HIGHER EDUCATION AND STUDENT SATISFACTION: A FSQCA-BASED CAUSAL ANALYSIS IN MOZAMBIQUE

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ABSTRACT: Student performance in the teaching-learning process is shaped by a variety of contextual factors, including teaching methodology, access to technological resources, student support services, infrastructure and sanitation, and faculty engagement. This study examines student satisfaction levels at Licungo University (UL) in Mozambique, with a particular focus on students from the Zambézia province. Data were collected from 244 students enrolled in 10 undergraduate programs within the Faculty of Education, using a 20-item Likert-scale questionnaire (rated from 1 to 10), grouped into five analytical dimensions. Applying the fuzzy-set Qualitative Comparative Analysis (fsQCA) and Ragin's calibration method, three causal configurations were identified as leading to high student satisfaction: (1) satisfaction with teaching methodology and technological resources, (2) the presence of quality infrastructure combined with effective instruction, and (3) strong academic support even in contexts with poor infrastructure. All configurations showed high consistency (>0.98), underscoring the interplay between pedagogical, technological, and structural dimensions. Conversely, dissatisfaction was associated with the convergence of low-quality indicators across several dimensions, with limited faculty engagement emerging as a recurring factor across all analyzed programs.

RESUMEN: El rendimiento estudiantil en el proceso de enseñanza-aprendizaje no depende únicamente del esfuerzo individual del alumno, sino que está profundamente influenciado por múltiples factores del entorno académico. Entre ellos se destacan la metodología de enseñanza, el acceso y uso de recursos tecnológicos, el apoyo institucional y los servicios ofrecidos al estudiante, la calidad de la infraestructura y del saneamiento, así como el compromiso del cuerpo docente. Este estudio se centra en analizar los niveles de satisfacción estudiantil en la Universidad Licungo (UL), en Mozambique, con especial atención a los estudiantes de la provincia de Zambézia. Para ello, se aplicó un cuestionario

tipo Likert de 20 ítems (valorados de 1 a 10) a una muestra de 244 estudiantes pertenecientes a 10 carreras de la Facultad de Educación. Las respuestas se organizaron en cinco dimensiones analíticas. Utilizando el enfoque de Conjuntos Difusos (fsQCA) y el método de calibración de Ragin, se identificaron tres configuraciones causales que explican altos niveles de satisfacción: (1) satisfacción conjunta con la metodología de enseñanza y los recursos tecnológicos; (2) disponibilidad de infraestructura de calidad combinada con una enseñanza efectiva; y (3) existencia de un sólido sistema de apoyo académico, incluso en contextos de infraestructura deficiente. Todas las soluciones presentaron una alta consistencia (>0,98), lo que refuerza la idea de que la satisfacción estudiantil emerge de la interacción entre factores pedagógicos, tecnológicos y estructurales. Por otro lado, los bajos niveles de satisfacción se relacionaron con la combinación de deficiencias en varias dimensiones, siendo el escaso compromiso docente un elemento recurrente en todos los cursos analizados.

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Palabras clave: Satisfacción estudiantil, fsQCA, Calidad pedagógica, Recursos tecnológicos.

1. Introduction

Education is the fundamental foundation for the development of any nation. The progress of a country essentially begins with the ability of its government to provide better educational conditions for its citizens. Governments around the world have demonstrated a continuous concern to prioritize education, with the main goal of empowering their human resources with excellence in knowledge and high productivity. In this context, educational institutions play a vital role in training graduates not only in quantitative terms but also qualitatively, preparing dynamic, innovative, and proactive individuals who act as catalysts for development. These institutions also contribute to the creation of a qualified workforce capable of meeting different levels of expertise (Yussoff & Nayan, 2020).

There is widespread recognition of the need for schools to adapt to various external and internal factors that influence the development of the educational field. External factors refer to those over which educational institutions have no direct control, while internal factors are under the responsibility and management of the institutions themselves. In this context, student satisfaction becomes a crucial reference in the evaluation of educational service quality. Studies show that student dissatisfaction with their learning experiences is often linked to inadequacies in infrastructure and administrative services, which frequently lack effective standard operating procedures (Aghamolaei & Zare, 2008; Widawati & Siswohadi, 2021; Rizos et al., 2022; De-Juan-Vigaray et al., 2024).

Recognizing that satisfaction results from the contrast between expectations and perceptions, it becomes essential for institutions to implement robust policies to minimize this gap. Student satisfaction is strongly associated with the quality of services offered, including teaching and learning activities, infrastructure, teacher engagement, administrative efficiency, access to technological resources, and academic support (Teeroovengadum et al., 2019; Alsheyadi & Albalushi, 2020; Thanh, 2021). The continuous improvement of these services is not only a differentiating factor but also a structural requirement for ensuring student development.

In light of these considerations, the present study aims to analyze student satisfaction at the Faculty of Education of Licungo University, Mozambique. Specifically, the objectives are to: (1). Evaluate student perceptions across five analytical dimensions of the educational service; (2). Identify conditions that are necessary or sufficient to achieve high levels of satisfaction; (3). Determine the causal configurations that explain both

satisfaction and dissatisfaction using fuzzy-set Qualitative Comparative Analysis (fsQCA).

