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Development of the Rough Set Method to Determine Lecturer Scholarship Opportunities

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Abstract: Currently, all groups can experience the development of artificial intelligence, this happens because artificial intelligence has experienced very significant changes. Artificial Intelligence (AI) consists of several branches, one of which is machine learning. Machine Learning (ML) technology is a branch of AI that is very interesting because it is a machine that can learn like humans. The method used here is the rough set method. In this research, a case will be raised to determine scholarship opportunities for lecturers based on predetermined criteria. To solve the problem above, machine learning was used using the Rough Set method, using Rosetta software. By the regulations determined by the scholarship provider, in this case, the institution concerned where the lecturer is registered as teaching staff to obtain a scholarship, criteria are needed to determine who will be selected to receive the scholarship. The distribution of scholarships is carried out to improve lecturer performance, as an achievement as well as an appreciation for the lecturer concerned for his long service to the institution.

Keywords: Artificial intelligence; Machine learning; Rough set; Rosetta; Scholarship

Introduction

The development of artificial intelligence is experiencing a very significant increase day by day (Ahmad et al., 2023; Johnson et al., 2022). Likewise, attention is paid to Machine Learning (ML) technology, as we know that machine learning is a branch of AI, where these machines work like humans who can also learn (Xu et al., 2021; Taye, 2023; Dwivedi et al., 2023). Machine learning methods have created an excellent framework for classification problems (Satinet & Fouss, 2022; Sarker, 2021; Li et al., 2022). Lecturers are very important teaching staff in a college because lecturers play many roles in every activity of a college (Keiler, 2018; Kusters et al., 2023). The opportunity to receive scholarships for lecturers is a program at universities as a form of commitment to realizing a quality teaching and learning process that produces reliable teaching staff (Chan, 2023; Kim et al., 2019).

This program can have a big influence on improving the quality of institutional learning and can carry out learning activities that run well (Ong & Quek, 2023; Haleem et al., 2022; Coman et al., 2020). Increasing knowledge by continuing school, at a higher level of education, is one of the obligations of lecturers at a tertiary institution as one of the elements in the tridharma of higher education, namely education and teaching (Riana, 2023).

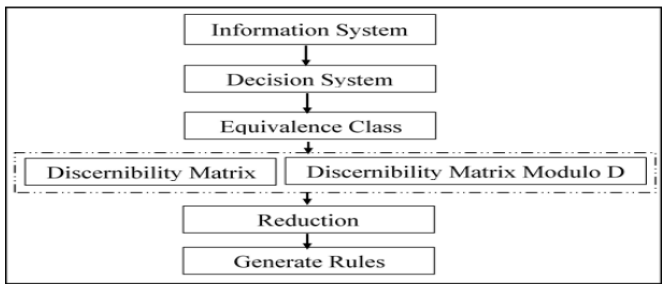

Figure 1. Algorithm for solving the rough set method

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To help realize this in determining the opportunity for a lecturer to get a scholarship, a technique or method is needed, where the method used here is the rough set method. The extension of the rough set model is a very important and broad research direction in rough set theory. Meanwhile, decision-making can be considered a mental process where humans make choices between several alternatives (Savioni et al., 2023; Willekens et al., 2017; Ibneatheer et al., 2023).

Method

The research method carried out is implemented to produce knowledge to obtain scholarship opportunities for lecturers based on the assessment provisions (Păunescu et al., 2022; Hauge, 2021). That have been determined with the stages of the research framework in the form of studying literature, identifying problems, collecting the necessary data, analyzing and carrying out design, testing the Rouht method set, the next implementation stage is testing the method used.

Result and Discussion

To increase the knowledge and mindset of a lecturer, apart from reading and improving their functional position, they also need to study and are advised to take part in a doctoral program. This is also a plan for universities to provide opportunities for their lecturers to take part in doctoral programs. To increase the potential of lecturers in developing human resources so that what is desired can be realized, of course, several things are needed regarding the opportunities that will be given to lecturers in the tertiary environment (Fadilah et al., 2022; Getie, 2020). This program not only benefits lecturers but also concerns the future of a university, to increase public trust, because many lecturers hold doctoral degrees at these institutions or universities. Based on the above, the problem that will be discussed here is how a lecturer can get a scholarship from a university, namely the place where they dedicate themselves (Compagnucci & Spigarelli, 2020).

