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Modeling in/from rural education: motivations guiding research and teaching practices

Modelación matemática en/desde la educación rural: motivaciones que guían la investigación y las prácticas docentes

Modélisation mathématique dans/depuis l'éducation rurale : des motivations qui guident la recherche et les pratiques pédagogiques

Modelagem matemática na/da educação do campo: motivações que guiam as pesquisas e as práticas docentes

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Abstract

This article is an excerpt from ongoing doctoral research that examines Mathematical Modeling and Rural Education. The study aims to discuss the elements that motivated rural educators to begin their journey with Modeling. Furthermore, we seek to identify the relationships between their motivations and the ways in which Modeling is conceived within this teaching modality. To conduct the research, we carried out a bibliographic analysis of 10 dissertations, 1 thesis and 24 articles on the topic published between 2008 and 2023 in Brazil. The analysis showed that the motivations described by the authors of the selected papers are based on: (1) the potential of Modeling; (2)

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concerns about and the desire to promote changes in pedagogical practice; (3) the need to make teaching and learning meaningful; (4) the possibility of contextualizing content, and (5) teaching practice and/or professional development. As a result, we understand that what drove rural educators to examine Modeling or integrate it into their practices was primarily the desire to "carry out transformations" and "transform themselves", thereby connecting teaching to (some of) the pedagogical principles of Rural Education. The teaching movement around Modeling gained traction when these professionals began to perceive themselves as "rural educators" and recognized the potential of this perspective for implementing the Rural Education proposal in mathematics classes. Therefore, we consider it essential to provide both initial and continuing education in Modeling to rural educators.

Keywords: Rural education, Mathematical modeling, Teaching practice.

Resumen

Este trabajo es un extracto de una investigación doctoral en curso que involucra un estudio sobre Modelación Matemática y Educación Rural. Nuestro objetivo en esta investigación es hacer consideraciones sobre qué motivó a los educadores rurales a iniciar su camino en/con el Modelado. Además, buscamos identificar las relaciones entre estas motivaciones y la forma de concebir el Modelado en esta modalidad de enseñanza. Para realizar la investigación, realizamos un análisis bibliográfico de 10 disertaciones, 1 tesis y 24 artículos que tratan el tema, publicados entre 2008 y 2023, en Brasil. El análisis mostró que las motivaciones explicadas por los autores en los trabajos analizados se basan en (1) el potencial del Modelado; (2) preocupaciones y deseo de promover cambios en la práctica pedagógica; (3) la necesidad de dar sentido a la enseñanza y el aprendizaje; (4) la posibilidad de promover la contextualización de contenidos y; finalmente, (5) en la docencia y/o posibilidad de desarrollo profesional. De esta manera, entendemos que lo que impulsó a los educadores rurales a insertar y/o investigar el Modelamiento en sus prácticas fue, principalmente, el deseo de "transformar" y "transformarse" para conectar la enseñanza con los principios pedagógicos (o parte de ellos). de Educación Rural. El movimiento docente por la Modelación se vio impulsado cuando estos profesionales se percibieron como "educadores rurales" y visualizaron el potencial de esta perspectiva para implementar la propuesta de Educación Rural en las clases de Matemáticas. Por ello, consideramos pertinente brindar formación inicial y continuada en Modelación a educadores rurales.

Palabras clave: Educación Rural, Modelación matemática, Práctica docente.

Résumé

Ce travail est un extrait d'une recherche doctorale en cours qui implique une étude sur la modélisation mathématique et l'éducation rurale. Notre objectif dans cette recherche est de réfléchir à ce qui a motivé les éducateurs ruraux à se lancer dans/avec la modélisation. De plus, nous cherchons à identifier les relations entre ces motivations et la manière de concevoir la modélisation dans cette modalité d'enseignement. Pour mener à bien la recherche, nous avons réalisé une analyse bibliographique de 10 thèses, 1 thèse et 24 articles traitant du sujet, publiés entre 2008 et 2023, au Brésil. L'analyse a montré que les motivations expliquées par les auteurs dans les travaux analysés reposent sur (1) le potentiel de la modélisation ; (2) les préoccupations et le désir de promouvoir des changements dans la pratique pédagogique ; (3) la nécessité de donner un sens à l'enseignement et à l'apprentissage ; (4) la possibilité de favoriser la contextualisation du contenu et ; enfin, (5) en enseignement et/ou possibilité de développement professionnel. De cette façon, nous comprenons que ce qui a poussé les éducateurs ruraux à insérer et/ou enquêter sur la modélisation dans leurs pratiques était principalement le désir de « se transformer » et de « se transformer » pour relier l'enseignement aux principes pédagogiques (ou à une partie de ceux-ci). de l'éducation rurale. Le mouvement d'enseignement de la modélisation a été lancé lorsque ces professionnels se sont perçus comme des « éducateurs ruraux » et ont visualisé le potentiel de cette perspective pour mettre en œuvre la proposition d'éducation rurale dans les cours de mathématiques. Il nous semble donc pertinent d'offrir une formation initiale et continue en modélisation aux éducateurs ruraux.

Mots-clés : Éducation rurale, Modélisation mathématique, Pratique pédagogique.

Resumo

Este trabalho é um recorte de uma pesquisa de doutorado em andamento que envolve um estudo sobre Modelagem Matemática e Educação do Campo. O objetivo desta investigação é tecer considerações acerca das motivações que levaram os educadores do campo a iniciarem sua trajetória com a Modelagem. Além disso, buscamos identificar as relações entre essas motivações e a forma de conceber a Modelagem nessa modalidade de ensino. Para a realização da pesquisa, foi realizada análise bibliográfica de 10 dissertações, 1 tese e 24 artigos publicados no Brasil entre 2008 e 2023, todos voltados à temática. A análise evidenciou que as motivações explicitadas pelos autores nos trabalhos examinados se fundamentam em: (1) nas potencialidades da

Modelagem; (2) nas inquietações e desejo de promover mudanças na prática pedagógica; (3) na necessidade de atribuir significado ao ensino e à aprendizagem; (4) na possibilidade de contextualizar os conteúdos; e, (5) na atuação docente e/ou na perspectiva de desenvolvimento profissional. Dessa forma, compreendemos que o que instigou os educadores do campo a inserirem e/ou pesquisarem a Modelagem em suas práticas foi, principalmente, o desejo de "transformar" e "transformar-se", conectando o ensino com os princípios pedagógicos (ou parte deles) da Educação do Campo. O movimento docente em torno da Modelagem ganhou força quando esses profissionais se reconheceram como "educadores do campo" e visualizaram as potencialidades dessa abordagem para a concretização da proposta da Educação do Campo nas aulas de Matemática. Portanto, consideramos pertinente viabilizar ações de formação inicial e continuada em Modelagem para os educadores do campo.