2. Literature Review

Educational institutions, whether public or private, must constantly improve their services and modernize their facilities to maximize the potential of their users. Educational services include essential activities within the educational system aimed at addressing community needs (Theron & Theron, 2014; Draganchuk, 2020; Paulava et al., 2020; Dinh et al., 2021; Husain et al., 2022). These services incorporate infrastructure and facilities that play a fundamental role in academic operations. Improvement in these areas requires strategies involving the continuous qualification of human resources and enhancement of institutional infrastructure (Siswanto & Hidayati, 2020; Pasaribu et al., 2020; Rohmah et al., 2020; Santika et al., 2021).

The literature consistently shows that students expect educational institutions to provide adequate facilities, resources, and administrative support to ensure effective learning processes. When these conditions are insufficient, dissatisfaction becomes more likely (Aghamolaei & Zare, 2008; Widawati & Siswohadi, 2021; Rizos et al., 2022; De-Juan-Vigaray et al., 2024). Since satisfaction is closely tied to perceived service quality, researchers emphasize the need to understand the multidimensional character of satisfaction and its causal determinants (Teeroovengadum et al., 2019; Alsheyadi & Albalushi, 2020; Thanh, 2021).

Regarding methodologies used in satisfaction studies, both quantitative and qualitative approaches are common (Herdlein & Zurner, 2015; Hui-Min et al., 2021; Luís & Mulema, 2021; Sáiz-Manzanares et al., 2022). Regression analysis is frequently used under additive and compensatory assumptions, which consider satisfaction criteria as independent. However, traditional quantitative approaches often fail to capture the interactions between multiple attributes that jointly influence satisfaction.

Given these limitations, fuzzy-set Qualitative Comparative Analysis (fsQCA) emerges as a suitable alternative. This method relaxes the assumption of additive independence and examines how combinations of conditions lead to specific outcomes. The method focuses on asymmetric causality, acknowledging that the same result (e.g., high satisfaction) may arise from different configurations of conditions (Woodside, 2013). Furthermore, fuzzy-set theory and rule-based systems provide advantages in analyzing interactions between attributes that traditional models may neglect, as highlighted in recent discussions (Krassadaki et al., 2021).

In summary, the literature positions student satisfaction as a multifactorial and complex construct influenced by pedagogical, administrative, infrastructural, and technological conditions. The fsQCA approach is particularly appropriate for studies seeking to identify configurations of factors rather than isolated effects.

3. Methodology

The fsQCA methodology was proposed by Charles Ragin in 1987, based on complexity theory and Boolean algebra. This technique aims to identify the necessary conditions and sufficient causal configurations for the presence or absence of a specific outcome (Shwonaider, 2012; Dom Luís at al., 2025).

The fsQCA method allows for the analysis of how different combinations of causal conditions contribute to the occurrence of a given outcome. Unlike traditional quantitative approaches, such as regression, which assume independence among variables, fsQCA does not rely on an analytical aggregation formula, thus overcoming the limitations of such approaches. Instead, it employs a methodology that considers the interaction among various variables and combinations of these variables to predict the occurrence of the desired outcome.

FsQCA is particularly useful for examining scenarios in which multiple combinations of conditions can lead to the same outcome. For example, a combination of dissatisfaction with infrastructure, delays, and lack of teacher commitment may result in the outcome "low satisfaction with the educational system offered by the institution." Figure 1 illustrates the steps of the methodology.

3.1. *Steps in Applying the fsQCA Method*

The application of fsQCA involves a well-defined sequence of steps, described as follows:

Step 1: Selection of Outcome and Cases – The first step is to choose the desired outcome and the corresponding cases. In the satisfaction survey, each case is represented by a response provided by a student, with the dependent variable being the average of the responses.

Step 2: Selection of Causal Conditions – Next, the causal conditions (independent variables) that may influence the outcome are selected.

Step 3: Data Calibration for the Fuzzy System – The input data (causal conditions and the outcome) are transformed into fuzzy sets using membership functions (MFs). These functions are calibrated through a logistic function that maps variable values to the interval from 0 to 1, allowing the representation of indecision or uncertainty in the cases' responses.

Step 4: Construction and Minimization of the Truth Table – The Truth Table is built to represent all possible combinations of the causal conditions. The table is then minimized to identify the combinations of causal conditions that are necessary and sufficient for the outcome. Minimization can produce three types of solutions: complex, intermediate, and parsimonious.