To solve the problem above, machine learning was used with the Rough Set method and the software used was Rosetta. This research raises a case to find the best results based on the conditions that have been set. The data required are group data (rank), lecturer loyalty, and length of service. This method will produce lecturers who are entitled to receive scholarships by existing and predetermined agreements.

Data Mining

Data mining is a field that makes full use of what is produced by a data warehouse, along with fields that deal with reporting and data management issues. Meanwhile, the data warehouse itself is tasked with querying data from raw databases to provide data results that will later be used by fields that handle management, reporting, and data mining. Inventory is closely related to company operations, both companies operating in trade and industry. Inventory handling that is not carried out properly will result in the risk of disrupting the production process or not fulfilling seven purchasing orders and the consequences can be detrimental to the company (Huang et al., 2023; Gurtu & Johny, 2021).

Rough Set

The Rough Set Method is a method of mathematical tools for dealing with clarity and uncertainty that is introduced to process uncertainty and imprecise information (Yu et al., 2019; Lin et al., 2023). This method can produce new information in the form of rule patterns that are used as a reference for selection assistance, so it is very helpful for the selection team in making decisions that are right on target (Rashid et al., 2019; Abubakar et al., 2019). The following image shows the algorithm for solving the Rough Set method.

The data required is intended as a requirement to obtain scholarship opportunities for lecturers. The data consists of Groups (Rank), where the groups or ranks taken as samples are those who have the functional position of expert assistant, lecturer with a minimum of 200, and lecturer with a minimum of 300. Loyalty, which needs to be considered here is very active, active, and less active. Work Period, where work period as a criterion is taken with a work period of less than 7 years, less than 9 years, and more than 10 years. Meanwhile, the desired decision is to get a scholarship opportunity. This data is used to determine condition attributes and decision attributes. The condition attributes of this problem are class, loyalty, and length of service, while the decision attribute is scholarship opportunities (Sellars et al., 2018; Seo et al., 2020). The goal resulting from this problem is to help universities provide scholarship opportunities to lecturers, applying one of the AI techniques using the Rough Set method, and generating knowledge from scholarship opportunity data sesuai (Michel-Villarreal et al., 2023).

Data Analysis Results

The Rough Set process is carried out by preparing data in the form of a decision system (Kristanto et al., 2021; Janusz et al., 2015). The following data is used as condition attributes and decision attributes. Class, loyalty, and length of service are condition attributes, while scholarship opportunities are decision attributes (Ishii et al., 2022; Lutfi & Aris, 2012).

Table 1. Decision System

	Group	Loyalty	Years of service	Scholarship_Opportunities
E1	Expert Assistant	Active	Less than 7 years	Not accepted
E2	Expert Assistant	Very active	Less than 9 years	Not accepted
E3	Lector200	Very active	Less than 7 years	Recommended Manage Jabfung
E4	Lector200	Active	Less than 9 years	Recommended Manage Jabfung
E5	Lector300	Active	Less than 9 years	Considered
E6	Lector300	Very active	Less than 9 years	Considered
E7	Expert Assistant	Active	Over 10 years	Not accepted
E8	Lector300	Active	Less than 7 years	Considered
E9	Lector200	Very active	Less than 7 years	Recommended Manage Jabfung
E10	Lector300	Very active	Less than 9 years	Considered
E11	Lector300	Active	Over 10 years	Accepted
E12	Expert Assistant	Less Active	Less than 7 years	Not accepted
E13	Expert Assistant	Active	Less than 9 years	Not accepted
E14	Lector300	Active	Less than 9 years	Considered
E15	Lector300	Very active	Less than 7 years	Considered
E16	Lector200	Active	Over 10 years	Recommended Manage Jabfung
E17	Expert Assistant	Very active	Less than 9 years	Not accepted
E18	Expert Assistant	Less Active	Less than 7 years	Not accepted
E19	Lector200	Less Active	Over 10 years	Recommended Manage Jabfung
E20	Lector300	Active	Less than 7 years	Considered

The decision system is source data that will be processed using Rosetta software.