Palavras-chave: Educação do campo, Modelagem matemática, Prática docente.

Modelagem matemática na/da educação do campo: motivações que guiam as pesquisas e as práticas docentes

I want a school of the countryside
That connects with life, with the people
Beloved and well-organized
And collectively guided.

Lyrics of the song "Construtores do Futuro"
By Gilvan Santos

Introduction

As educators, we develop and implement various didactic and methodological tools to support teaching and learning in the classroom. In teaching practice, we are continually in search of new possibilities that contribute to enhancing educational quality and to promoting the holistic development of students. According to Bisognin and Bisognin (2012), the teaching and learning process is complex and strongly influenced by what educators know and believe. In this context, teachers find themselves in constant reflection, aiming to improve their pedagogical practice based on the experiences accumulated throughout their professional journey.

When it comes to Rural Education (RE), this journey of transforming and adapting pedagogical practice becomes even more intensified due to formative demands and pedagogical principles that aim to foster critical and interdisciplinary approaches linked to students' struggles and realities (Leite, 2018). In light of this, educators have been seeking methodologies that contribute to the type of education envisioned in this modality of teaching.

According to Ledur, Keifer and Mariani (2023), specifically in the field of Mathematics, teachers have grounded their pedagogical practices in Ethnomathematics, Mathematical Modeling, Mathematical Investigations, and Problem Solving, which are methodological approaches aligned with the principles of Mathematics Education.

Focusing more specifically on the articulation between RE and Modeling[4], the doctoral research sought to investigate "the role Modeling has played in Rural Education", aiming to examine *whether* and *how* Modeling has been proposed, conceived and implemented in rural schools or undergraduate programs in Rural

[4] In this text, the terms *Modeling, Mathematical Modeling* and *Modeling in Mathematics Education* are used as synonyms.

Education, as well as the contributions it has provided within these educational spaces[5].

In this context, to better understand how rural educators began their journey with Modeling, we conducted a bibliographic analysis of theses, dissertations and articles published between 2008 and 2023, seeking to highlight teachers' motivations for proposing and developing Modeling activities in RE. In addition, we aimed to identify the relationships between these motivations and the ways in which Modeling is conceived within this modality of teaching. Understanding what leads educators who work in Rural Education to incorporate Modeling into their pedagogical practices supports reflections on how, and to what extent, this approach has gained ground in schools and in academic research. Moreover, it contributes to reflections on teachers' perceptions and their connection to the *Por uma Educação do Campo* movement. This analysis, in turn, provides elements that support reflection on the orientations of mathematics education for rural communities.

Given the aforementioned context, this study aims to present and discuss data obtained from one of the categories of analysis that composed the investigation. It is noteworthy that the thesis encompasses five categories of analysis[6]; however, this article presents and discusses the results of category *C1 – Motivations for proposing/researching Modeling in Rural Education*. This category contains information that enables us to understand educators' intentions, causes and purposes for proposing and implementing Modeling activities in/for RE, as well as their relationships with distinct ways of viewing and conceiving Modeling within this educational context.

Formative Demands of Rural Education

The *Por uma Educação do Campo* movement emerged in the 1990s, stemming from the demands of social movements – especially the Landless Workers' Movement (MST) – for the right to education for peasant populations. According to Caldart (2008), the mobilization of these social movements arose as a critical response to the educational situation of Brazilian people who work and live in rural areas, seeking to pressure the State to develop an educational policy that addressed the specificities of peasant communities, particularly in land-reform encampments and settlements.

In light of this, Rural Education (RE) was conceived based on the understanding

[5] For further information, we recommend consulting the first author's thesis, available at: https://repositorio.ufsc.br/bitstream/handle/123456789/264318/PECT0607-T.pdf?sequence=-1&isAllowed=y.

[6] Each category will be explained in detail in the Methodological Procedures section.

that individuals have the right to attend school in the place where they live, within an educational project that values their identity and takes into account their reality, culture, ways of life and modes of production. In addition, RE emerged as a proposal of resistance by the peasant population against the logic of capitalist expansion in rural areas, particularly that associated with agribusiness. According to Caldart (2002, p. 26), Rural Education

> [...] emerged in struggles for schools and public schools […] and, at the same time, from the radical perspective of the Pedagogy of Social Movements, it was born affirming that education is more than school…, connecting with social struggles aimed at a fuller humanization: the struggle for land, for work, for the de-alienation of labor, for the democratization of access to culture and its productions, for political participation, and for the defense of the environment.

As a result of the work carried out by the *Por uma Educação do Campo* movement over the years, public policies relevant to the Brazilian countryside have been designed and implemented, such as the *Diretrizes Operacionais para a Educação Básica das Escolas do Campo* (Brazilian Department of Education, 2002) – Operational Guidelines for Basic Education in Rural Schools (free translation) – and *Referências para uma Política Nacional de Educação do Campo* (Brazilian Department of Education, 2003) – Nacional References for Rural Education, (free translation). According to Alencar (2015), these documents seek to construct the identity of the rural school and to provide guidance on how to implement the principles of RE in different contexts.

Referências para uma Política Nacional de Educação do Campo (Brazilian Department of Education, 2003) establishes, in detail, the ideals that should guide educational practice within the context of rural schools, that is, the pedagogical principles of Rural Education: (i) the role of the school in shaping individuals, grounded in a project of human emancipation; (ii) the valuing of distinct forms of knowledge within the educational process; (iii) the formative spaces and times of learning subjects; (iv) the school's place as connected to the reality of the subjects; (v) education as a strategy for sustainable development; and (vi) autonomy and collaboration between rural subjects and the national education system.

According to these principles, the countryside is conceived as a space of life and production, market by specificities that cannot be overlooked in pedagogical practice. These principles assume that educational actions should promote the teaching and learning of scientific knowledge while simultaneously cultivating a sense of collectivity, cooperation and solidarity, thereby fostering the reaffirmation of the identity of rural

populations. Moreover, they should encourage reflection, critical thinking and engagement in the struggle for justice and social transformation, envisioning a new model of society and a rural project that is fairer, more egalitarian and sustainable.