Step 5: Analysis of Necessary and Sufficient Conditions – fsQCA uses two distinct algorithms: one for identifying sufficient conditions and another for necessary conditions. The resulting "if-then" rules indicate which combinations of causal conditions lead to the desired outcome.
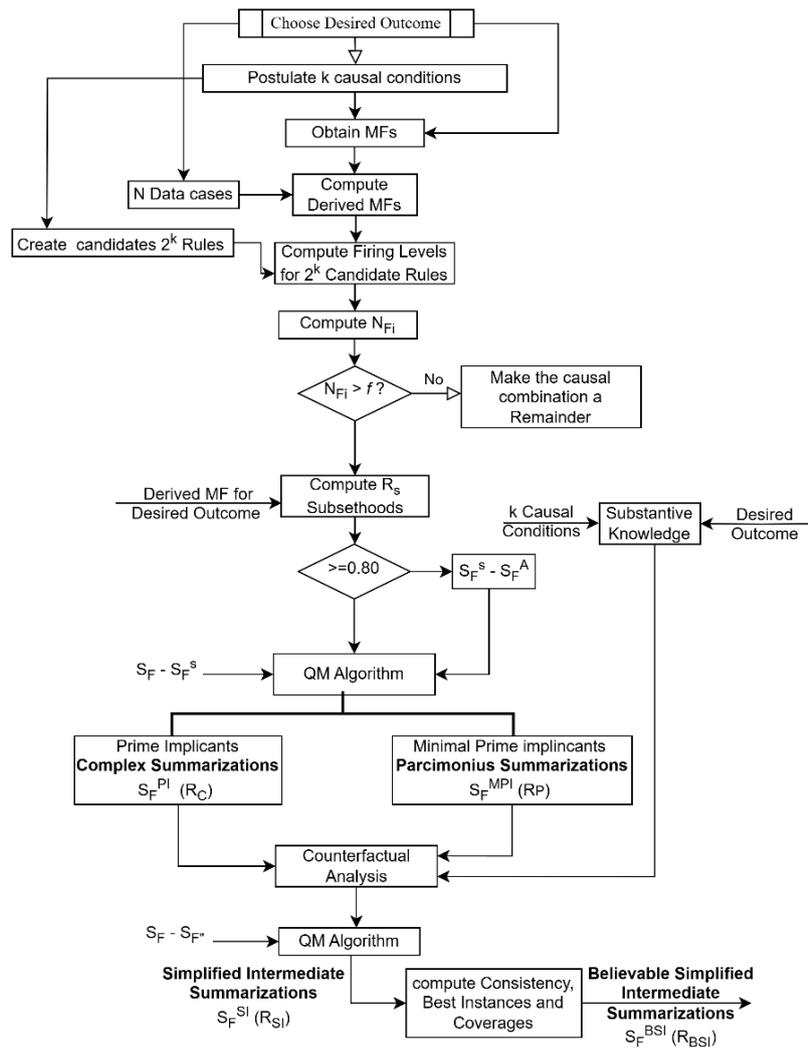
Figure 1: Steps of the methodology

Step 6: Evaluation of Real Causal Combinations – After minimization, the real causal combinations are evaluated, i.e., those that exhibit a consistency greater than or equal to the predefined threshold (usually 0.75). These real causal combinations are the most robust and reliable for explaining the phenomenon under study.

Step 7: Minimization of Causal Combinations and Interpretation of Solutions – The logical minimization of causal combinations aims to eliminate redundancies and simplify the   rules.

Consistency and coverage are two essential indicators for evaluating the quality of solutions generated by fsQCA. Consistency measures the extent to which a causal configuration consistently produces the desired outcome, i.e., the proportion of cases in which the combination of causal conditions leads to the outcome. The formula to calculate consistency is given by:

$$\text{Consistency}(X_i \leq Y_i) = \frac{\sum(\min(X_i, Y_i))}{\sum X_i} \qquad (1)$$

Where satisfactory cases are those in which the combination of causal conditions leads to the observed outcome, and the expected cases are those in which, according to theory or the "if-then" rules, the outcome should occur.

Coverage measures the relevance of the identified solution, that is, the proportion of cases in which the identified causal configuration appears. The formula for coverage is:

$$Coverage\ (X_i \leq Y_i)\ = \frac{\sum(\min(X_i, Y_i))}{\sum Y_i} \qquad (2)$$

Coverage helps us understand how representative the solution is in relation to the total number of observed cases.

These two indicators are essential for evaluating and interpreting the solutions produced by fsQCA, as they allow us to assess both the reliability (consistency) and the relevance (coverage) of the identified solutions.

4. Application of fsQCA in Higher Education Satisfactions

4.1. *Data Collection Instrument*

The main goal of the research was to analyze the causal conditions of the global (dis)satisfaction of students at UniLicungo, considering various factors that influence their academic experience. Specifically, it aimed to assess how students perceive the quality of teaching, available resources, institutional support, and other aspects of the academic environment. This analysis was essential to understand students' perceptions of different components of the educational process in a general sense.

4.2. *Sampling*

To ensure that the sample was representative of the population of future teachers at UniLicungo, stratified sampling was used, with the stratification criterion based on the course. This approach allowed for capturing the diversity of student experiences from different areas of teacher training. The research covered 10 courses from the Faculty of Education, aimed at teacher training. These courses were chosen because they represent a diverse sample of the teaching areas offered by the university, enabling a comparative analysis of different disciplines. The courses analyzed were: English Language Teaching, Geography Teaching, Chemistry Teaching, Biology Teaching, Psychology Teaching, Mathematics Teaching, Physics Teaching, Portuguese Language Teaching, French Language Teaching, and Visual Education Teaching. These courses focus on teacher training in various fields, with the goal of preparing students for basic education. The study aimed to understand how students from different areas of knowledge perceived the quality of teaching and the services provided by the university. A total of 244 students were selected, ensuring that all courses in the Faculty of Education were adequately represented in the study.

4.3. *Analysis of Demographic Characteristics*

Table 1 presents the distribution of the main demographic characteristics of the students from the Faculty of Education programs who participated in the satisfaction study.