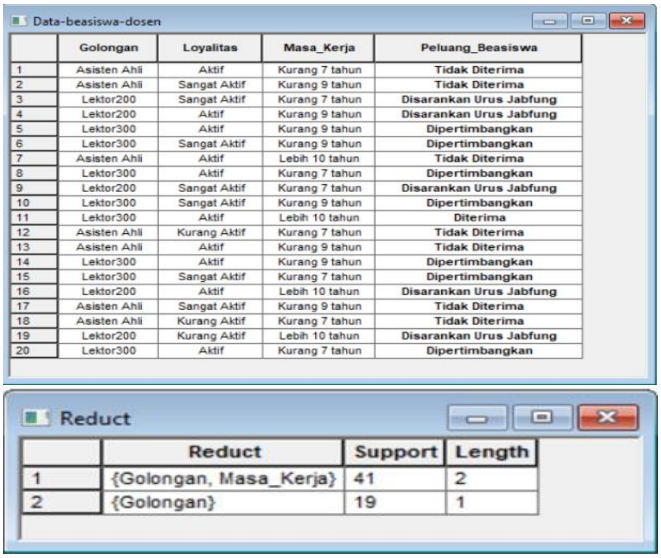

Figure 2. Reduce produced from Rosetta

Next, rules are generated with the results in Figure 3:

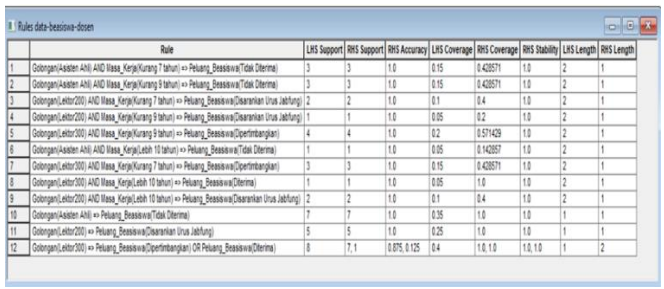

Figure 3. Generated rules

Analysis of Test Results

Prepare data in the form of a decision system

The data is prepared in tabular form consisting of condition attributes and decision attributes. Where the condition attributes are placed in the left column, while the decision attributes are placed in the right column. The following data will be used:

Table 2. The Decision Attributes are Placed in the Right

	Group	Loyalty	Years of service	Scholarship Opportunities
E1	Expert Assistant	Active	Less than 7 years	Not accepted
E2	Expert Assistant	Very active	Less than 9 years	Not accepted
E3	Lecturer 200	Very active	Less than 7 years	Recommended Manage Jabfung
E4	Lecturer 200	Active	Less than 9 years	Recommended Manage Jabfung
E5	Lecturer 300	Active	Less than 9 years	Considered
E6	Lecturer 300	Very active	Less than 9 years	Considered
E7	Expert Assistant	Active	Over 10 years	Not accepted
E8	Lecturer 300	Active	Less than 7 years	Considered
E9	Lecturer 200	Very active	Less than 7 years	Recommended Manage Jabfung
E10	Lecturer 300	Very active	Less than 9 years	Considered
E11	Lecturer 300	Active	Over 10 years	Accepted

	Group	Loyalty	Years of service	Scholarship Opportunities
E12	Expert Assistant	Less Active	Less than 7 years	Not accepted
E13	Expert Assistant	Active	Less than 9 years	Not accepted
E14	Lecturer 300	Active	Less than 9 years	Considered
E15	Lecturer 300	Very active	Less than 7 years	Considered
E16	Lecturer 200	Active	Over 10 years	Recommended Manage Jabfung
E17	Expert Assistant	Very active	Less than 9 years	Not accepted
E18	Expert Assistant	Less Active	Less than 7 years	Not accepted
E19	Lecturer 200	Less Active	Over 10 years	Recommended Manage Jabfung
E20	Lecturer 300	Active	Less than 7 years	Considered

Forming an Equivalence Class

By grouping objects that have the same condition attribute values:

Table 3. 14 Data that have the Same Condition Attributes

Equivalence Class	Group (A)	Loyalty (B)	WorkTime (C)	Scholarship Opportunities
EC1	Expert Assistant	Active	Less than 7 years	Not accepted
EC2	Expert Assistant	Very active	Less than 9 years	Not accepted
EC3	Expert Assistant	Active	Over 10 years	Not accepted
EC4	Expert Assistant	Less Active	Less than 7 years	Not accepted
EC5	Expert Assistant	Active	Less than 9 years	Not accepted
EC6	Lecturer 200	Very active	Less than 7 years	Recommended Manage Jabfung
EC7	Lecturer 200	Active	Less than 9 years	Recommended Manage Jabfung
EC8	Lecturer 200	Active	Over 10 years	Recommended Manage Jabfung
EC9	Lecturer 200	Less Active	Over 10 years	Recommended Manage Jabfung
EC10	Lecturer 300	Active	Less than 9 years	Considered
EC11	Lecturer 300	Very active	Less than 9 years	Considered
EC12	Lecturer 300	Active	Less than 7 years	Considered
EC13	Lecturer 300	Active	Over 10 years	Accepted
EC14	Lecturer 300	Very active	Less than 7 years	Considered

Forming a Discernibility Matrix

The steps taken here are that the columns in the matrix are filled with a set of condition attributes that have different condition values. In this case, the discernibility matrix is obtained as follows:

Table 4. Matrix Filled with a Set of Condition Attributes that have Different Condition Values

	EC1	EC2	EC3	EC4	EC5	EC6	EC7	EC8	EC9	EC10	EC11	EC12	EC13	EC14
EC1	X	BC	C	B	C	AB	AC	AC	ABC	AC	ABC	A	AC	AB
EC2	BC	X	BC	BC	B	AB	AB	ABC	ABC	AB	A	ABC	ABC	AC
EC3	C	BC	X	BC	C	ABC	AC	A	AB	AC	ABC	AC	A	ABC
EC4	B	BC	BC	X	BC	AB	ABC	ABC	AC	ABC	ABC	AB	ABC	AB
EC5	C	B	C	BC	X	ABC	A	AC	ABC	A	AB	AC	AC	ABC
EC6	AB	AB	ABC	AB	ABC	X	BC	BC	BC	ABC	AC	AB	ABC	A
EC7	AC	AB	AC	ABC	A	BC	X	C	BC	A	AB	AC	AC	ABC
EC8	AC	ABC	A	ABC	AC	BC	C	X	B	AC	ABC	AC	A	ABC
EC9	ABC	ABC	AB	AC	ABC	BC	BC	B	X	ABC	ABC	ABC	AB	ABC
EC10	AC	AB	AC	ABC	A	ABC	A	AC	ABC	X	B	C	C	BC
EC11	ABC	A	ABC	ABC	AB	AC	AB	ABC	ABC	B	X	BC	BC	C
EC12	A	ABC	AC	AB	AC	AB	AC	AC	ABC	C	BC	X	C	B
EC13	AC	ABC	A	ABC	AC	ABC	AC	A	AB	C	BC	C	X	BC
EC14	AB	AC	ABC	AB	ABC	A	ABC	ABC	ABC	BC	C	B	BC	X

Matrix Discernibility Modulo D

What is done in the discernibility modulo D matrix is that the columns in the matrix are filled with a set of condition attributes that have different condition values and also different decision values. This means that if we find different condition attributes but the same decision attributes, then the column is written X (cross) (Ideno et al., 2020). For the discernibility matrix modulo D, it can be seen in the following table:

Table 5. Matrix Discernibility Modulo D

	EC1	EC2	EC3	EC4	EC5	EC6	EC7	EC8	EC9	EC10	EC11	EC12	EC13	EC14
EC1	X	BC	C	B	C	AB	AC	AC	ABC	AC	ABC	A	AC	AB
EC2	BC	X	X	X	X	AB	AB	ABC	ABC	AB	A	ABC	ABC	AC
EC3	C	X	X	X	X	ABC	AC	A	AB	AC	ABC	AC	A	ABC
EC4	B	X	X	X	X	AB	ABC	ABC	AC	ABC	ABC	AB	ABC	AB
EC5	C	X	X	X	X	ABC	A	AC	ABC	A	AB	AC	AC	ABC
EC6	AB	AB	ABC	AB	ABC	X	X	X	X	ABC	AC	AB	ABC	A
EC7	AC	AB	AC	ABC	A	X	X	X	X	A	AB	AC	AC	ABC
EC8	AC	ABC	A	ABC	AC	X	X	X	X	AC	ABC	AC	A	ABC
EC9	ABC	ABC	AB	AC	ABC	X	X	X	X	ABC	ABC	ABC	AB	ABC
EC10	AC	AB	AC	ABC	A	ABC	A	AC	ABC	X	X	X	C	X
EC11	ABC	A	ABC	ABC	AB	AC	AB	ABC	ABC	X	X	X	BC	X
EC12	A	ABC	AC	AB	AC	AB	AC	AC	ABC	X	X	X	C	X
EC13	AC	ABC	A	ABC	AC	ABC	AC	A	AB	C	BC	C	X	BC
EC14	AB	AC	ABC	AB	ABC	A	ABC	ABC	ABC	X	X	X	BC	X