Thus, teaching in rural schools, regardless of the curricular component of field of knowledge, requires considering such principles within the scope of teaching practice in order to ensure that learning aligns with the educational project envisioned for rural populations.

When it comes to Mathematics teaching, this logic remains the same. Mathematical knowledge, when articulated with the principles of RE, becomes an instrument of collective and structural organization in the struggles for land reform and social transformation sought by this movement. This idea is grounded in the premise that Mathematics is an important tool for social questioning, as argued by Barbosa (2001) and Meyer, Caldeira and Malheiros (2013). In this regard, Lima asserts that, in Rural Education, Mathematics can support inquiries and interventions that contribute to the development of peasant territories – a fundamental aspect to transform reality in favor of equity and social justice.

From this perspective, thinking about Mathematics and Rural Education entails considering how the knowledge of this discipline can be relevant to each educational territory and how it can contribute to the emancipation of the subjects who live there. According to Silva (2018, p. 19, our translation), Mathematics teaching in Rural Education must be effective in order to "[…] overcome the hegemonic model of knowledge and value local knowledge in relation to universal knowledge; strengthen the struggles of peasant populations and their culture, thus contributing to local development, production and work".

Several publications discuss how Mathematics should be implemented in Rural Education (RE), but significant challenges remain before meaningful progress can be achieved. According to Silva (2018), "in many rural schools, Mathematics teaching is guided by a sequential approach to content progression, which is mostly axiomatic and does not consider the sociocultural context of students and the school". This form of Mathematics teaching does not align with the principles or the educational project of RE. Therefore, it is essential to promote a pedagogical renewal capable of challenging standardized ways of conceiving Mathematics and its teaching in rural schools, in order to foster an education that meets the formative demands of this educational modality.

In view of this, the following questions emerge: How can we put into practice a form of Mathematics education aligned with the principles of RE? How can we

implement Mathematics teaching that meets the demands and specificities of peasant territories? Which Mathematics should be taught in RE? What is the social function of Mathematics in rural schools? What strategies or approaches can be used to foster the type of Mathematics teaching envisioned in RE? Some of these questions have gained prominence in discussions among rural educators.

In their study, Lima and Lima (2013) propose articulating Rural Education and Critical Mathematics Education (CME), whose theoretical foundations are also grounded in Freirean principles, in order to promote emancipatory education aimed at social transformation, given that in CME students are encouraged to observe, problematize and intervene in reality. Freire (1983, p. 33, our translation) states that "through the problematization of the human-world relationship, or of the human being in their relations with the world and with others, [it can] enable them to deepen their awareness of the reality in which and with which they exist".

The discussions conducted by Lima and Lima (2013) on the articulation between Rural Education and Mathematics Education have given rise to a promising field of investigation, encouraging in-depth studies on the mathematical and sociopolitical education of educators who teach in rural schools and on their conceptions of teaching and learning.

This debate has also stimulated reflection on how to explore Mathematics within rural schools, mobilizing teachers in the search for methodologies that can contribute to the type of mathematics education envisioned in this educational modality. In this context, it is possible to observe that some teachers have grounded their pedagogical practices in perspectives such as Ethnomathematics, Mathematical Modeling, Mathematical Investigations, and Problem Solving, which are methodological approaches that align with the principles of Mathematics Education.

In light of teachers' choice to adopt Modeling, this text seeks to highlight how rural educators began their journey with this perspective. By identifying and understanding what leads educators and researchers in RE to incorporate Modeling into their investigations and teaching practices, it becomes possible to reflect on how Modeling has gained prominence both within schools and in investigations. Furthermore, it allows us to offer considerations on teachers' perceptions and their commitment to the *Por uma Educação do Campo* movement. What, then, does Modeling entail?

Mathematical Modeling and its Connections with Rural Education

In Brazil, Mathematical Modeling has been proposed and discussed by educators and researchers since the 1980s. Over the years, it has taken on various interpretations, which have progressively reshaped how it is conceived in the classroom. One of these definitions was proposed by Barbosa (2001, p. 6, our translation), who argues that Modeling "is a learning environment in which students are encouraged to inquire and/or investigate, through Mathematics, situations derived from other fields of reality". According to the author, Modeling encompasses spaces for discussion that extend beyond the learning of mathematical content or the understanding of reality through the mathematization of problem-situations, thus fostering a learning environment in which reality is questioned.

The conception of Modeling defended by Barbosa (2001) was inspired by the perspective of Critical Mathematics Education (CME), proposed by Ole Skovsmose, which examines the sociopolitical role of Mathematics Educations and seeks to promote the emancipatory education of students so that they can act democratically within society. Barbosa's (2001) conception is recognized as a Sociocritical perspective of Modeling.

Sociocritical Modeling prompted the development of new proposals and publications linked to the theoretical perspective of CME, such as the studies by Araújo (2009), Almeida and Dias (2004), Caldeira (2005, 2009) and Meyer, Caldeira and Malheiros (2013). These authors, like Barbosa (2001), grounded their work in principles proposed by Paulo Freire (1996) and Ole Skovsmose (2001), focusing on dialogical and critical education; therefore, they are relevant, as they envision providing students with a more meaningful mathematical education. All the aforementioned studies discuss the potential of Modeling beyond the mere instrumentalization of Mathematics, emphasizing that its priority is to foster critical agency within society.

In this direction, we highlight the conception of Modeling defended by Meyer, Caldeira and Malheiros (2013, p. 33, our translation), according to which "modeling aligns with a conception related to 'educating mathematically'". The authors argue that,

> [...] to understand modeling as a perspective of educating mathematically, we should consider mathematics a set of rules and conventions established within a specific social, historical and cultural context, shaped by power relations […]. Thus, we should problematize Modeling by conceptualizing mathematics from this sociocultural perspective, emphasizing that we believe that there are various forms of mathematics, rather than only one, and the one we learn and teach in schools is a specific set of these rules and conventions (Meyer, Caldeira & Malheiros, 2013, p. 33, our translation).

The aforementioned authors' perspective reflects their stance toward Mathematics and its teaching, with an emphasis on interpreting and "reading the world through Mathematics". According to them, "*educating mathematically*" strengthens students' perception that they need Mathematics in their lives and encourages educators to consider which forms of mathematical knowledge their students need in order to better intervene in reality.