77.46% of the sample come from Language (Letras) programs, while 22.54% are from Science programs.

Table 1: Description of the demographic characteristics of the sample members

Variable	Response options	Humanities	Sciences	Total
Gender	Male	104 (42,62%)	31 (12,70%)	135 (55,33%)
	Female	85 (34,84%)	24 (9,84%)	109 (44,67%)
Age	17-23 years	81 (33,20%)	25 (10,25%)	106 (43,44%)
	24-30 years	72 (29,51%)	22 (9,02%)	94 (38,52%)
	31-36 years	38 (15,57%)	0 (0,00%)	38 (15,57%)
	37 years or older	2 (0,82%)	1 (0,41%)	3 (1,23%)
Area of Residence	Urban area	72 (29,51%)	20 (8,20%)	92 (37,70%)
	Peri-urban area	54 (22,13%)	19 (7,79%)	73 (29,92%)
	Suburban area	63 (25,82%)	16 (6,56%)	79 (32,38%)
Year	1st Year	61 (25,00%)	22 (9,'2%)	83 (34,02%)
	2nd Year	41 (16,80%)	21 (8,61%)	62 (25,41%)
	3rd Year	43 (17,62%)	8 (3,28%)	51 (20,90%)
	4th Year	44 (18,03%)	4 (1,64%)	48 (19,67%)
Total		189 (77,46%)	55 (22,54%)	244 (100,00%)

Source: Author's own elaboration

Most participants are male (55.33%), particularly predominant in the Language (Letras) programs. Regarding age, the sample shows a young profile, with 43.44% of students aged between 17 and 23 years. Concerning the area of residence, there is a relatively balanced distribution among students from urban, peri-urban, and suburban areas, with a slight predominance of urban areas (37.70%). Regarding the year of study, the distribution is relatively homogeneous, although there is a slight predominance of first-year students (34.02%).

4.4. *Data Collection Instrument*

Data collection was conducted through an online questionnaire developed on the Google Forms platform, containing 20 closed-ended questions, based on a Likert scale ranging from 1 to 10. This scale allowed participants to express their degree of satisfaction in detail, from 1 (completely dissatisfied) to 10 (completely satisfied). The questionnaire was designed clearly and objectively to capture the overall perception of students regarding the quality of teaching and the services provided by the institution.

The questionnaire was organized into five dimensions, addressing different aspects of the students' academic experience. Each dimension contained specific questions to assess the students' general perception of these key areas of the educational process at the university:

- Dimension 1: Teaching Methodology and Academic Quality (TMAQ) - This dimension sought to understand student satisfaction with the teaching methodologies used by teachers, the quality of the pedagogical content, the appropriateness of the teaching materials, and the effectiveness of the assessment methods applied. The questions were designed to assess whether students felt that

the teaching was of high quality, up-to-date, and if the methodologies were suitable for their formative needs.

- Dimension 2: Accessibility and Technological Resources (ATR) - This dimension evaluated physical accessibility to university facilities (classrooms, libraries, laboratories, etc.) and digital access, including the quality and speed of internet service provided. The questions aimed to determine whether students had the necessary technological resources and infrastructure to effectively follow the course.
- Dimension 3: Student Support and Services (SSS) - Focused on student satisfaction with institutional support offered by the university, such as academic assistance, pedagogical guidance, library services, and psychological support. The questions aimed to assess whether students felt supported by the institution in facing academic and personal challenges during their training.
- Dimension 4: Infrastructure and Sanitation (IS) - Analyzed the quality of physical facilities at the university, including the cleanliness and maintenance of spaces such as classrooms, bathrooms, lounges, and other academic areas. The questions evaluated whether students were satisfied with the comfort, security, and hygiene of university facilities, factors that directly contribute to the learning environment.
- Dimension 5: Punctuality and Commitment of Teachers (TPC) - This dimension focused on the punctuality of teachers and their commitment to fulfilling academic activities. The questions aimed to assess students' perceptions regarding the responsibility of teachers, whether they adhered to schedules, and whether they provided quality education that met students' needs and expectations.

4.5. *Reliability Test*

Before proceeding with a detailed data analysis, the reliability of the data collection instrument was verified. Reliability refers to the ability of the questionnaire to produce consistent and stable results in repeated applications (De Franco & Josefina, 2009). For this purpose, the Cronbach's Alpha coefficient was calculated, which is widely recommended in the literature to assess the internal consistency of instruments composed of Likert-type scales. Table 2 presents the values obtained for each of the five dimensions of the questionnaire.

The results show that all Cronbach's Alpha values are above 0.85, indicating acceptable levels of reliability according to the criteria established by Ruiz Bolívar (2002) and Palella & Martins (2003). These results confirm the suitability of the instrument for the current investigation.

Table 2 – Questionnaire Reliability Report

Construct Description	No. of Items	Cronbach's Alpha
Teaching Methodology and Academic Quality	4	0.868
Accessibility and Technological Resources	4	0.930
Student Support and Services	4	0.917
Infrastructure and Sanitation	4	0.956
Punctuality and Commitment of Teachers	4	0.853

Source: Author's own elaboration

After reliability test, the results were organized by course, and the average satisfaction scores for each dimension were calculated (see Table 3). This process allowed for a detailed analysis of the perceptions of each group regarding their education.