Reduction Process

Next, a reduction process is carried out to select condition attributes that will be used to generate knowledge by creating Boolean algebra equations (Rathore, 2014; Maharana et al., 2022). Where the reduct that is produced when repeated is taken only one of them. The blue text is what will be removed due to repetition, and will then be included in the following table 7.

Table 6. Reduction Process to Select Attributes

	EC1	EC2	EC3	EC4	EC5	EC6	EC7	EC8	EC9	EC10	EC11	EC12	EC13	EC14
EC1	X	BC	C	**B**	**C**	AB	AC	**AC**	ABC	**AC**	**ABC**	A	**AC**	**AB**
EC2	BC	X	X	X	X	AB	**AB**	ABC	**ABC**	**AB**	A	**ABC**	**ABC**	AC
EC3	C	X	X	X	X	ABC	AC	A	AB	**AC**	**ABC**	**AC**	**A**	**ABC**
EC4	B	X	X	X	X	AB	ABC	**ABC**	AC	**ABC**	**ABC**	**AB**	**ABC**	**AB**
EC5	C	X	X	X	X	ABC	A	AC	**ABC**	**A**	AB	**AC**	**AC**	**ABC**
EC6	AB	**AB**	ABC	**AB**	**ABC**	X	X	X	X	**ABC**	AC	**AB**	**ABC**	A
EC7	AC	AB	**AC**	ABC	A	X	X	X	X	**A**	**AB**	**AC**	**AC**	**ABC**
EC8	AC	ABC	A	**ABC**	**AC**	X	X	X	X	**AC**	**ABC**	**AC**	**A**	**ABC**
EC9	ABC	**ABC**	AB	AC	**ABC**	X	X	X	X	**ABC**	**ABC**	**ABC**	**AB**	**ABC**
EC10	AC	AB	**AC**	ABC	A	**ABC**	**A**	**AC**	**ABC**	X	X	X	C	X
EC11	ABC	A	**ABC**	**ABC**	AB	AC	**AB**	**ABC**	**ABC**	X	X	X	BC	X
EC12	A	ABC	AC	AB	**AC**	**AB**	**AC**	**AC**	**ABC**	X	X	X	**C**	X
EC13	AC	ABC	A	**ABC**	**AC**	**ABC**	**AC**	**A**	AB	C	BC	**C**	X	**BC**
EC14	AB	AC	ABC	**AB**	**ABC**	A	**ABC**	**ABC**	**ABC**	X	X	X	**BC**	X

Table 7. Reduce Produced

Class	Boolean Algebra	Result	Reduct
E1	(BVC)^C^(AVB)^(AVC)^(AVBVC)^A	CA	{CA}
E2	(BVC)^(AVB)^(AVBVC)^A^(AVC)	CA + BA	{CA}, {BA}
E3	C^(AVBVC)^(AVC)^A^(AVB)	CA	{CA}
E4	B^(AVB)^(AVBVC)^(AVC)	BC + BA	{BC}, {BA}
E5	C^(AVBVC)^A^(AVC)^(AVB)	CA	{CA}
E6	(AVB)^(AVBVC)^(AVC)^A	A	A
E7	(AVC)^(AVB)^(AVBVC)^A	A	A
E8	(AVC)^(AVBVC)^A	A	A
E9	(AVBVC)^(AVB)^(AVC)	A + BC	{A}, {BC}
E10	(AVC)^(AVB)^(AVBVC)^A^C	AC	{AC}
E11	(AVBVC)^A^(AVB)^(AVC)^(BVC)	AC + AB	{AC}, {AB}
E12	A^(AVBVC)^(AVC)^(AVB)	A	A
E13	(AVC)^(AVBVC)^A^(AVB)^C^(BVC)	AC	{AC}
E14	(AVB)^(AVC)^(AVBVC)^A	A	A