Considering the formative assumptions envisioned by Modeling from a Sociocritical perspective, it is possible to observe an alignment with the principles of Rural Education, suggesting that there is potential for articulating both perspectives (Bertol, 2021; Dufeck, 2017; Feyh, 2013; Leite, 2018; Nahirne, 2017; Osti, 2022; Paiva, 2021). Along these lines, it is understood that there are theoretical intersections between these proposals and that Modeling can contribute significantly to the materialization of dialogical, critical and emancipatory education for peasant populations (Leite, 2018; Osti, 2022; Paiva, 2021). Moreover, Modeling has a direct connection to public policies guiding Rural Education. Article 6 of Decree No. 7,532, of November 4, 2010, emphasizes the need to address the specificities of rural subjects and "present content related to the knowledge held by rural populations, considering the communities' own forms of knowledge, in line with academic knowledge and with the construction of contextualized proposals for rural education" (Decree No. 7,532, 2010, our translation). In this context, some educators and researchers have been encouraged to reflect on the theme, analyzing theoretical convergences and the potential of Modeling within the scope of Rural Education.

The first publication addressing Modeling and Rural Education was the 2013 dissertation by Cleonice Ricardi Nunes Feyh. In her study, the author discusses how Modeling can contribute to fostering a closer relationship between school Mathematics and the local culture of rural students. Grounded in the perspective of Modeling proposed by Biembengut (2013), the research underscores the effectiveness of teaching practices involving Modeling in RE for students' individual and collective cognitive development, as well as its potential to spark students' interest and to facilitate the articulation between school knowledge and traditional knowledge.

Later, new studies addressing the articulation of both perspectives were conducted, progressively highlighting Modeling as a potential tool for achieving a form of teaching and learning that aligns with the proposal of Rural Education (Bertol, 2021; Dufeck, 2017; Leite, 2018; Nahirne, 2017; Osti, 2022).

According to Nahirne (2017, p. 148, our translation),

> The articulation of Rural Education and Mathematical Modeling can contribute to high-quality critical education, as both aim to cultivate in students a form of mathematical knowledge fostered through society's reflective and transformative action. As a result, their identity, culture and knowledge are valued, and these elements are characterized as the social practices of rural workers and communities.

According to Leite and Silveira (2022), Modeling has the potential to foster reflection and, when articulated with Rural Education (RE), can stimulate young peasants to develop the habit of observing and questioning reality. In this regard, implementing Modeling activities in rural schools is considerably important for the formation of critical and reflective individuals.

> As a teaching methodology within the scope of Rural Education, Mathematical Modeling has contributed to the development of curiosity and motivation, as well as to the strengthening of students' autonomy, reasoning and creative thinking. In Modeling, students have the opportunity to construct mathematical knowledge through themes of their interest; therefore, it can contribute to their lives and work on farms by employing themes that involve agricultural production or farm management.

The aforementioned authors underscore the contributions of Modeling, as it promotes discussions and transformations in rural populations' lifestyles and modes of production, given that it mobilizes knowledge that supports interventions in reality. Such interventions may result in improvements on farms, the enhancement of production systems, or the facilitation of daily work in family farming. Thus, Leite and Silveira (2022) highlight Modeling as a pathway for learning and for social transformation in RE, as it stimulates reflection and critical thinking and guides actions aimed at intervening in reality, aligned with principles of inclusion, sustainable development and social justice in the Brazilian countryside.

Although the advantages of articulating Modeling and Rural Education have been acknowledged, there is little evidence of its utilization in rural schools, as the production of knowledge on this theme remains limited. Nevertheless, existing publications enable us to infer that there is concern with enhancing pedagogical practices in rural schools through the development of Modeling activities.

In this regard, while conducting this research, we identified the need to understand the motivations that led educators to propose and implement Modeling activities in RE, aiming to examine potential relationships among these motivations and how Modeling could be conceived within this modality of teaching.

Methodological Procedures

This study presents an excerpt of the results of a doctoral study that examines the role of Modeling in Rural Education and proposes a type of Modeling that is both *in* and *from* Rural Education. The excerpt and the discussions presented in this text are based on a literature review that mapped studies conducted in Brazil regarding the articulation between these perspectives.

According to Fonseca (2002, p. 32, our translation),

> A literature review is carried out based on the survey of theoretical references that have been analyzed and published through print and electronic media, such as books, scientific articles and webpages. Every scientific study begins with a literature review, which enables researchers to become familiar with existing productions on the theme. However, there is scientific research solely based on literature reviews, surveying theoretical references in order to map prior knowledge or information on the issue for which answers are sought.

To compose the corpus analyzed in this study, three types of data sources were used: theses and dissertations; articles published in journals; and articles published in conference proceedings. The time frame adopted for selecting the material to be reviewed spans from 2008 – marked by the emergence of undergraduate programs in Rural Education (LEdoC) and the intensification of debates on teaching and learning in rural schools – to 2023.

With regard to dissertations and theses, the selection encompassed academic works that addressed Modeling within the scope of Rural Education and were published in the *Catálogo de Teses e Dissertações da CAPES* and the *Biblioteca Digital Brasileira de Teses e Dissertações* (BDTD). For this search, the following descriptors were used: "Rural Education" AND "Mathematical Modeling"; "Rural Education" AND "Modeling". In total, 11 publications were found (10 dissertations and 1 thesis). These materials were coded using an alphanumeric system combining letters and numbers, based on the type of publication: the dissertations were identified by the letter "D", followed by an identification number, while the thesis was identified by the letter "T", followed by an identification number.

Regarding journals, a survey was conducted on Plataforma Sucupira within the scope of Rural Education, Science Teaching, and Mathematics Education. From this initial survey, we selected the journals rated by CAPES as top-tier or high-quality, that is, those ranked Qualis A1, A2, A3, A4 and B1 between 2017 and 2020.

With respect to conference proceedings, the following events were selected: *Encontro Nacional de Educação Matemática (ENEM), Seminário Internacional de Pesquisa em Educação Matemática (SIPEM), Conferência Nacional de Modelagem na*

Educação Matemática (CNMEM) and *Seminário Internacional e Fórum de Educação do Campo (SIFEDOC)*. These events were selected due to their nationwide relevance within the field of study – Rural Education (RE) or Mathematics Education.