Table 3: Average student satisfaction scores per dimension.

Cases	TMAQ	ATR	SSS	IS	TPC	OS*
English	7.04761	2.666667	6.845238	7.97619	8.178571	7.738095
Geography	7.25000	4.000000	6.900000	6.88000	7.000000	7.600000
Chemistry	7.148148	3.407407	6.027778	7.059259	7.222222	6.481481
Biology	7.407895	3.736842	6.934211	6.978947	7.842105	7.894737
Psychology	7.708333	3.166667	7.083333	7.300000	7.083333	7.500000
Mathematics	6.652778	3.166667	5.972222	8.488889	7.694444	7.611111
Physics	6.181818	3.424242	6.174242	7.296970	6.545455	6.818182
Portuguese	7.544355	3.354839	7.431452	7.238710	8.040323	8.161290
French	5.676471	3.058824	5.250000	5.270588	5.941176	6.117647
Visual Educa.	5.650000	3.666667	5.116667	6.733333	6.166667	6.133333

* Overall Satisfaction

4.6. *Calibration and Data Processing*

Calibration is a fundamental step in fsQCA, as the membership scores obtained during this process guide all subsequent stages of analysis. It transforms raw numerical data into fuzzy scores, defining membership levels as "fully in" (fuzzy = 1.0), "fully out" (fuzzy = 0.0). This process relies on both empirical and theoretical thresholds, ensuring that the scores reflect clear and meaningful levels of membership in the sets (Ragin, 2008; Schneider and Wagemann, 2012).

In this study, we employed Ragin's direct calibration method with three anchors, which were defined based on qualitative and empirical thresholds. The original data consisted of ordinal categorical scores ranging from 1 (Very dissatisfied) to 10 (Very satisfied). The calibration process followed Dusa (2019) proposal, which advocates the use of location measures as cut-off points. Specifically, we used percentiles (P5, P50, and P95) to define the anchors, ensuring a balance between theoretical understanding and empirical representation of the measured concepts. This approach guaranteed that the fuzzy scores faithfully represented the substantive meanings of the conditions analyzed.

Particular care was taken to avoid the crossover point of 0.5, which represents maximum ambiguity, as this could introduce uncertainty into the results. Table 4 presents the calibrated data derived from Table 3, ensuring that no values equal to 0.5 are included. By adopting this careful calibration approach, we achieved a clearer and more accurate analysis of student satisfaction responses, avoiding uncertainties and providing a robust mapping of satisfaction perceptions. The calibration process, contextual by nature, reflects the attribute and quality of the information, combining empirical and conceptual knowledge for optimal results.

Table 4**:** Calibrated Data

Cases	TMAQ	ATR	SSS	IS	TPC	OS
English	0.4781	0.0200	0.9035	0.9018	0.9590	0.7558
Geography	0.7052	0.9746	0.9112	0.3480	0.4018	0.5745
Chemistry	0.5786	0.5402	0.7064	0.4514	0.5551	0.0997
Biology	0.8498	0.8910	0.9157	0.4040	0.8930	0.8881
Psychology	0.9668	0.2380	0.9330	0.6045	0.4559	0.4742
Mathematics	0.2889	0.2380	0.6868	0.9728	0.8415	0.5907
Physics	0.1335	0.5647	0.7542	0.6026	0.1674	0.1814
Portuguese	0.9225	0.4657	0.9613	0.5650	0.9388	0.9752
French	0.0516	0.1478	0.0970	0.0108	0.0389	0.0497
Visual Educa.	0.0490	0.8439	0.0316	0.2725	0.0685	0.0513

4.7. *Truth Table*

fsQCA uses the truth table as a central tool to present and analyze the various configurations of causal conditions that lead to the occurrence of a given outcome (see Table 5). In the present study, we analyzed five causal conditions and one outcome, and according to Ragin's (2008) approach, the number of possible combinations of these conditions is given by 25 = 32, meaning there are 32 possible causal configurations for this study. The analysis revealed that, although there are 32 possible combinations of causal conditions, only 8 configurations of (in)satisfaction were observed, reflecting the actual interactions between the conditions that affect student satisfaction. Of these, 4 causal configurations are associated with student satisfaction, while the other 4 are linked to dissatisfaction.

The courses that presented causal configurations leading to student satisfaction include English, Mathematics, Geography, Chemistry, Biology, and Portuguese. These courses stand out for showing satisfactory results based on the identified causal conditions. In contrast, the courses of Visual Education, Psychology, and French were associated with causal configurations indicating dissatisfaction, reflecting the negative influence of some specific conditions in these courses.

The other 24 possible combinations of causal conditions, which were not observed in the analysis, are referred to as "remainders" or "logical leftovers," according to Ragin's (2008) terminology. These "logical leftovers" represent combinations of conditions that, although theoretically possible, did not manifest significantly in the study's data (Dusa, 2019). This suggests that not all causal configurations are equally relevant or possible within the specific context of Licungo University. fsQCA not only captures the causal configurations observed in the dataset but also includes those that are not empirically supported by the data.

