas of information hiding. Accordingly, the motifs can serve as a meaningful learning context that bridges formal mathematical reasoning, digital literacy, and local cultural heritage in university-level mathematics education.

However, this work remains conceptual and has not been empirically tested in instructional settings or in more complex computational environments. Therefore, the effectiveness of the proposed learning sequence and the robustness of motif-based message embedding cannot yet be evaluated empirically.

Future studies are recommended in three directions. First, researchers should implement the proposed learning sequence with pre-service teachers and evaluate its impact on conceptual understanding (e.g., binary and modulo reasoning), learning motivation, and students' ability to justify rules derived from patterns. Second, technical studies may conduct computational testing to examine the robustness of motif-based embedding under varied pattern windows, decoding constraints, and noise conditions, potentially supported by simple algorithms, digital simulations, or visual-based tools. Third, the structural analysis can be expanded by incorporating motif variations from other Banjar houses or comparable cultural artifacts from South Kalimantan, and by exploring additional formal approaches (e.g., graph theory, combinatorics, or pattern transformations) to deepen the characterization of mathematical features in traditional weaving motifs.

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AUTHOR'S BIOGRAPHY

Dr. Arifin Riadi, M.Pd.

Born in Nagara, December 21, 1990. A Mathematics Education lecturer at Universitas PGRI Kalimantan. Completed a Bachelor's degree in Mathematics Education at Universitas Lambung Mangkurat Banjarmasin in 2012, a Master's degree in Mathematics Education at Universitas Negeri Yogyakarta in 2014, and a Doctoral's degree at Universitas Pendidikan Indonesia in 2025.

Prof. Turmudi, M.Ed., M.Sc., Ph.D.

Born in Ciamis, January 12, 1961. Currently a lecturer in the Mathematics Education Study Program at FPMIPA, Universitas Pendidikan Indonesia. Completed a Bachelor's degree in Mathematics Education at IKIP Bandung, graduating in 1986; a Master's degree in Math Education at La Trobe University, Australia, graduating in 1997; a Master's degree in Instructional Design at Twente University, Netherlands, graduating in 1999; and a Ph.D. in Math Education at La Trobe University, Australia, graduating in 2007.

Prof. Dr. Dadang Juandi, M.Si.

Born in Tasikmalaya, January 17, 1964. Currently a lecturer in the Mathematics Education Study Program at FPMIPA, Universitas Pendidikan Indonesia. He completed his bachelor's degree at UPI Bandung in 1989, his master's degree at UGM in 1997 and his doctoral degree at UPI Bandung in 2000.

Prof. Dr. Jarnawi Afgani Dahlan, M.Kes.

Born in Sumedang, May 11, 1968. Currently he is head of the Mathematics Education Study Program, FPMIPA UPI Bandung. He completed his bachelor's degree at UPI Bandung in 1990, his master's degree at Universitas Airlangga in 1998 and his doctoral degree at UPI Bandung in 2004.

Rolina Amriyanti Ferita, M.Pd.

A Mathematics Education lecturer at Universitas Nahdlatul Ulama Kalimantan Selatan. Completed a Bachelor's degree in Mathematics Education at Universitas Negeri Yogyakarta in 2012 and a Master's degree in Mathematics Education at Universitas Negeri Yogyakarta in 2015.