After selecting the journals and conference proceedings to be examined, their tiles, abstracts and keywords were read in search of the terms "Modeling" or "Mathematical Modeling", and "Rural Education" or "rural school". In total, 11 articles published in scientific journals and 13 published in conference proceedings (7 at CNNEM and 6 at ENEM)[7] were found. Following the aforementioned alphanumeric coding, all articles were identified by the letter A, followed by an identification number (for example, A1, A2, A3…).

Next, we proceeded to examine the publications, aiming to categorize and code the data gathered in this process, reading them attentively in order to highlight and systematize the information contained in the texts. The material was then processed using ATLAS.ti [8] software, which highlighted the data and organized them into categories.

Inspired by the work of Silva (2018) and grounded in the theoretical and methodological foundations of qualitative research, as well as in the critical perspective of Modeling and in Rural Education references previously discussed in this text, five categories of analysis were defined: C1-Motivations for proposing/researching Modeling in Rural Education; C2-Meanings attributed to Modeling in the context of rural schools; C3-Contributions of practice in relation to Rural Education principles; C4-Knowledge developed/mobilized through Modeling; C5-Repercussions of Modeling practices in Rural Education. These categories emerged from a dialogue between the theoretical framework and the empirical material, based on an understanding of categories as analytical-interpretative devices that highlight relevant aspects of teaching practice within the context of rural schools.

In this article, we focused our analysis on category C1-Motivations for proposing/researching Modeling in Rural Education. This category seeks to identify the elements that mobilize educators to propose Modeling activities in the context of rural schools and to understand the causes, intentions and purposes that led teachers to propose and discuss Modeling activities in/for RE. These data contribute to the reflection on how, and to what extent, Modeling has gained prominence in schools and academic

[7] The full list of publications can be consulted in the thesis.
[8] ATLAS.ti is a qualitative data analysis application that enables the construction of analytical categories and expands the possibilities for visualizing and comparing data.

investigations. Additionally, they allow for considerations regarding teachers' perceptions and their connections to the *Por uma Educação do Campo* movement.

After the texts were read and category *C1-Motivations for proposing/researching Modeling in Rural Education* was coded and composed, we identified the need to group the data according to the justifications and reasons that led the authors to conduct studies on Modeling in Rural Education. Thus, five subcategories – or Units of Record – were created to characterize the authors' justifications and motivations for researching or proposing Modeling in Rural Education: (U1) The potential of Modeling; (U2) Concerns about and the desire to promote change; (U3) The need to make teaching and learning meaningful; (U4) The possibility of contextualizing content; and, finally, (U5) Teaching practice and/or professional development.

Results and discussion

Based on the previously presented discussions, we observed that Modeling has been regarded as relevant by educators and researchers in Rural Education (RE). Thus, we sought to highlight how the authors of the analyzed publications justified their choice of this theme.

As explained in the methodological procedures, the reading and examination of the analysis corpus led to the emergence of five Units of Record, which express the motivations that drove the authors to propose or investigate Modeling in RE. Next, we present and discuss selected data highlighted within each of these Units of Record.

The first Unit of Record (UR) brings together studies that justified the choice of Modeling based on the recognition of its potential. Among the analyzed texts, five presented justifications that fit this subcategory. Considering that it is not possible to present all the data and excerpts highlighted in the original research, we selected three passages to guide our reflection:

> ***D4:155*** *In this regard, for believing that Mathematical Modeling can significantly contribute to teaching and learning in Rural Education as an important teaching tool/strategy within this field of knowledge, I dedicated myself to investigating the advantages of articulating Rural Education and Mathematics Education through Modeling.*
>
> ***A8:10*** *By taking into consideration students' everyday life in mangrove areas, it is believed that Mathematical Modeling can foster their motivation, encouraging them to investigate particular themes drawn from their daily lives.*

D9:65 *One of the possibilities I identified for valuing the knowledge brought by rural subjects was the development of MM activities. Engaging in these activities supports the understanding of the sociocultural role of mathematics, and this is directly connected to the interest in educating individuals to participate actively in society and to become capable of analyzing how mathematics is used in social debates.*

According to Magnus (2018), the emergence of the Modeling perspective in the Brazilian context is related to teachers' concerns regarding teaching and student learning. In this regard, the objective was to facilitate Mathematics teaching by "modeling" everyday situations, given the recognition of the potential of this type of activity in terms of motivation, interest and learning. This acknowledgment is also present in the analyzed texts: several authors who examined Modeling in Rural Education recognized that grounding their educational activities in this approach could be meaningful for rural students' learning and engagement, that is, this methodology constitutes a potentiality within this teaching modality.

In excerpt A8:10, it is possible to observe that the author understands Modeling as a methodology capable of fostering student motivation by encouraging them to investigate everyday life. According to Malheiros (2012, p. 5, our translation), Modeling can stimulate "[…] students' engagement with Mathematics by relating it to facts in their everyday lives or, more incisively, to the everyday needs of their communities". In light of this, the reasons that guided the choice of Modeling, in this case, were "the contributions it may offer" in terms of student engagement. The same aspect can be observed in excerpt D4:155, in which the investigation was justified by the assumption that Modeling can "significantly contribute to teaching and learning in Rural Education", underscoring an interest in clarifying the "advantages" of employing this methodological approach in the classroom. Similar notions guide other studies analyzed.

In all cases, the authors focused on what Modeling can offer to the teaching and learning process in rural schools, that is, on its "potentialities". According to Forner (2018, p. 23, our translation), Modeling is one of the "approaches capable of challenging the current educational model by proposing actions that intervene in students' context" and, therefore, it is understandable that educators attentive to the pedagogical principles of RE justify their choice of Modeling based on the

aforementioned potentialities.

It is worth noting that, in some of the analyzed papers, this is not the only motivation that leads to the development of practices or studies on Modeling in RE. Nevertheless, it is a motivation imbued with relevant meanings because by justifying their choices based on the potentialities of Modeling, the authors acknowledge it as an important tool within this teaching modality. Thus, it can contribute to (re)thinking pedagogical practices and educational activities that are more closely aligned with the principles of Rural Education, whether in relation to education by area of knowledge (D4:155), to the connection with everyday life (A8:10) or to the valuing of knowledge (D9:65), for example.

The second Unit of Record of category C1 (U2) compiles studies in which authors' motivations stem from educators' desire to modify their own practices, from concerns about how teaching and learning are conducted in Rural Education and/or from the desire to "transform themselves". Among the analyzed studies, eight presented justifications that fit this subcategory. For the purposes of analysis, we selected two excerpts that clearly reveal teachers' concerns and their desire for change and allow for an exploration of the meanings attributed to these perceptions. The remaining excerpts can be consulted in the thesis.