Table 5: Truth table

TMAQ	ATR	SSS	IS	TPC	OUT	n	cases
0	0	1	1	1	1	2	English , Mathematics
1	1	1	0	0	1	1	Geography
1	1	1	0	1	1	2	Chemistry, Biology
1	0	1	1	1	1	1	Portuguese
0	1	0	0	0	0	1	Visual Educa.
0	1	1	1	0	0	1	Physics
1	0	1	1	0	0	1	Psychology
0	0	0	0	0	0	1	French
0	0	0	0	1	?	0	
0	0	0	1	0	?	0	
0	0	0	1	1	?	0	
0	0	1	0	0	?	0	
0	0	1	0	1	?	0	
0	0	1	1	0	?	0	
0	1	0	0	1	?	0	
0	1	0	1	0	?	0	
0	1	0	1	1	?	0	
0	1	1	0	0	?	0	
0	1	1	0	1	?	0	
0	1	1	1	1	?	0	
1	0	0	0	0	?	0	
1	0	0	0	1	?	0	
1	0	0	1	0	?	0	
1	0	0	1	1	?	0	
1	0	1	0	0	?	0	
1	0	1	0	1	?	0	
1	1	0	0	0	?	0	
1	1	0	0	1	?	0	
1	1	0	1	0	?	0	
1	1	0	1	1	?	0	
1	1	1	1	0	?	0	
1	1	1	1	1	?	0	

5. Results

The analysis of the necessary conditions for student satisfaction was conducted using the R software (Dusa, 2019). In the analysis of necessary conditions, two important metrics are provided to evaluate consistency and coverage. Consistency assesses how consistently a condition variable leads to the outcome variable, while coverage measures the proportion of cases where the identified configurations are observed (Schneider & Wagemann, 2012).

In fsQCA, a condition is considered necessary if the consistency score is above 0.80 (Ragin, 2009) and the coverage score is above 0.50 (Schneider & Wagemann, 2012). For the present study, the thresholds were set at a consistency score of 0.85 (Chester et al., 2019) and a coverage score of 0.50 for the outcome variable. Table 6 presents the results of the necessary conditions analysis. The consistency scores for each condition variable and its negation ranged from 0.23 to 0.99. Student services support (consistency = 0.99, coverage = 0.57) and teacher commitment (consistency = 0.95, coverage = 0.83) exceeded the consistency (0.85) and coverage (0.50) thresholds, indicating they can explain 57% and 83% of the cases, respectively.

Table 6. Necessary conditions analysis for satisfaction and non-satisfaction with the education system

Condition variables	Satisfaction with the education system		Non-satisfaction with the education system	
	Consistency	Coverage	Consistency	Coverage
TMAQ	0.845	0.818	0.454	0.658
~TMAQ	0.442	0.632	0.794	0.875
ATR	0.605	0.706	0.589	0.741
~ATR	0.619	0.691	0.605	0.729
SSS	0.993	0.575	0.621	0.465
~SSS	0.231	0.773	0.572	0.995
IS	0.75	0.746	0.56	0.695
~IS	0.54	0.685	0.692	0.816
TPC	0.946	0.834	0.462	0.622
~TPC	0.388	0.649	0.826	0.955

Note: The symbol '~' refers to the negation of the condition.

5.1. *Analysis of Sufficient Conditions for Student Satisfaction and Non-Satisfaction with the Education System*

To analyze the sufficient conditions that lead to the outcome, the Quine-McCluskey algorithm was used, a method employed to minimize boolean mathematical functions. The consistency value for sufficient conditions must be at least 0.75 (Schneider & Wagemann, 2012), with 0.80 generally recommended (Peng et al., 2022; Song et al., 2022). Unlike consistency, there is no lower limit for coverage. In the present article, three sets of solutions were analyzed: parsimonious solutions, intermediate solutions, and complex solutions.

$$TMAQ * ATR + TMAQ * {\sim}IS + SSS * {\sim}IS -> OS$$

Table 7: Parsimonious Solution for the Satisfaction of Future Teachers at UniLicungo

General Model: $Stsfa = f(TMAQ, ATR, SSS, IS, TPC)$ Parsimonious Solution			
	consisten. U=0.900	cobe. Mod . = 0.819	Consist. of Mod. = 0.985
Configuration	Coverage	Consistency	
TMAQ*ATR	0.811	0.985	
TMAQ*~IS	0.819 (high satisfaction coverage)	0.985	
SSS*~IS	0.783	0.988(high consistency of satisfaction)	

The first solution presents students who are highly satisfied with the teaching methodology and academic quality, along with a high level of satisfaction regarding accessibility and technological resources. With a consistency of 0.985, this configuration indicates that most future teachers share these characteristics, and the gross coverage of 0.811 reveals that a significant portion of satisfied students is explained by this combination.

The second solution, with a consistency of 0.819, involves students who are satisfied with the teaching methodology and academic quality, as well as a high level of satisfaction with infrastructure and sanitation. These conditions demonstrate that satisfaction with the physical environment and pedagogical quality play a crucial role in the positive perception of the training received.

The third and final parsimonious solution shows the highest consistency (0.988) and is composed of students with a high level of satisfaction with the support provided by teachers and the services available, alongside a high level of dissatisfaction with infrastructure and sanitation.