The resulting reduct: {A, C} = {Group, Working hours}, {A}= { Group }. The reduction process to obtain the reduct is carried out using Boolean algebra:

E1 = (BVC)^C^(AVB)^(AVC)^(AVBVC)^A
= (B+C) *C*(A+B) *(A+C) *(A+B+C) *A
= CA
E2 = (BVC)^(AVB)^(AVBVC)^A^(AVC)
= (B+C) *(A+B) *(A+B+C) *A*(A+C)
= CA + BA
E3 = C^(AVBVC)^(AVC)^A^(AVB)
= C*(A+B+C) *(A+C) *A*(A+B)
= CA
E4 = B^(AVB)^(AVBVC)^(AVC)
= B*(A+B) *(A+B+C) *(A+C)
= BC + BA
E5 = C^(AVBVC)^A^(AVC)^(AVB)
= C*(A+B+C) *A*(A+C) *(A+B)
= CA
E6 = (AVB)^(AVBVC)^(AVC)^A
= (A+B) *(A+B+C) *(A+C) *A
= A
E7 = (AVC)^(AVB)^(AVBVC)^A
= (A+C) *(A+B) *(A+B+C) *A
= A
E8 = (AVC)^(AVBVC)^A
= (A+C) *(A+B+C) *A
= A
E9 = (AVBVC)^(AVB)^(AVC)
= (A+B+C) *(A+B) *(A+C)
= A + BC
E10 = (AVC)^(AVB)^(AVBVC)^A^C
= (A+C) *(A+B) *(A+B+C) *A*C
= AC
E11 = (AVBVC)^A^(AVB)^(AVC)^(BVC)
= (A+B+C) *A*(A+B) *(A+C) *(B+C)
= AC + AB
E12 = A^(AVBVC)^(AVC)^(AVB)
= A*(A+B+C) *(A+C) *(A+B)
= A
E13 = (AVC)^(AVBVC)^A^(AVB)^C^(BVC)
= (A+C) *(A+B+C) *A*(A+B) *C*(B+C)
= AC
E14 = (AVB)^(AVC)^(AVBVC)^A
= (A+B) *(A+C) *(A+B+C) *A
= A

Generating Knowledge (Knowledge)

The reduce results obtained are used to produce knowledge: {A, C} = {Group, Years of work}

If Group = Expert Assistant and working period less than 7 years Then Scholarship Opportunity = Not accepted

If Group = Expert Assistant and working period less than 9 years Then Scholarship Opportunity = Not accepted.

If Group = Lector 200 And the working period is less than 7 years Then Scholarship Opportunity = Recommended to Apply for Jabfung

If Group = Lector 200 And the work period is less than 9 years Then Scholarship Opportunities = Recommended to Manage Jabfung

If Class = Lector 300 And the work period is less than 9 years Then Scholarship Opportunity = Considered

If Group = Expert Assistant And the work period is more than 10 years Then Scholarship Opportunity = Not accepted.

If Class = Lector 300 And the work period is less than 7 years Then Scholarship Opportunity = Considered

If Group = Lector 300 And the work period is more than 10 years Then Scholarship Opportunity = Accepted

If Group = Lector 200 And the work period is more than 10 years Then Scholarship Opportunities = Recommended to Apply for Jabfung

{A} = {Group}

If Class = Expert Assistant Then Scholarship Opportunity = Not accepted.

If Group = Lector 200 Then Scholarship Opportunities = Recommended to Manage Jabfung

If Class= Lector300 Then Scholarship Opportunity = Considered or Scholarship Opportunity = Accepted

Conclusion

By using the roughest method, in determining scholarship opportunities, it can be concluded that the scholarship opportunity prediction system using the roughset method can be used in higher education. This method will make it easier to provide an overview of the opportunities for getting scholarships for lecturers based on test results using Rosetta software, the results of predicting scholarship opportunities produce knowledge, and predictions are taken from scholarship opportunities, which are decision attributes in rough set method calculations.

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Author Contributions

Conceptualization, S., and S. D., methodology, S.; validation, S. D.; formal analysis, S.; investigation, S. D.; resources, S. and. S. D.; data curation, S: writing—original draft preparation, S. D. and S.; writing—review and editing, S. D.: visualization, S. and S. D. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest
The authors declare no conflict of interest.

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