> ***A15:10*** *As a professor in the Rural Education undergraduate program, certain concerns emerged and led me to reflect on the particularities of the countryside. That is, how could individuals who live in rural areas recognize themselves in Mathematics classes and activities? How could these individuals and voices gain visibility? How could Mathematics contribute to the diversity in rural areas? How could Mathematical Modeling contribute to these discussions? These problematizations guide me in organizing, planning and implementing my classes.*
>
> ***D5:106*** *At the end of 2016, while analyzing the positive results obtained from pedagogical practices developed through research projects, I felt motivated to pursue new methodological possibilities to be incorporated into my teaching practice.*

In the first case (A15:10), we have the account of a teacher educator in a Rural Education undergraduate program who took action by questioning her own teaching practice and reflecting on how she could give visibility to the mathematical knowledge

of rural subjects'. The "concerns" mentioned by the educator guide her working practice and reveal her desire to promote a form of education aligned with the premises of RE. These reflections fostered a "pedagogical renewal", as discussed by Munarim (2008), arising from challenging traditional practices that do not align with the principles of rural schools and their subjects, and aiming to promote a contextualized and emancipatory education for rural populations. Thus, by selecting Modeling as a means of transforming her educational actions and aligning them with the principles of RE, the educator promoted a "renewal" in her way of thinking about and conceiving teaching.

In the second case (D5:10), the researcher reports having had different educational experiences, which were positive and, in our view, encouraged reflection on her own practice, leading her to feel "motivated" to pursue new methodological alternatives. These two cases reveal that the educators problematized and reflected on their pedagogical practice, demonstrating a concern with improving their planning and actions, as well as with "improving themselves", in order to promote more efficient Mathematics teaching and learning, whether in teacher education or in basic education.

According to Micheletto and Levandovski (2008, p. 7, our translation), engaging in reflection and self-reflection generates an emancipatory form of rationality, which "strengthens the educational process in its purpose of contributing to education and autonomy". In this context, and considering the specificities of RE, reflection and self-reflection prove to be particularly relevant, as they support educators in guiding and adjusting their planning and actions in line with the social struggles and ways of life of rural populations, thereby fostering the process of human and social emancipation.

Drawing on the writings of Paulo Freire (1996), we emphasize his reflections on the importance of teachers recognizing themselves as educators and, consequently, assuming their social responsibility in processes of transformation and liberation. When aware of their social role, educators are able to promote a liberating education through the act of educating, making their educational *praxis* a tool for challenging the so-called Banking Education.

> [...] the practice of critical teaching, implicit in a correct way of thinking, involves a dynamic and dialectical movement between "doing" and "reflecting on doing". […] All that is necessary is that, through reflection on a given practice, ingenuous curiosity perceive itself as such so as to advance to the critical stage. […] (Freire, 1996, p. 38).

In this regard, by "having concerns" and "reflecting" on strategies, methodologies and their own practice, we observe teachers' engagement and movement towards transformation – a type of transformation that takes Modeling as its pathway. By adopting Modeling as a possibility and as a response to their concerns, teachers acknowledge that it enables them to "make things different", attributing greater meaning to their pedagogical practice and to the process of knowledge construction within the scope of RE. Therefore, Modeling is a pathway that emerges as a "response" to these concerns.

The third Unit of Record (U3) contains excerpts that characterize studies focused on making teaching and student learning more meaningful. In this case, unlike what was previously presented, by applying Modeling in RE, educators/researchers express their desire to contribute to learning, placing students as the central motivation for their choice. Among the analyzed productions, five presented justifications that fit this subcategory. The excerpts that compose this Unit of Record can be consulted in full in the thesis. For the purposes of this article, two excerpts are presented as follows.

D2:31 *Therefore, teaching students how to build a water-source protection is a way of contributing to the population's quality of life while, at the same time, presenting content to students within each discipline in a dynamic and meaningful way.*

D1:56 *[...] I observed the opportunity to contribute to studies and agency by exploring mathematical knowledge grounded in Rural Education, organizing content according to students' interests, leading to a form of learning that connects academic knowledge to their local reality.*

Reading excerpts D2:31 and D1:56 leads us to understand that the educators/researchers also engaged in a reflective process regarding their own practice, but with a distinct sensitivity. In this case, what motivated them to modify their teaching practices and explore Modeling in RE was the interest in providing students with a more "dynamic and meaningful" form of teaching, aligned with their "desires" and grounded in "local knowledge".

The act of rethinking the educational process based on the observation of students – while considering their needs, expectations and interests – draws on the Freirean perspective of education, according to which the planning of pedagogical

activities must take into account the subjects of learning and their demands. Freire (1996) argues that the act of teaching must be articulated with students' specificities and social context, thus fostering a critical and emancipatory form of education. By engaging with topics rooted in their everyday lives, students become capable of reflecting on and intervening in their own reality, gaining protagonism in their learning and formulating their own interpretations, which may lead them to plan and participate in actions aimed at transforming society (Freire, 1996).

In this regard, according to Gomes and Guerra (2020, p. 7, our translation), "the teacher, who is also a learner, plays a fundamental role in encouraging student autonomy, considering the diversity of knowledge they hold based on personal experiences". In light of this, the analysis of this Unit of Record demonstrates that part of the motivation driving educators to employ Modeling in RE is linked to the desire to enhance teaching quality, thus attributing meaning to Mathematics learning. This perspective is in line with the educational proposal of RE and underscores Modeling as an alternative for conceiving teaching and learning based on the student, while considering both their cognitive and sociopolitical-cultural development.