Overall, the three solutions achieved a consistency of 0.98, highlighting the robustness of the model in explaining 98% of the analyzed cases (see Table 7).

$$TMAQ * ATR * SSS \; + \; SSS * IS * TPC \; -> \; OS$$

Table 8: Intermediate Solution for the Satisfaction of Future Teachers at UL

General Model: $Stsfa \;=\; f(TMAQ, ATR, SSS, IS, TPC)$ Intermediate Solution		
		Consist. of Mod. = 0.836
	Consist. U =0.892	Cov.. Mod . = 0.722	
Configuration	coverage	consistency
TMAQ*ATR*SSS	0.699	0.825
SSS*IS*TPC	0.739 (high satisfaction coverage)	0.852 (high consistency of satisfaction)

In the intermediate solution, the model demonstrates a consistency greater than 0.800, highlighting a high level of satisfaction with student support and the services provided, along with a high level of satisfaction regarding infrastructure and sanitation, as well as the punctuality of teachers and educational commitment. These causal conditions are more predominant in the English, Mathematics, and Portuguese courses.

$$TMAQ * ATR * SSS * {\sim}IS \; + \; {\sim}ATR * SSS * IS * TPC \; -> \; OS$$

Table 9: Complex Solution for the Satisfaction of Future Teachers at UL

General Model: $Stsfa \;=\; f(TMAQ, ATR, SSS, IS, TPC)$ Complex Solution

	Consist.. U=0.707	Cov. Mod . = 0.831	Consist. of Mod. = 0.835
Configuration	coverage	consistency	
$TMAQ * ATR * SSS$ $* \sim IS$	0.475	0.809	
$\sim ATR * SSS * IS$ $* TPC$	0.599 (high satisfaction coverage)	0.824 (high consistency of satisfaction)	

Note: (~) signifies the absence of the condition. (*) represents the logical connector AND.
Source: Prepared by the authors based on research data.

In the complex solution, the model showed an overall consistency of 0.835 (see Table 9). The second configuration displayed high consistency and is composed of students who exhibit a significant dissatisfaction with accessibility and technological resources, a high level of satisfaction with student support and the services offered, as well as a high level of satisfaction with infrastructure and sanitation. Additionally, there is a strong sense of contentment regarding the punctuality of teachers and their commitment to the educational system.

Furthermore, the causal conditions for student dissatisfaction at the Licungo University in Mozambique were analyzed. Table 10 illustrates three main causal conditions for dissatisfaction among students at this institution. The first condition is composed of students with a high level of dissatisfaction with Teaching Methodology and Academic Quality (TMAQ), a high level of dissatisfaction with Student Support and Services (SSS), a high level of dissatisfaction with Infrastructure and Sanitation (IS), and a high level of dissatisfaction with the Punctuality and Commitment of Teachers (TPC). This dissatisfaction configuration is generally represented by students from the Visual Education and French programs. The Physics and Psychology programs also showed high levels of dissatisfaction. The variable Commitment of Teachers (TPC) was common across all courses analyzed as a key factor contributing to dissatisfaction, as shown in Table 10.

$$(\sim TMAQ * \sim SSS * \sim IS * \sim TPC) + (\sim TMAQ * ATR * SSS * IS * \sim TPC) + (TMAQ * \sim ATR * SSS * IS * \sim TPC) \leftrightarrow \sim OS$$

Table 10: Complex Solution for the Non-Satisfaction of Future Teachers at UL

General Model: $Stsfa = f(TMAQ, ATR, SSS, IS, TPC)$ Complex Solution			
	Consist.. U=0.911	Cov. Mod . = 0.781	Consist. of Mod. = 0.982
Configuration	coverage	consistency	
$\sim TMAQ*\sim SSS*\sim IS*\sim TPC$	0.500(high Non-satisfaction coverage)	0.971(high consistency of Non-satisfaction)	
$\sim TMAQ*ATR*SSS*IS*\sim TPC$	0.357	0.867	
$TMAQ*\sim ATR*SSS*IS*\sim TPC$	3.432	0.880	

Note: (~) signifies the absence of the condition. (*) represents the logical connector AND.
Source: Prepared by the authors based on research data.

6. Discussion

The results of this study indicate that certain conditions are particularly relevant in explaining student satisfaction at the Faculty of Education, Licungo University. In the sufficiency analysis, using consistency and coverage thresholds of 0.85 and 0.50, respectively, following Chester et al. (2019), it was found that student services support (consistency = 0.99; coverage = 0.57) and teacher commitment (consistency = 0.95; coverage = 0.83) meet the established criteria, highlighting their central role in shaping student satisfaction. These findings are consistent with previous research indicating that institutional support and teacher dedication are key determinants of positive academic experiences (Teeroovengadum et al., 2019; Alsheyadi & Albalushi, 2020).

The application of the Quine-McCluskey algorithm allowed the identification of three parsimonious solutions explaining student satisfaction with consistencies above 0.80, confirming the robustness of the model. The first solution combines high satisfaction with teaching methodology, academic quality, accessibility, and technological resources (consistency = 0.985; coverage = 0.811). This finding suggests that educational experiences integrating technological innovation and accessibility enhance students' positive perceptions, in line with Husain et al. (2022), who emphasize the importance of integrating technology and accessible pedagogical strategies for effective learning.