The excerpts that compose the fourth Unit of Record (U4) group texts that present Modeling as a "possibility for contextualizing content", grounding their motivation in this aspect. Among the analyzed texts, seven offered justifications that fit this subcategory. For the purposes of this analysis, we selected the following excerpts:

D7:42 *I was a student in this type of environment for several years, so I soon learned the importance of contextualization for the development of learning.*

D7:44 *In this regard, my research focuses on Rural Education, which has always been part of my life. Moreover, the aim of this study is to support educators in the process of contextualization and teaching, and to engage with a reality that has been scarcely explored in academic research.*

A10:26 *In rural schools, traditional teaching methods have not significantly impacted student learning or driven change. In light of the reality that permeates rural schools, educators are encouraged to reflect on their teaching practices and adopt pedagogical approaches that involve contextualized activities and investigations, thus enhancing teaching and learning by challenging traditional education.*

The excerpts above express researchers' and educators' concerns with promoting

teaching and learning articulated with reality, so that the educational process becomes meaningful to students. In both cases, the contextualization of teaching is treated as a priority: in the first (D7:42 and D7:44), the author highlights it based on her own perceptions, linked to her student and academic trajectory; in the second (A10:26), it is conceived as a strategy for "challenging traditional education". It is worth noting that, in some texts, the motivation is not exclusively connected to concerns about contextualization, yet this aspect is one of the elements that lead researchers to adopt Modeling, as they recognize in it the possibility of conceiving teaching and learning in articulation with students´ contexts.

As mentioned earlier, grounding the production of knowledge in reality is one of the intrinsic principles of RE. This principle relates to the need to attribute meaning to teaching and learning by valuing rural populations' ways of life and modes of production. According to Freire (1996, p. 30, our translation), it is essential that education take as its starting point "knowledge socially constructed in community practices and discuss with students the rationale behind this knowledge in relation to content teaching". Engaging with the reality of RE enables the reading of productive and cultural processes, strengthens identity and fosters an understanding of the connection between education and production in rural territories.

Thus, teachers' concerns with the contextualization of teaching prove to be particularly relevant, as they express their unease and desire to make learning meaningful based on what rural communities experience in their everyday lives. According to Fernandes, Magnus and Roseira (2023, p. 7, our translation), rural educators play a fundamental role as agents of educational processes in the community, as they serve as "mediators between school and the community". Although the authors emphasize that this mediating role poses challenges to educational practice, we reinforce the need for educators to assume this role and take into consideration the most intrinsic dimensions of communities – their structure, culture, worldviews, and their ways of producing and reproducing existence – when planning teaching and learning.

The firth Unit of Record (U5) brings together productions that address Modeling during teaching practice or in activities focused on professional development, such as

the development of postgraduate research. Among the analyzed studies, eleven presented justifications that fit this subcategory. For example, this phenomenon can be observed in the following excerpts.

D7:44 *For this reason, I sought admission to a graduate program, focusing on my professional development as an educator and aiming to offer my contribution to teaching.*

A18:42 *This study was conducted at a rural school because, at the time of the research, the first author was teaching in projects developed within the school.*

D5:105 *Combining my admission to the graduate program with my desire to contribute to Rural Education and to involve Escola Thomé in a research project focused on the rural context […].*

A12:8 *This study is the result of a dissertation project in which we sought to examine the contribution of Mathematical Modeling to Rural Education in order to connect cultural plurality to mathematical knowledge.*

According to Garcia (2009, p. 9, our translation), teacher professional development is a process grounded in "a permanent attitude of inquiring, formulating questions and searching for solutions". The author argues that these processes can be individual or collective, but never decontextualized or detached from the teacher's workplace – the school –, as this is the space where teaching practice contributes to the development of professional competencies through diverse forms of experiences, both formal and informal.

This permanent reflective attitude suggests that educators are involved in a continuous process of professional development that extends throughout life (Garcia, 2009). This notion is also mentioned by Medeiros and Amorim (2018, p. 580, our translation), who understand "the teacher as an unfinished being in their professional, intellectual and historical dimensions". While focusing on Rural Education, Medeiros and Amorim (2018, p. 583, our translation) stated

> When addressing, more specifically, the professional development of rural educators, we should validate some components that are essential to their development. Among them, we examine educational policies, the reality of rural schools, curricula detached from rural communities, the undervaluing of rural areas as spaces for social development, the constitution of the identity of rural educators and their relation to the communities in which they teach.

Along the same lines, the analysis of the fragments within U5 allows us to understand that, consistent with the intention to pursue professional development, the articulation between Modeling and RE carried out by the authors emerges as a possibility for making teaching practice more closely aligned with the principles advocated by the movement. This can be observed, for example, in items D5:105, A12:8 and D7:44.

The analysis reveals that the connection with rural school drives educators to seek professional development in order to address the specificities of their students. According to Garcia (2009), the school is a space that mediates teacher professional development, as it is the setting where the needs, doubts, uncertainties and motivations of teaching work emerge. In this regard, according to Medeiros and Amorim (2018, p. 591, our translation), as rural educators are social agents, their professional development "is guided towards a project of rural development that is incorporated into the construction of a form of education committed to social transformation".

Considering that a significant number of educators who work in rural areas teach without having received specific training for rural schools (Medeiros & Amorim, 2018), the investigative processes that occur in graduate programs enables them to become familiar with the proposal of Rural Education and reflect on how to implement it in the classroom.

In general, this phenomenon is extremely important for the educational context, but when it comes to RE, it becomes even more prominent. This occurs because most educators who teach in rural schools and in Rural Education programs come from undergraduate programs shaped by traditional teaching, and therefore, they do not know how to integrate the pedagogical principles of RE into Mathematics teaching. This is highlighted, for instance, in studies by Santos (2015) and Silva (2018), who examined the articulation between mathematical content and peasant agricultural and productive activities in the Northeast of Brazil. Both authors state that, although educators recognize the importance of connecting mathematical content to students' reality, they are unable to put this into practice. As a result, classroom activities remain predominantly based on pure Mathematics.

Both Santos (2015) and Silva (2018) relate this difficulty to teacher education,

recognizing that the absence of adequate mathematical education directly shapes how rural school teachers implement teaching in the classroom. Thus, due to insufficient training, many professionals end up disregarding the principles of RE, which leads them to reproduce banking education, even within rural territories. In this context, the permanent attitude of inquiry, questioning and search for solutions that underpins the process of teacher professional development, as explained by Garcia (2009), constitutes an essential step toward connecting teaching practice to the proposal of RE.

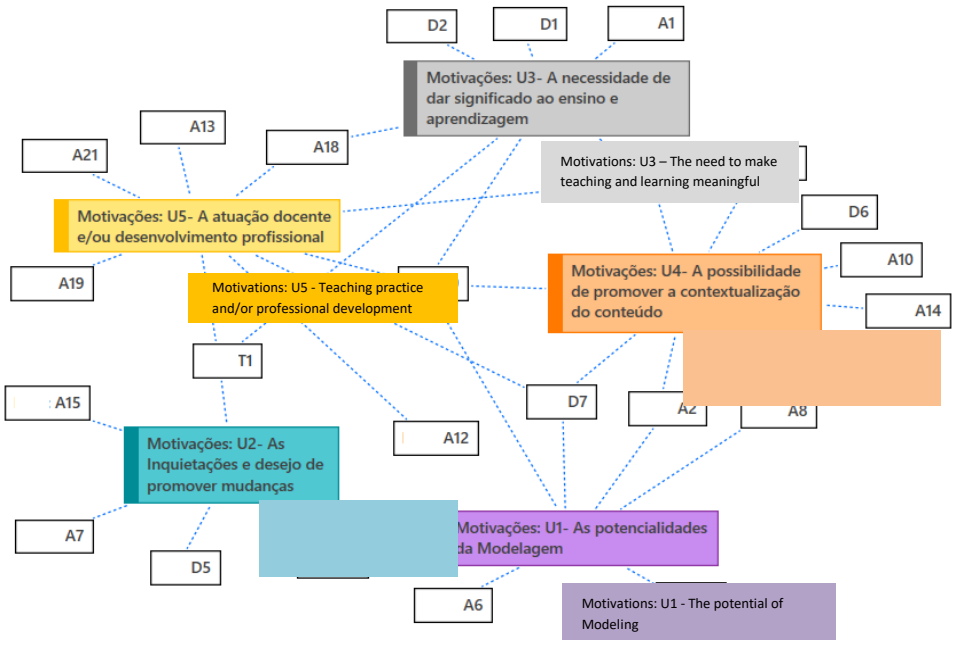
It is worth noting that some studies suggest that the development of Modeling activities occurred as an isolated intervention or discussion, with an emphasis that was partially limited to academic investigation, as in the case of excerpt A18:42. This aspect does not diminish the relevance of the studies in any way. Rather, it leads us to question whether the motivation to investigate or to propose Modeling in RE emerged out of convenience, given that the educator taught at the school, or whether there were other motivations more closely aligned with the objective of enhancing pedagogical practice in the rural school from the perspective of Modeling.

What do these observations reveal?

Based on the description and analysis of the Units of Record that constitute the C1 category, we offered some considerations regarding the "Motivations for proposing/researching Modeling in Rural Education". We created a diagram (Figure 1) in ATLAS.ti that facilitates the visualization of how the category was structured.

Figure 1

Relationship between studies and motivations for proposing and researching Modeling in RE.



The analysis of the excerpts reveals what motivated educators to articulate Modeling and RE, whether in the development of teaching practice or in theoretical studies on the theme. This phenomenon reflects a "teaching movement" in pursuit of strategies that contribute to materializing a form of teaching and learning that is more meaningful for rural students, reinforcing that there is active mobilization in favor of a type of education more closely aligned with the RE proposal.

The motivations expressed by the authors in the selected texts, as illustrated in Figure 1, are interconnected. It is possible to observe that several studies present more than one motivation for proposing or researching Modeling in RE. For instance, most of the studies grouped in U5, which relate to teacher professional development, offer multiple justifications: there is concern with professional enhancement, but there is also a focus on student learning, as in T1, or on the contextualization of Mathematics teaching, as in D7. Similar relationships can be observed in the connections established among the other Units of Record.

In this regard, the teaching movement around Modeling, whose motivations stem from the need to "transform one's own practice" in order to foster more contextualized and engaging teaching and learning, recognizes modeling as a "potentiality", "a possibility for contextualization", which appears to be a promising approach for Rural Education. This teaching movement around Modeling can be understood as an

opportunity for "pedagogical renewal", as suggested by Munarim (2008).

By revisiting the first two lines of the song cited at the beginning of this text, we can establish a connection between the song and the theme under discussion. The lyrics *I want a school of the countryside / That connects with life, with the people* evoke one of the deepest concerns of the Por uma Educação do Campo movement: the construction of a school whose educational project positions rural subjects as protagonists, focuses on their specificities and has an emancipatory and liberating character.

According to Caldart (2010), despite the advances achieved through current Rural Education public policies, the ideal rural school still does not exist; it must be constructed/achieved. Along these lines, building a rural school grounded in the premises of peasant movements depends, in part, on the educators' agency in materializing the principles of RE in the classroom. Therefore, it is essential that educators be "motivated" and "mobilized", especially regarding the "transformation of their own practice" and their conceptions of teaching in schools. Transforming the classroom and the ways of proposing and understanding teaching and learning can be the first step toward the transformation of school.

Conclusion

This article sought to understand and discuss how rural educators began their journey in/with Modeling. Through a literature review of theses, dissertations and articles on the theme, we highlighted teachers' motivations for proposing and implementing Modeling activities in RE and identified the relationships among these motivations and the ways educators view Modeling within this teaching modality.

The motivations described by the authors in the analyzed texts are grounded in five main aspects: (1) The potential of Modeling; (2) Concerns about and the desire to promote change; (3) The need to make teaching and learning meaningful; (4) The possibility of contextualizing content; and (U5) Teaching practice and/or professional development.

The analysis revealed that these motivations are interconnected, demonstrating concerns both with teaching/learning and with how pedagogical practice is carried out in RE educational spaces. Furthermore, it is possible to observe a recognition of the

advantages of Modeling for Rural Education, as most of the studies involve activities within the context of teacher professional development. Despite their different motivations, the studies converge on the idea of fostering a form of teaching and learning more closely aligned with the principles of RE.

Thus, we understand that what leads educators who teach in RE to integrate Modeling into their practices is the desire to "transform" and "transform themselves" by connecting teaching to (some of) the principles of Rural Education. This desire for transformation, combined with the recognition of the potentialities of Modeling, has contributed to the growing presence of this perspective both in schools and in academic research.

In this regard, we are led to consider that the growing movement of teachers who use Modeling gains prominence when these professionals come to perceive themselves as "rural educators", recognizing the principles of RE and strengthening their connection to the For a Rural Education movement.

As a strategy that fosters a contextualized, critical and emancipatory form of Mathematics learning aligned with the principles of RE, Modeling makes it possible to envision new directions for the education of peasant populations. Therefore, it is essential that Modeling be incorporated into the curricula of Rural Education undergraduate programs and that continuing education initiatives in Modeling be implemented, aiming to enable and encourage educators and future educators to provide high-quality Mathematics Education to rural populations.

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