The second solution shows that infrastructure and sanitation, combined with pedagogical quality, are also critical determinants (consistency = 0.819). These results support the literature highlighting adequate infrastructure as essential for student well-being and for creating a conducive learning environment (Pasaribu et al., 2020; Dinh et al., 2021). The link between quality physical spaces, sanitation, and positive student perceptions indicates that the physical context directly influences the academic experience.

Intermediate and complex solutions reveal additional nuances. In the intermediate model, satisfaction with student support, infrastructure, and teacher punctuality was prevalent in specific courses, such as English, Mathematics, and Portuguese (consistency > 0.800). This specificity suggests that disciplinary context can shape satisfaction perceptions, consistent with Dylan et al. (2019), who noted the variable impact of institutional conditions across different fields of study. The complex solution highlights configurations including dissatisfaction with accessibility and technological resources but maintaining high satisfaction with support and infrastructure, showcasing the complexity of conditional interactions and the importance of considering multiple factors simultaneously.

The analysis of these solutions suggests the need for an integrated approach to improving the educational experience. The high consistency of the solutions indicates that the results are robust and provide strong empirical evidence for practical interventions. Policies aimed at strengthening infrastructure, promoting accessibility, and providing adequate technological support could significantly enhance student satisfaction. Furthermore, continuous attention to pedagogical quality and teacher commitment remains essential, as both are central determinants of the academic experience, as demonstrated in this study and previous research (Thanh, 2021; Alsheyadi & Albalushi, 2020).

7. Conclusions and future research directions

7.1. *Conclusions*

This study provided an in-depth analysis of the conditions influencing student satisfaction in higher education, employing fsQCA to identify significant causal configurations. The findings highlighted that student service support and faculty commitment are essential determinants of satisfaction. These conditions not only met the consistency and coverage thresholds but also robustly explained student satisfaction, with high consistency values above 0.85, indicating their central role in shaping a positive educational experience.

The analysis of parsimonious solutions further revealed that the combination of effective teaching methodology, academic quality, accessibility, and technological resources had a significant impact on student satisfaction (consistency = 0.985; coverage = 0.811). These results align with previous studies, such as Husain et al. (2022), emphasizing the importance of technological innovation and accessibility in fostering a satisfying educational environment. A second solution emphasized the relevance of infrastructure and sanitation, supporting the literature that identifies physical infrastructure as a critical factor for student well-being and overall satisfaction (Pasaribu et al., 2020).

Intermediate and complex solutions highlighted additional nuances. Specific courses, including English, Mathematics, and Portuguese, demonstrated that disciplinary context, student support, and faculty punctuality influence satisfaction perceptions. This finding reinforces the idea that student satisfaction is multi-dimensional and context-dependent, emphasizing the need for institutional strategies that consider both general and course-specific factors.

In terms of practical implications, the results suggest that institutional policies aimed at strengthening infrastructure, improving accessibility, and investing in technological resources are crucial for increasing student satisfaction. Additionally, sustained focus on faculty commitment and pedagogical quality remains essential to ensure high-quality education. Overall, this study provides a robust empirical foundation for institutional interventions designed to enhance the educational experience and improve student satisfaction.

Despite the contributions of this study, several limitations should be acknowledged. First, the analysis is based on a self-reported student satisfaction survey, which inherently carries a high degree of subjectivity. The study does not include objective indicators of academic performance, such as learning outcomes, grades, or students' labour market insertion, which could complement and validate the subjective perceptions captured in the questionnaire.

Second, the data were collected exclusively from a single higher education institution, Licungo University. This institutional specificity limits the generalizability and the potential extrapolation of the findings to other universities in Mozambique or beyond, as student satisfaction is strongly influenced by institutional context, resources, and organizational culture.

Third, although fsQCA is a powerful tool for identifying causal configurations, it presents methodological limitations. The results can be sensitive to the calibration choices, including anchor-point selection and the avoidance of crossover values, as well as to the definition of consistency and frequency thresholds in the truth table. Moreover, fsQCA does not allow probabilistic inference nor the estimation of marginal effects, which limits direct comparisons with traditional statistical models.

7.2. *Future Research Directions*

Building on the present study, several avenues for future research are recommended. First, a comparative analysis between fuzzy-set QCA (fsQCA) and fuzzy association rule mining could provide additional insights into the patterns and combinations of factors that lead to student satisfaction. While fsQCA identifies necessary and sufficient causal conditions, association rule mining can reveal frequent patterns and relationships across a broader set of variables, offering a complementary perspective.

Second, the integration of advanced machine learning algorithms, such as artificial neural networks, random forests, and gradient boosting, could be employed to predict student satisfaction and assess the relative importance of each determinant in a non-linear, data-driven manner. Combining these approaches with fsQCA could help to validate causal inferences and identify previously unobserved interactions between variables.

Third, future studies could explore cross-institutional comparisons, analyzing student satisfaction in multiple universities within Mozambique and across different African countries. This would allow researchers to identify region-specific factors, common patterns, and institutional best practices, thereby increasing the generalizability of the findings.

Finally, longitudinal studies could investigate how changes in infrastructure, technological integration, faculty training, and student support services over time influence satisfaction trajectories. This approach would provide dynamic insights into the sustainability and long-term effects of institutional interventions, supporting evidence-based policy-making in higher education.

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